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"To the solid ground
Of nature trusts the Mind that builds for aye"—WORDSWORTH

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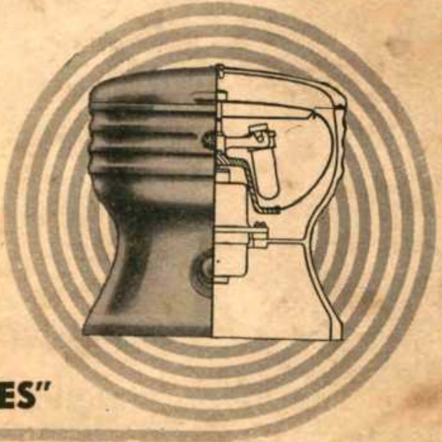

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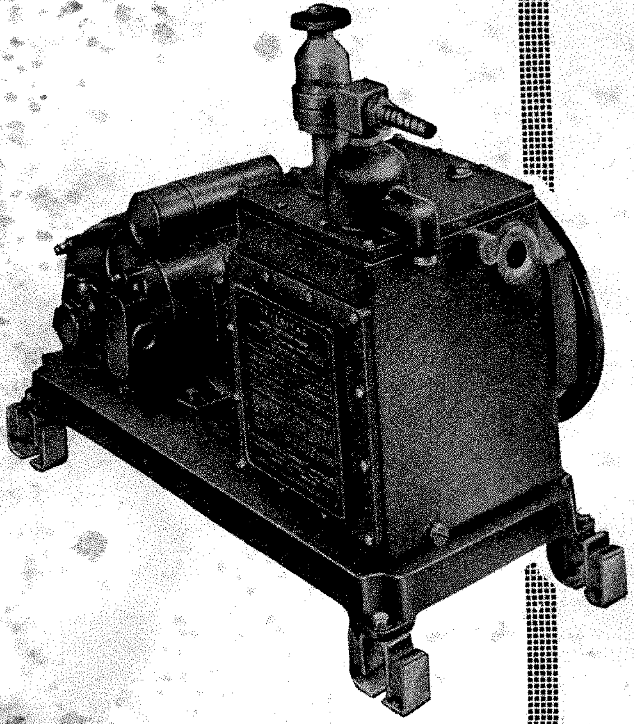

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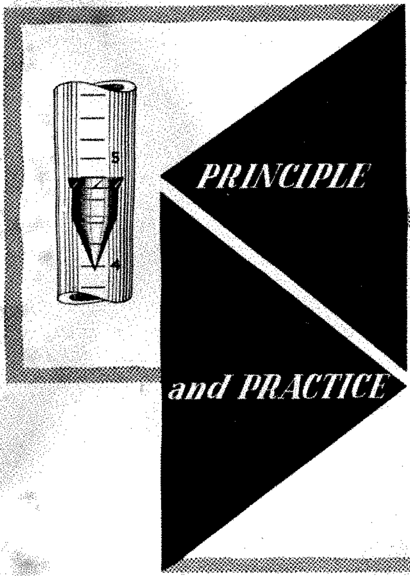

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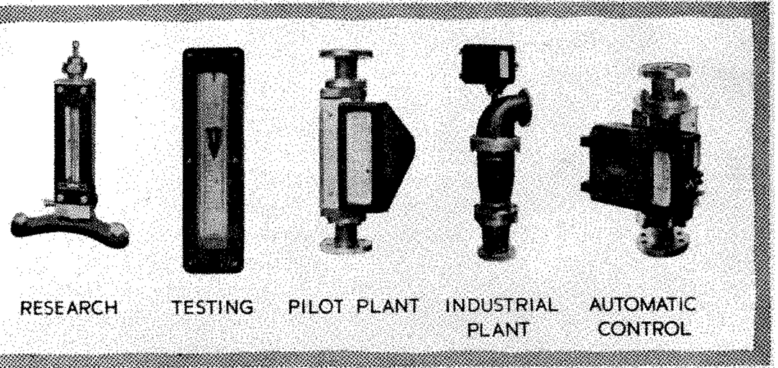

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THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

"*When I was young Science was regarded as a poor relative of the Arts—now it is the Rich Uncle on whom we all depend.*"—The Marquess of Salisbury.

SCIENCE needs more and more advertisement, interpretation and promotion. The British Association for the Advancement of Science was founded 126 years ago for this purpose, though its charter was not worded in such forthright terms. For many years after its foundation, the Association fulfilled its functions well, especially during those decades when there was nothing much more than a few newspapers and book-publishing houses which were able to act as means of mass communication and education. Then things went well, and the scientists of those days looked forward to their annual meeting from one year to the next. Nevertheless, only for one week during each year was the public able to learn a little about science and scientists, and for the other fifty-one weeks it had scarcely anywhere to turn for scientific enlightenment, unless an individual was sufficiently intrigued to join some local society. Moreover, only a few incidents, such as the Wilberforce–Huxley controversy at Oxford, seemed to arouse widespread and long-continued interest through the medium of the British Association.

Gradually times and outlook began to change, and more recently attitudes towards things scientific have become quite serious and acute. Once upon a time, the British Association was not only the main forum for public discussion of science and the main medium for the promotion of interest in science (apart from the Royal Institution), but also its own agent. Except the learned journals and the more cultured (and therefore the less-widely read) newspapers, there was little or no means available to the non-scientist for following the advances being made in the various branches of science. The layman was left in the dark; certainly his curiosity was not aroused. Now all that has changed—indeed by science itself; and we have sound radio, television, the cinema, more and more popular newspapers and a few first-class journals which include in their multifarious activities the interpretation and also the criticism of science.

But for some time, in fact until comparatively recently, the British Association seemed to be unaware of this, and appeared oblivious of the demands of the public and the excellent opportunities developing around it. It seemed to be gradually drifting into dangerous complacency and even sterility due mainly to lack of youthful vigour. The meetings became annual events supported for one week by a few perennial scientific pillars intermingling with the city fathers at an always-changing venue. Naturally such people looked forward to that week; but the younger and more productive scientists stayed away, and the public consequently suffered. During those times, the non-scientific public was apathetic anyhow, for was not science the poor relative of the arts? Nevertheless, the British Association did little to stir the public out of its apathy; in fact, the annual meeting became the subject of keen criticism and complaint among the younger scientists, pressmen and the more interested general public.

It would serve no useful purpose to seek the reasons for all this: it is sufficient to realize that the present officers of the Association are aware that such things did happen. Now it has become increasingly evident, especially during the past few years, that the British Association is determined to put its house in order. It is now alive to its limitations and very aware of its opportunities. The main conditioning factor is the financial one, and here it is the duty of others to help. The opportunities for valuable work are now available, and, given relief from financial anxiety, the Association is becoming fully equipped and anxious to take advantage of them.

It is desirable, however, to point out a few changes in policy which appear to have been deliberately, though quietly, instigated, for they point the way to still further improvements. It is certain that during the past few years each annual meeting has been better organized, with the result that the Association is attracting more interest and more and more publicity, and thus doing what it was always meant to do—reaching the public eye and ear. For a long time, the elected presidents seemed to alternate in interest and achievement—one year a man from the life sciences followed the next year by one from the physical sciences. This must have made things somewhat difficult for the Council. It certainly resulted sometimes in the election of a president whose claim to the great honour was based mainly on the fact that he was a successful scientist and possibly had attended the annual meetings with uninterrupted regularity over a long period. The result was now and then disappointing, on occasions even lamentable; and some presidential addresses proved to be incomprehensible even to the scientists themselves. It seemed, moreover, that this tendency to specialize percolated throughout the entire organization, affecting (as was once pointed out by Sir Arthur Keith) the sections and their presidents. The few younger research workers who attended the meetings often did so with the main purpose of presenting a research paper which should never have been accepted by the British Association at all; for the Association is not in the academic sense a learned society but rather a teaching and promotion organization.

Reaction to this over-specialization began to set in, and too many scientists either lost or never even gained any interest in the activities of the Association; some who were interested in its fundamental aims lost heart, and the public grew bored. Moreover, some newspaper editors and reporters waxed critical and resentful because they could find little at a British

Association meeting likely to interest their readers; not so much because interesting topics were absent but because they were presented and interpreted so badly that those responsible for writing news or feature articles found themselves out of their depth.

Recent presidential elections and changes in general organization, however, have revealed a determination to get away from all this. The Association is wisely selecting each year as president a man who is not only a scientist but also one of many parts. He is not one of Lord Hailsham's "egg-heads", but a man who is sincerely concerned with the advancement of science outside his own subject and who has proved himself capable of discussing science, its applications and implications, in a very comprehensive and picturesque way which the public likes and can assimilate and appreciate. Some such presidents have been men of drive, fearless in the expression of their views, even when these have been unpopular at the time. This is the kind of president the British Association needs, and will always need; and it is the kind which it has been having more recently, such as H.R.H. The Duke of Edinburgh, Sir John Russell, Prof. P. M. S. Blackett (the outgoing president) and Sir Alexander Fleck (the incoming one).

As in any such large organization, individuals are important to the British Association, and this does does not mean just members of Council and those who, in their turn, make their appearance before the public. Many ideas must inevitably emanate from the permanent staff, in spite of the fact that they may have to be put into effect by the president, presidents of sections, recorders, and those taking part in the reading of papers and in discussions. In the case of the British Association itself, important changes and developments have recently been instituted, others are in process of expansion, and still others are contemplated and being discussed (see p. 8 of this issue). It can be taken for granted that much of this welcome activity was initiated by Sir George Allen, who took office as secretary as recently as 1954. In appointing him, the Association wisely took account of the fact that he is a man with a background not only of academic achievement or work confined within college cloisters or research laboratories. He was formerly vice-chancellor of the University of Malaya, and no vice-chancellor can afford to ignore the environment of his university or the community of peoples which his university serves. Sir George looks upon the problems facing the British Association in various ways: as individual tasks to be tackled efficiently with the assistance of the right people (for example, Sir Hugh Beaver and his Committee appointed to investigate and report on the practicability, implications, consequences both international and domestic, and the cost of the change-over to the metric system by the United Kingdom), and as problems forming a coherent whole whereby in solving them the British Association will become one of the greatest means of advancing and interpreting science.

In our opinion, the Council of the British Association has always been too large and therefore too cumbersome; it does not meet often enough; and it has seldom seemed disposed to enlist the help of younger and more energetic members. The result has been that for too long a time, in spite of occasional, though unsustained, efforts to break away from tradition, the Association has continued to be, at any rate for the layman for whom it really exists, nothing but an annual event of one week spent in useful and pleasurable activities with the rest of the time spent in suspended animation. Now, we are glad to learn, the Association has decided to change that also and become an active and effective force throughout the year.

A new policy is announced for implementing those functions for which the Association was originally founded, but—and this is important—taking into consideration the rapid changes in conditions and attitudes. No longer will the Association be content to remain centred in London, going outside it once each year; for Area Committees are to be formed. Moreover, at the centre, there is to be a Programme Advisory Committee which will work in close liaison with the Section Committees. This is indeed a welcome departure; for now the Association will have the machinery for arranging programmes which itself can be periodically modified or rebuilt to meet the ever-changing needs and demands of science and the community which it serves. It is to be hoped that the Area Committees will not be confined to academic centres throughout the country, but will also be set up wherever density of population or accumulation of industry warrants them. Thus will the Association extend its influence in time and place and so, as never before, take the message of science to all and sundry.

The Area Committees are to work with already existing bodies such as youth organizations, women's institutes, educational associations, and so forth. We would advise such bodies to welcome any approach that an Area Committee may make to them. In this connexion, we would strongly recommend the Rotary movement to the British Association Area Committees. Rotarians meet every week throughout the year, and they have many clubs in towns and cities everywhere. At most meetings there is a short talk, sometimes followed by a discussion. Any scientist who is able to lecture well and is in sympathy with the objectives of the British Association should be pleased to have the opportunity of addressing Rotary clubs, for each club is a good cross-section of the local community—commercial, professional, social and academic. What better audience could the Association wish for? A speaker finds himself treated as an honoured guest, and is presented with the opportunity not only of bringing enlightenment to those sincerely wishing to learn but also of preaching to the unconverted—and the latter is the most important of all audiences.

The organization of a "Junior B.A. Meeting" is also an important step in the right direction. At the Belfast meeting (1952) of the British Association there was a well-attended series of lectures for juvenile audiences. This was an excellent idea, well conceived and executed (no doubt by Sir Eric Ashby, vice-chancellor of The Queen's University of Belfast, and other local individuals and authorities working in collaboration with Association officials). But the idea was not followed up as closely as it should have been. Now sixth-formers are invited to read papers to adult audiences at the meetings—also a good idea. Perhaps the proposed Junior Association will combine the two movements and thus capture the interest and imagination of hundreds of people at the right time and the most significant age. Here the Association will have excellent chances for work in connexion with science in schools. It is to be hoped that it will not confine itself to grammar schools, but will also approach secondary modern schools and even junior schools, for all these have their problems concerning the presentation of science. At the upper end, of course, there is still much work to be done in connexion with sixth-form science as a stepping-stone from school to university and technical college. Neither should the Association ignore school science as a cultural subject in its own right, that is, not as a means to an end, but as an end in itself.

So far as juvenile and lay audiences are concerned, there is an important point which the Association has not always taken into consideration in the past—that is, choice of lecturer. The man or woman needed for this work is not necessarily one who has made a name for himself or herself in the laboratory. In fact, some such people have been known to drive people away rather than attract them. Obviously a lecturer must know something about the subject; but he need not necessarily be a specialist. He must, however, essentially have presence, poise and personality which will command attention as soon as he mounts the platform. A bad lecturer can easily stifle interest in an interesting subject. This point of view the Association would ignore at its peril, for without the inherent ability to grip the attention of his audience (and many scientists lack such ability), a lecturer would do more harm than good and send his audience away bored or amused or even resentful.

During its earlier years, when science was not so advanced as it is to-day, the Association was able to carry on by itself with the help of a few newspapers and journals. But now times have changed, and, to say the least, the public is curious about science. Moreover, to-day the Association has at its disposal extra-mural departments of universities, the Workers' Educational Association, schools, local societies, the Rotary, Round Table and Soroptimist movements, sound broadcasting and television, the cinema and the whole of the newspaper Press and many journals. It is good to learn that the Association proposes making more advances to some or all of these agencies for mass communication and education. Conversely it is to be hoped that such agencies will welcome the advances to be made, for this can bring nothing but good to all concerned and consequently to the community which they serve.

As *The New Scientist* of December 19 states: "Unity among scientists is essential—but it is not enough. Equally important is the interpretation of science to laymen so that they can intelligently insist upon its discoveries being used for the benefit of mankind. . . . This can only be done with any degree of success in a community which is so educated and informed that it is eager to listen to and able to comprehend what the scientists are talking about. It cannot be done by merely introducing more teaching about science and its background, aims and objectives in our schools and then sitting back. On leaving school, our young people go out into a world of high-powered promotion, advertisement and indoctrination. . . . Recognizing that such heavily promoted attractions [such as entertainment, sport, high-pressure salesmanship, and even politics] may always be with us, science cannot afford to sit on the fence. It must enter the lists with its own promotion and continue plugging it long after school-days are past". The British Association is offered, and is now about to take, the wonderful opportunity of becoming a unifying influence, a leading example, in the promotion of science, through its own activities extended through time and area, and in collaboration with other authorities and associations.

The Association is to be congratulated on the greatly modified, and in some cases new, steps which it is about to take, for much work will be involved in all this. The Association has excellent tools for the job at its disposal; moreover, it has the background of past achievements and even mistakes made from which it can draw inspiration and take warnings. Every support from all possible sources should be extended to this important movement. Workers, organizers and good lecturers are to be found in plenty, and no doubt they will willingly come forward. But the whole movement (and here we have been able to refer to only some aspects of it) will essentially incur considerable expense. Yet it will mean money being in good hands and well and wisely spent. It is clear that the Association should be freed from financial anxiety. Obviously such a body cannot expect to depend solely on the subscriptions of its members, especially if the membership is to embrace more younger people. Neither can those who will have to do the work shoulder the expenses. But industry and the Press (to mention only two examples) can, and we hope will, give financial support, not only for their own benefit but also for the good of the community. A sum of £40,000 has already been received: this is good, but by no means enough. We would therefore appeal to industry and the newspaper Press to support this valuable movement; for to them it is a splendid investment which will pay handsome dividends. Industry is constantly demanding more scientists; the expansion of interest in, and knowledge of, science is the first step towards getting them. The Press can now expect bigger and better opportunities for finding interesting 'copy' out of the meetings to be organized by the Association.

If, and when, therefore, the British Association for the Advancement of Science decides to extend its appeal for funds (especially capital funds), it is to be hoped that such an appeal will meet with a generous response.

BIOLOGY OF MAMMALS

Life of Mammals

By Prof. J. Z. Young. Pp. xv+820 (338 figures). (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 84*s*. net.

"THE Life of Mammals" is in a sense a sequel to Prof. Young's "The Life of Vertebrates" published seven years ago, and is an equally massive work. In conception it is entirely original, drawing its subject-matter both from medical anatomy and physiology and from vertebrate and experimental zoology. It is a systematic text-book full of factual information, and will be extremely useful as a work of reference; but it also characteristically presents an important central theme running through the whole book, which is to reveal the fundamentally mechanical nature of living systems, and of their remarkable powers of self-regulation or homeostasis. Prof. Young outlines this theme in Chapter 1 with admirable and stimulating clarity, using the analogies of man-made machines and communication devices with their servo-mechanisms and attainment of regulation by the use of feed-back. He returns to it time and again in the subsequent pages.

In all there are forty-seven chapters arranged in a morphological sequence, starting with the integument and the mechanical systems of the body, and proceeding next in turn to the digestive, circulatory, respiratory and excretory systems. These carry the reader to Chapter 16. Seven chapters follow on the nervous system and five on the various types of receptors; five more deal with endocrinology, and the remaining fourteen chapters are taken up with reproduction and embryology. A bibliography gives a small number of selected references for each chapter, and finally there is an index of 15 pages (30 columns), which incidentally seems barely generous enough for so large a book. For the convenience of those to whom it will be a standard work of reference an index double the size would not have been excessive.

The one obvious criticism to be made stems from the title, which may very well lead the reader to expect an entirely different sort of book. The emphasis here is on life-processes, illustrated for the most part by one or both of two selected types, the primate (especially man) and the rabbit; and it must be admitted that occasionally an impression is given by the author that what applies to this selected material applies to the mammals as a whole, when this is by no means the case. There is actually very little on either the natural history of mammals or on their comparative anatomy and physiology, though these are the particular subjects which one might expect to form the main substance of such a book, judging from the title alone. Students who specialize in the study of mammals may be excused if they feel a momentary disappointment in discovering that, after all, they have still to wait for the particular kind of text-book on mammalian zoology in English that they so badly need; but they may remember that Prof. Young has previously devoted more than two hundred pages to a comparative review of the mammals in "The Life of Vertebrates".

"The Life of Mammals" will commend itself to anatomists and physiologists, partly for the great amount of information it contains which is either new or has never before appeared in a text-book. This applies with particular force to the second half of the book, dealing with the nervous and endocrine systems and with development. But over and above the value of having so much recent material from very diverse sources collected together, they will benefit from the recurring sections in which the author pauses to interpret the facts and explore the general principles or ideas which emerge from them; these are frequently highly original and stimulating, and succeed to an important degree in extending the boundaries of the reader's insight and understanding. As might be expected, the text is very readable. The book can be commended equally well to students of zoology, some of whom may discover in it with advantage many of the classical facts of medical anatomy and physiology for the first time.

Great care has been taken with the illustrations, a large number of which are new and have been specially drawn with considerable skill; they include a very useful series on the anatomy of the rabbit (for which a finding index would be a welcome addition). The general standard of production is excellent, and in relation to the enormous labour of producing such a book the number of minor errors is small. It may be hoped that the complicated task of revising it at intervals to keep pace with advancing knowledge will prove to be possible for many years to come.

V. C. WYNNE-EDWARDS

LANDMARK IN COAL SCIENCE

Coal Science

Aspects of Coal Constitution. By Prof. D. W. Van Krevelen and J. Schuyer. Pp. xii+352. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd.; Princeton, N.J.: D. Van Nostrand Company, Inc., 1957.) 55*s*.

A STUDY of coal in all its varieties involves most of the pure sciences. The basic economic importance of coals, and especially the baffling complexity of some of their properties, justify the treatment of coal science as a separate branch. Coals are porous and amorphous, and appear to consist of aperiodic macromolecules; few standard techniques can be applied to their study without modification, and the results are frequently ambiguous or less informative than those obtained with simpler organic compounds. Special methods have been developed, many unorthodox and most containing an element of empiricism.

It is not easy to assess the significance of the reported results, which vary widely in quality. Owing to the rapid current advance in the subject and the increase in team effort throughout the world, a simple exposition of coal science as a whole is a compelling need, but its satisfaction is correspondingly difficult. The text-book under review, in spite of shortcomings to be expected in a pioneer venture, must be acclaimed as a considerable achievement in this direction.

Coal petrology and systematics together with related physical and colloidal studies—primarily observational approaches—are concisely and authoritatively treated in Part 1 ("Coal in its Various Aspects"); and chemical studies of coal constitution—primarily experimental—are fully described in Part 2 ("Constitution of the Coal Matrix"). It is an especial merit of this book that a powerful attempt is made to integrate these two major branches of coal science, hitherto independent developments.

In Part 2 there is a full description of the novel methods of statistical structural analysis—based on the approximate additivity of certain physical properties in terms of atomic and structural features —which the authors have developed to enable them to estimate numerical parameters of the average molecule once the qualitative pattern has been established by other means. Such methods are especially useful when investigating substances that are intrinsic mixtures, that is, those the molecules of which vary in detail around a norm.

Part 3 of the book ("Principal Physical and Chemical Properties") is concerned largely with the relation of the physical and mechanical properties of coals to their chemical structure, with their oxidation, and with the phenomena that occur when coals are heated. In the chapter on pyrolysis and carbonization, though it is of great interest, insufficient attention is paid to the detail necessary to enable fundamental studies markedly to influence the practice of carbonization.

In parts of the book there is a lack of balance; for example, less prominence might have been given to views and investigations now superseded. Frequently the impression is conveyed that the results and methods discussed have been established with certainty and are universally accepted; the inexperienced reader might wrongly deduce that little remains to be done. There is sometimes a tendency to discount important divergences between different sets of results. These remarks apply especially to parts of Chapters 5–7, 11, 13 and 14.

"Coal Science" is excellently conceived and produced and reasonably priced. Few misprints have been noticed; only the column headings of Table V.4 are misleading from this cause. Stimulating to read and provocative of thought, this book contains a wealth of information indispensable to the student and research worker. It is to be warmly recommended as the most topical and critical text-book available on its subject.

I. G. C. Dryden

THE PROBLEM OF PERSONALITY

The Three Faces of Eve

By Corbett H. Thigpen and Hervey M. Cleckley. Pp. 313. (London: Martin Secker and Warburg, Ltd., 1957.) 18*s.* net.

PERSONALITY has been defined as the integrated activity of all the reaction-tendencies of the daily life of the individual. Yet we must admit that even in normal persons the integration is not always as complete as it might be. Most people, for example, when deep in thought, have found that they have driven a car long distances, but not appreciated they have done so until they 'come to themselves'. Most of us show a different personality when having tea with the vicar and at a riotous reunion. Mothers often say to an erring small daughter, "That's not my little girl", and, indeed, in the sense in which it is said, it is not, since the child is behaving in a way that actors call 'out of character'. However, in spite of such deviations, most personalities are sufficiently united to stand considerable strain before disintegrating. Yet there are others of the hysterical type which divide easily and the reactions split into different groups. This may result in a hysterical fugue, or loss of memory, or in more complicated conditions, dual or multiple personalities. The classical case of the latter was described by Morton Prince in his famous "Clinical and Experimental Studies in Personality". This was an account of a Miss Beauchamp, whose personality divided into a number of parts, some of which were unaware of the consciousness of the others. This may seem difficult to those who do not understand that consciousness is the appreciation of incoming sensations in the light of acquired and inherited reactions. It is apparent that a partial group of such reactions can interpret sufficiently to acquire consciousness.

"The Three Faces of Eve" is a popular account, told in a journalistic fashion with plenty of wonderment, of a woman whose unhappy marriage led to such a breaking of her personality. This was apparently the result of childhood stress with regard to death: first of a man drowned in a pond; and then of seeing her dead grandmother, and being forced, against her will, to touch her face. However, it seems that an unhappy marriage had much to do with the immediate behaviour, since the patient's recovery was consequent to her divorce and remarriage to a man who was more suited to her and whom she loved.

The case-history was read before the American Psychiatric Association in 1954 and published in the *Journal of Abnormal and Social Psychology*. It certainly shows a number of curious personalities, but how far these were unconsciously encouraged by the psychiatrists in charge of her, and how far they emerged spontaneously, it is difficult to say. The morality of expanding technical scientific articles about real persons into matter which is little better than a novel is questionable. Those who enjoy reading sensational psychiatric books will find this one amusing, but the serious workers will probably wish to go to the original publication.

Clifford Allen

PHYSICAL OPTICS

Physical Optics

By Dr. R. A. Houstoun. Pp. vi+300+16 plates. (London and Glasgow: Blackie and Son, Ltd., 1957.) 40*s.* net.

Wave Optics

Interference and Diffraction. By Dr. C. Curry. Pp. viii+155. (London: Edward Arnold (Publishers), Ltd., 1957.) 21*s.* net.

DR. R. A. HOUSTOUN'S book is intended for two types of post-intermediate university student—the physics specialist in the early stages of the honours course, and the non-specialist whose study of optics is subsidiary to that of some other branch of science. For the physics student, as it is essentially a shortened version of the author's "Treatise on Light", it should be a useful introduction to advanced work; although in some places, notably in the chapter on the electromagnetic theory, the attempt to simplify by mere abridgement seems to have operated the other way. The range of topics should give readers of the second type a sound and accurate background, but here it must be remembered that the biologist and the engineer, for example, expect to treat a physics book as a work of reference. It is true that the principles are well explained, and that many recent developments are mentioned; but one feels that a fuller descriptive treatment of spectroscopy, photometry, colour, and the eye, would have been welcomed by such readers. The action of prism and grating on a 'light-pulse', and the problems of Talbot's bands, which figured prominently in the intriguing Chapter 21 of the "Treatise" forty years ago but seem less significant to-day, are mentioned rather too briefly for either type of reader to make much of them. In short, this is a comprehensive and authoritative book which students could profitably use under tutorial guidance, but which would be difficult reading on its own.

Also intended for the post-intermediate student, Dr. Curry's book is a detailed and critical examination of the principles of wave-optics. It is written for only one type of reader, whose mental attitude and difficulties have been very carefully considered by the author. This is the good student who has mastered the usual Advanced-level work on interference and diffraction (with its deceptive appearance of completeness), and is rather appalled when he finds in his honours course that the real depth of the subject is so much greater than the apparent depth as he knew it. This book bridges the gap between the two stages, and does so excellently. The diagrams are good, and except in the sections on the wave theory of aberrations and on the Fresnel integrals, the mathematical work is relatively simple, or is so well explained that it seems so. University teachers often complain that their students arrive with a store of factual knowledge, but with the ability to think as a physicist quite undeveloped; and the reviewer always replies that the schoolmaster does his best, but that this development can only be expected at the university. Dr. Curry would surely concur. Needless to say, this is a book that should be made available to sixth-form boys at school in their last year, so that the proper outlook can begin to penetrate; and, as the author has assessed the needs of the younger university student accurately, and met them uncompromisingly, it should prove very valuable for its intended purpose.

G. R. Noakes

THE THEORY OF ELECTRICAL NETWORKS

The Theory of Networks in Electrical Communication and Other Fields

By F. E. Rogers. Pp. 560. (London: Macdonald and Co. (Publishers), Ltd., 1957.) 65s. net.

FOR some time now university electrical engineering departments have been aware of the dangers of dichotomy between heavy- and light-current engineering, the fundamentals of which are essentially the same. The author of this book on networks is fully aware of the problem, and he has set himself the task of treating the subject from a fundamental viewpoint applicable to heavy-current as well as light-current engineering. Though there is a reference in the second chapter to the Heaviside transient solution, the book is essentially concerned with the sinusoidal approach. The general theory of circulating currents and the solution of mesh equations (Chapter 3) is followed by a statement and explanation of the four important network theorems (Chapter 4) and a discussion of ladder, T and π structures in Chapter 5. The next section, on equivalent networks, is of considerable interest to power engineering students, who will be disappointed that it is not illustrated by examples drawn from complicated power distribution networks. The same opportunity is lost in Chapter 8 on transmission along uniform lines and cables. The value of Foster's reactance theorem is well illustrated under two-terminal networks. The last four chapters on four-terminal networks, insertion loss, filters and measurements are mainly of interest to the light-current engineer.

There are a number of American and English books on networks, and comparison with these is inevitable. In this respect the author is not helped by his publishers, whose ideas of presentation are old-fashioned. The diagrams look amateurish, the lettering often being far too big, and many of the diagrams insufficiently reduced and sometimes not placed in the best position. Typical examples of these faults are found on pages 36 and 236. The author is not entirely blameless for he is not consistent in the captions of the figures, and on page 281 this inconsistency accompanied by a footnote causes confusion; the value of heavy type to denote the so-called vector quantities of current and voltage is doubtful, adding to the cost of production and making a page look untidy.

So far as the material and the manner of using it is concerned, the author has produced a useful contribution to the teaching of fundamental network theory, and the many worked-out examples taken from internal and external examination papers of the University of London will commend it to teachers and undergraduates alike. To get full value from the book the undergraduate needs an understanding of Heaviside's operational calculus, complex quantities, determinants and Fourier analysis; a selected list of references at the end of each chapter contains the names of books which will help the student in furthering his knowledge of the subject.

K. R. Sturley

ADVANCED ORGANIC CHEMISTRY

Organic Chemistry

By Dr. I. L. Finar. Vol. 2: Stereochemistry and the Chemistry of Natural Products. Pp. xi+733. (London and New York: Longmans, Green and Co., Ltd., 1956.) 40s. net.

THIS text-book is written primarily for students who are reading for Part II of a special honours degree in chemistry. It is divided into two main sections; the first part, 177 pages, is concerned with stereochemistry, and the rest, 571 pages, is devoted to the chemistry of the more important types of natural products.

The discussion of stereochemistry is not up to the high standard of the rest of the book. It begins with a chapter devoted to the relationship between physical properties and chemical constitution, but some of the statements in this chapter are not well based. For example, in the section dealing with ultra-violet spectra (p. 16), it is stated that "By this means the main structural features (if not all) may be obtained, and thereby lead to a structure being assigned to a compound under investigation. Thus having obtained a tentative structure, the final proof is obtained by synthesis". This is, of course, quite incorrect and is certainly not good advice for chemists during the final year of their undergraduate training.

There are other chapters dealing with optical isomerism, Walden inversion, geometrical isomerism, the stereochemistry of diphenyl compounds, and the stereochemistry of elements other than carbon. The definitions given (p. 23) for stereoisomerism, optical isomerism and geometrical isomerism are not satisfactory; in fact, absolutely identical descriptions of optical and geometrical isomerism are given. The section dealing with the resolution of racemates is very interesting, but it is unfortunate that a detailed description of current views on the mechanism of substitution reactions is hidden in the chapter "Walden Inversion". This book certainly suffers from the lack of a chapter on the electronic mechanism of organic reactions, and when mechanisms are illustrated the symbolism which is used (for example p. 158) does not agree with that now generally accepted. The author has included terms such as centro-asymmetric (p. 40), auto-racemization (p. 47), asymmetric decomposition (p. 54), and stereomutation (p. 105) which are not generally used.

In the first four chapters it is unfortunate that there are many cases where the numbers referring to diagrams do not match those given in the text. For example, on p. 27, Fig. 6 in the text refers to a diagram labelled Fig. 2.6.

The most important recent development in stereochemistry is conformational analysis and one would certainly expect a discussion of this topic in a general text-book having a long section dealing with stereochemistry. The treatment is unfortunately much too brief, and the terms axial and equatorial are now used rather than the alternatives mentioned (p. 113). Presumably this omission is due to the delay which occurs between the writing and printing of text-books; this also probably accounts for the incorrect statement (p. 220) that sucrose has not yet been synthesized chemically.

The second section, which deals with natural products, is excellent and is certainly one of the best accounts of the subject which has been written at this level. It consists of thirteen chapters which are devoted to carbohydrates, terpenoids, steroids, amino-acids and proteins, alkaloids, anthocyanins, purines and nucleic acids, vitamins, antibiotics and chemotherapeutic agents, hæmoglobin and chlorophyll. Sections dealing with aromatic hydrocarbons, certain heterocyclics, and phthalocyanines are also included.

The treatment of the proof of structure of natural products by degradation and by synthesis is excellent and would certainly excite the interest of the reader in this type of work.

The presentation used in this text-book is very good. The formulæ are well drawn and the index is very comprehensive; the error in the formula of quininic acid (p. 558) should be corrected in future editions. At its price, this second volume of Finar's "Organic Chemistry" is excellent value. W. D. Ollis

HUMANITY AND SCIENCE

What Man May Be

The Human Side of Science. By George Russell Harrison. Pp. iv+262. (London: Cassell and Co., Ltd., 1957.) 18s. net.

It has been estimated that each year sees the discovery of at least one million new scientific facts. Very few of us who are scientists have the capacity to digest more than a minute fraction of this feast, and to see the pattern to which it contributes. Yet we are vastly better off than the non-scientists, whose main contact with science is "through its slums, the half-world of such things as flying saucers and water dowsing". It is for the benefit of both the professional and the non-professional that Prof. G. H. Harrison, dean of the School of Science at the Massachusetts Institute of Technology, has written this book, "What Man May Be".

In at least one respect it is an astonishing book. For there seems scarcely any corner of the vast field of science about which Prof. Harrison is not able to write, simply and interestingly. Beginning with a chapter on what is meant by man's growing control of matter, he goes on through a survey of the human need for energy to the biology of living things, including man. Then he considers how life could first begin and afterwards become increasingly complex; he discusses the 'sharpening of the senses' by our inventions which can do for us things that we could not do by ourselves; this leads to a discussion of the control of information; and thus to an account of what is meant by human personality. The book concludes with a chapter on the age-old conflict between science and religion, and a glimpse into the possibilities for human life in centuries to come.

It is obviously a breath-taking tour of human knowledge, yet the writer bustles us along with an exuberant confidence that seems scarcely to have heard the word 'doubt'. Perhaps the confidence is a little too assured, as when we are told that carbon atoms "have an outer structure consisting of four electrons at the points of a pyramid"; but the number of these false statements is remarkably small for a book that covers so immense a variety of topics. It would indeed be hard to imagine anyone who would not continually find himself arrested, as he read this book, by some chance remark thrown off to illustrate a particular scientific influence. I made a note of two or three dozen such myself, varying from the fact that since he now needs to do less physical work than his father, the average American eats just one-half as much starch as in 1900, to the fact that the troublesome head noises which some people hear continually in their ears are probably the result of Brownian motion, so sensitive is the mechanism of hearing.

It would be impossible to write a book of this kind without raising certain fundamental questions. Prof. Harrison is aware of this, and tries, as dispassionately as possible, to deal with them. But I wonder whether he recognizes quite fully how far his own mode of description commits him to a kind of vitalist position. We find "Mother Nature" all over these pages; and such sentences as, "in the midst of this degeneration appears the directing force called life". Even genes "gradually learn the advantages of co-operation", and "Nature spends eons of time tinkering with her devices before she brings them to perfection". This is a fair enough way of talking if we know why we are doing it. But it can be dangerous; and when it leads the author to suggest that "there is evidence of servo-mechanisms in the soul", we may feel that something is somehow missing in the whole account. The chapter on religion makes clear that this missing element is a sense of the tragic in all life. "Physical pain is a form of evil"; it can be cured by more knowledge: "science furnishes us with one of the best means that men have discovered for discriminating between good and evil". It is so obviously partly true, but yet one cannot help feeling that one dimension in human experience had got left out in the telling.

This is an excellent book to give to almost anyone who wants to understand the way that science has changed both the things we do, and the way we think. There is not a dull moment in its reading, and probably most of those who do read it will catch something of the infectious optimism that underlies each page. Onward and upward in the best of all possible worlds. C. A. Coulson

INTERPRETATION OF SCIENCE TO THE PUBLIC

FUTURE ACTIVITIES OF THE BRITISH ASSOCIATION

THAT the British Association for the Advancement of Science is now seeking new ways of fulfilling its original functions is in keeping with its long tradition and a measure of the influence which it has exerted on scientific thought and public opinion during its 126 years of life. The announcement, made at the 119th annual meeting in Dublin in September 1957, that its activities would in future be continuous throughout the year has, therefore, been the subject of much favourable comment. The Council of the Association has adopted this policy because it is convinced that the more intensive development of scientific resource and talent can only be ensured by increased public understanding of the issues involved. To create this understanding it is essential to communicate authoritatively, objectively and continuously the significance of scientific discovery and its impact on society. It is essential, too, that such communication should be carried out much more intensively in the future than in the past, for the rate of scientific advance has accelerated enormously. Modern science is the greatest force for good or ill in the world to-day. Man has released vast forces of Nature which he is still struggling to control. An understanding of these forces and of the possibility of using them to improve the well-being of mankind is necessary for every citizen, both young and old, who wishes to grasp the essential facts of the contemporary scene.

The Council of the Association does not wish to give the impression that, in any way, it under-rates the important work now being done in this field by many agencies. The activities of the extra-mural departments of the universities, the Royal Institution, the Workers' Educational Association, the schools, local societies and many other organizations—to say nothing of the Press and the broadcasting and television authorities—are of vital importance. The intention of the Association is to help to fill such gaps as exist, to co-operate with other organizations where such co-operation is desired, and to help in the co-ordination, on a national basis, of this urgent task of presenting and disseminating facts about science to the public at large.

Summary of Proposals

(1) *The Annual Meeting.*—This must continue to be the most important single activity of the Association. The objectives of the annual meeting have been recently re-stated, and the main functions of the Association—namely, discussion, integration and dissemination—have been given a fresh emphasis.

The Council has adopted proposals which should make these great meetings even more effective in the future. They include the setting up of a Programme Advisory Committee charged with the duty of ensuring that there is in the programme a proper balance between specialized items, integrating items and popular exposition. The Section Committees are co-operating fully in making these proposals effective, as was evident from the coherent and well-correlated programme of the Dublin meeting, at which special attention was paid to some of the growing-points of science and to topics of broad public interest. The marked success of this year's meeting is proof—if proof were needed—of the importance of the Association's work in this field. A science correspondent, writing from Dublin, summed it up thus: "It is one of the more useful functions of the British Association that it makes visible not only the leaves and branches of the scientific tree of knowledge, but also some of its roots. And it is abundantly clear that the scientific revolution is only beginning". It is also the intention of the annual meetings to provide more frequently a platform on which industrialists and administrators can join scientists in discussions on the social and political consequences of science, because it is clear that modes of thought other than the scientific must contribute to the solution of situations arising out of scientific discovery.

(2) *Inter-Meeting Activities.*—(*a*) The Association proposes to organize throughout the year, in suitable centres and particularly in places outside the immediate range of the universities and colleges, special lectures, exhibitions, discussions and 'brains trusts'. It is hoped, in this way, to reach audiences representative of diverse local groups such as women's societies, scientific societies and trade unions, as well as young people.

(*b*) The organization of a 'Junior B.A. Meeting', with special lectures, demonstrations and exhibitions, designed to stimulate the imagination of young people and to stress the adventure of scientific discovery.

(*c*) The publication of suitable pamphlets and special reports.

(*d*) The organization of conferences on scientific subjects or on subjects arising from the application of science, which are of immediate national or public importance, whenever it is apparent that authoritative and objective comment is necessary.

(*e*) The appointment of study groups to investigate and report upon specific problems.

(*f*) Liaison with the Press, Radio and Television Services to provide more coverage for science throughout the year.

Organization

In order to implement these proposals effectively, it will be necessary to consult and co-operate fully with other organizations concerned directly or indirectly with the exposition of scientific achievement and adaptation. The Council has therefore decided to set up area committees throughout the United Kingdom, which will be composed of members of the Association drawn from as many fields of science as possible and of representatives of other national and local organizations. The functions of these committees will be to advise and consult with the Council of the Association on one hand and local bodies on the other, on the desirability and feasibility of arranging meetings and other activities to present science suitably to various groups in the area; to undertake the arrangements and publicity for such activities through local organizations, and to provide local speakers for certain activities in the area. The Association's Assembly of Corresponding Societies, to which are affiliated some 170 local scientific societies, will—it is expected—be able to contribute to the successful running of these committees. It is hoped to appoint several of these area committees during the first half of 1958. This proposal has been welcomed by several of the large national organizations during preliminary informal discussions, and it is expected that their branches will co-operate fully when the area committees come into being.

The Association is already in close contact with the younger generation through its annual meetings, but it believes that there is much more which it can do to engage the interest of young people in science and scientific careers.

The successful presentation of science, particularly to young people, will depend *inter alia* on the use of good visual material, and the Association seeks the co-operation of industrial and other organizations in arranging exhibitions and illustrating special lectures. Meanwhile, a start is being made by staging, in collaboration with the Director of Education and the schools in the Glasgow area, a special programme for young people at the annual meeting which will be held there during August 27–September 3, under the presidency of Sir Alexander Fleck. The programme will include twelve special lecture demonstrations by distinguished scientists, a science exhibition organized by the schools in the area, a special exhibition arranged by the Association, an open forum with a panel of scientists and a selection of scientific films. It is proposed to hold a Junior British Association meeting in 1959, independently of the annual meeting, organized on the basis of the experience gained in planning the Glasgow programme.

Quite apart from major annual events of this sort, it is planned also to organize a series of special lectures for young people in the schools. The first of these will be given under the auspices of the Association in Ipswich in February 1958, when Prof. J. Rotblat will speak to two audiences totalling more than nine hundred schoolchildren from schools in East Suffolk. These lectures are being organized with the co-operation of the Chief Education Officer and his colleagues in the schools of that area.

The effect which the Association is able to give to its plans in the future will depend in no small measure both on securing the co-operation of scientists who are prepared to lecture to non-specialist audiences and to take part in discussion groups, and on the degree to which it is able to secure support for its primary conviction that the ability to communicate the results and significance of scientific work is of major importance in the world to-day. A panel of speakers is now being compiled, and the ready response is an augury of the success of these activities. The possibility of creating a number of special lectureships to encourage younger scientists to participate in this kind of exposition is also being explored.

It is only possible to report briefly, at this stage, on the many other arrangements that are being made. A conference on "Science in Schools", with particular reference to the urgent problems of the supply of science teachers and the provision of adequate laboratory accommodation and equipment, is now being organized and will be held in London during the coming Easter holidays.

A committee under the chairmanship of Sir Hugh Beaver has been appointed by the Council to investigate and report upon the practicability, implications, consequences both international and domestic, and the cost of a change-over to the metric system by the United Kingdom.

Discussions are now being held with the Atomic Scientists Association about the possibility of the British Association assuming responsibility for bringing before the public of Great Britain the facts about atomic energy and their implications.

Preliminary discussions have already been held with representatives of the British Broadcasting Corporation on science programmes in the radio and television services, and these will soon be resumed.

Development in the past has been hampered by lack of funds, and to carry out the present plans a substantial addition to the Association's present income will be required. As a result of approaches to a small number of leading industrialists in 1957, a significant addition to income has already been obtained. A sum of more than £40,000, mostly on seven-year covenants, has been received, giving an additional £8,000 income for the present year. It is now proposed to extend the appeal, and it is hoped that the response will be sufficient to enable the Association to implement fully its plans. In the first place, it will be necessary to augment the present small staff of the central office and to procure immediately adequate office accommodation. A start, however, has already been made possible as a result of the generosity of the above-mentioned firms.

These are the beginnings. Given more financial support, the establishment of area committees, co-operation from the many organizations concerned with, or affected by, the impact of science on society, and the co-operation of scientists and the schools, there is little doubt that the present plans can be effectively carried out. It is believed that, in these ways, the British Association will be enabled to make a substantial contribution to bringing about that better understanding of the significance of science which is so urgently needed to-day—and so add to its already historic reputation in this field.

SCIENTIFIC CENTENARIES OF 1958

By JOAN M. EYLES

TO pursue the study of both medicine and mathematics would be very unusual, if not impossible, to-day, but this combination of subjects was not uncommon in the sixteenth century. Mathematics led to astronomy, a subject at that time closely linked with astrology, and the supposed advantages of a knowledge of astrology in maintaining good health were generally recognized.

Two well-known men who died in 1558 were both physicians with considerable aptitude in mathematics. Jean Fernel, born in 1497, studied in Paris for several years and then found himself equally attracted by mathematics and medicine. He qualified to practise medicine in 1530, but could not resist the lure of astronomy. It is said that he made use of his wife's dowry to pay for the construction of instruments which he had designed, and this led to a domestic crisis, in which mathematics lost and Fernel agreed to devote himself to medicine. Although his first published book was a mathematical one, it is by his medical works that he has been remembered. He wrote an early account of syphilis, and his books on "Physiologia" and "Pathologia" marked the first introduction of these terms to medicine. He died of a fever in 1558, keeping to the last an accurate record of his symptoms.

Another physician who loved mathematics was the Welshman Robert Recorde, born at Tenby about 1510. His early studies were pursued at Oxford, and in 1531 he became a Fellow of All Souls. At that time his interests appear to have been confined to mathematics, and in 1540 he brought out the first arithmetic to be written in the English language, the "Grounde of Artes", of which many editions appeared during the next 150 years. Recorde then moved to Cambridge to study medicine, graduating M.D. in 1545. He practised as a physician, and is said to have been physician to Edward VI; but unlike Fernel, he did not give up mathematics. He published further books in English on geometry, astronomy and algebra. In his last work, the "Whetstone of Witte", he introduced the sign = for equality, although it did not become universally used until long afterwards. Recorde was one of the first English writers to adopt the Copernican system. His studies seem to have brought him very little worldly profit, for he died while imprisoned for debt in the King's Bench prison, in 1558. His friend John Robins, another Fellow of All Souls, died a month or so later. Although Robins had chosen the Church as a profession, and was made a canon of Christ Church, and later of Windsor, his bent, too, was towards mathematics and astrology, in which, it was said, "he became the ablest person of his time, not excepting his friend Recorde, whose learning was more general". Robins was buried in St. George's Chapel, Windsor.

The year of birth of yet another mathematician, Edward Wright, seems a little uncertain, but is generally taken to have been 1558. Born in Norfolk and educated at Caius College, Cambridge, he applied his mathematical knowledge to navigation, and his ensuing publication, "Certaine Errors in Navigation detected and corrected" (1599), can be said to have revolutionized this science. Wright was for a time mathematical tutor to Henry, Prince of Wales, son of James I, and also gave lectures in mathematics for the East India Company. He died in London in 1615.

When Thomas Brattle, a young American born in Boston in 1658, first went to Harvard, he found he had to teach himself mathematics; but this did not deter him. He watched the comet of 1680 through the Harvard telescope and sent his observations to Flamsteed, the Astronomer Royal, and they were afterwards used by Newton in his "Principia". Brattle also contributed astronomical observations to the *Philosophical Transactions of the Royal Society*. He became a wealthy merchant and made many gifts to Harvard.

The interests of Count Luigi Ferdinando Marsigli (1658–1730) lay in quite a different field. Born in Bologna and by profession a soldier, he spent some years in Turkey, and later fought against the Turks, but was captured and sold to a pasha. Later he was released, but leaving the army he turned to the study of natural history, particularly that of the sea, and he became a pioneer in oceanography. His classic work, entitled "Breve Ristretto del Saggio Fisico intorno alla Storia del Mare", was published in 1711. In 1712 he presented his collections to Bologna, and they formed the nucleus of the Bologna Institute of Science and Arts.

Before passing on to those who died in 1758, we may note that in the present year falls the two hundred and fiftieth anniversary of the death of Edward Tyson and the birth of Albrecht von Haller (1708–77), both well known in their own fields, Haller as a physiologist and Tyson as an anatomist.

Important events in the first half of the eighteenth century were the French scientific expeditions to determine the length of a degree of longitude near the equator and in the north of Sweden. The equatorial party, led by De la Condamine, included Pierre Bouguer (1698–1758), and the measurements made in Peru were published by him in "La Figure de la Terre déterminée" in 1749. At the same time he made the first comparison between the mass of the earth and that of a mountain, Chimborazo in the Andes, and his name is perpetuated by geophysicists in the term 'Bouguer anomaly'. Bouguer made several other contributions to physics, for he invented a photometer in 1729, and later a heliometer, and measured the intensity of the light of the Sun compared to that of the Moon.

One of the party of Frenchmen accompanying De la Condamine and Bouguer was the botanist Joseph de Jussieu. The name De Jussieu is familiar in botanical literature, and an elder brother, Antoine (1686–1758), was professor at the Jardin des Plantes in Paris. Antoine travelled in Spain and Portugal but published little of importance, and his nephew Antoine Laurent de Jussieu is better known.

The year 1758, in which the skies were being eagerly watched for the predicted return of Halley's comet, was also that of the birth of the German astronomer H. W. M. Olbers (died 1840), who evolved a new and accurate method of determining the orbit of a comet. In 1781 he took up residence as a physician in Bremen, but spent many nights at his telescope. He discovered the asteroids Pallas and Vesta, and suggested that their origin was due to the explosion of a primordial planet. In 1815 he observed a comet which became known as Olber's Comet, and which re-appeared in 1887.

Although the study of astrology passed out of favour with medical men as the knowledge of medicine and astronomy increased, there was a period when phrenology seemed almost as popular. The old plaster casts of heads on which phrenological charts are delineated may be the last relics of this period. The founder of this now discredited science was Franz Joseph Gall (1758–1828), born at Tiefenbronn, Baden. Gall was a noted physiologist, and made a special study of the brain, publishing his researches in "Anatomie et Physiologie du Système Nerveux en Général" (1810–19). He compared the shape of the brain and skull with the development of the faculties in men and animals. His lectures on phrenology given in Vienna were extremely popular until in 1802 they were forbidden as dangerous to religion. From 1807, until his death, he resided in Paris.

To occupy a chair of botany for thirty-six years and in this period to give only one lecture (said to be "unsuccessful") may well be a record. The botanist was Humphrey Sibthorp, and the chair was the Sherardian one at Oxford. Humphrey resigned his chair to his son John Sibthorp in 1783, and it is the anniversary of John's birth in 1758 which falls this year. The younger man, who had studied medicine at Edinburgh, was an ardent plant collector. Between 1786 and 1795 he travelled in Greece, Cyprus and Crete in search of plants, but unfortunately caught a cold which led to consumption and he died at the age of thirty-seven. He was buried in Bath Abbey; his collections and books were bequeathed to the University of Oxford, and his name is perpetuated in the Sibthorpian chair of rural economy which he endowed.

Sibthorp was accompanied on one of his botanical journeys by Ferdinand Bauer, the elder of two brothers, Austrian by birth, who were well-known botanical draughtsmen. Both the brothers were protégés of Sir Joseph Banks, the arch-pàtron of young naturalists. Franz Bauer (1758–1840) retains a place in the history of biology for having in 1823 made a drawing of blood corpuscles in which the 'nucleus' was indicated, which seems to be the first use of the word in this connexion. Ferdinand is better known for having accompanied the Scottish botanist Robert Brown (1773–1858) on the voyage of the *Investigator* under Captain Flinders, to explore the coasts of Australia and Tasmania. Brown and Bauer together collected nearly 4,000 species of plants, many new to science, and returned to Britain in 1805. Brown was appointed librarian to the Linnean Society, and later became librarian to Banks and curator of his collections. After Banks's death, the botanical collections were deposited in the British Museum and Brown was appointed keeper. For his many valuable contributions to botany he was awarded a Copley Medal in 1839 by the Royal Society, of which he had been elected a Fellow in 1811. His name will always be associated with the 'Brownian movement', which he was the first to observe. His death took place in London, on June 10, 1858, only ten days before that of his close friend Dawson Turner (born 1775), a wealthy antiquary and amateur botanist, the author of a "Natural History of Fuci" (1808–19). Turner's elder daughter Maria married Sir William Jackson Hooker, and thereby many of his collections are preserved at Kew, though his rich library was sold at auction. The genus *Dawsonia* was named by Brown in honour of his friend.

Two other botanists who died in 1858 were C. G. Nees von Esenbeck (born 1776), and Aimé Bonpland (born 1773). Nees von Esenbeck was professor of botany in Breslau and the author of works on fungi and mosses. For his political activities he was deprived of his chair and spent his remaining years in poverty. Aimé Bonpland, a French naturalist, suffered a rather similar misfortune. As a young man he travelled in Mexico and the Andes with Humboldt. In 1816 he left Paris for South America and was appointed professor of natural history at Buenos Aires, but in 1821, while journeying up the Paraná to collect plants, he was arrested by order of Francia, dictator of Paraguay, and detained for nine years. In spite of these vicissitudes, he lived to be eighty-five.

Passing from botany to chemistry, two chemists who died in 1858 must be mentioned here. Robert Hare (1781–1858) was professor of chemistry in the University of Pennsylvania, and noted for his inventive genius. When only twenty he demonstrated to the Chemical Society of Philadelphia an oxyhydrogen blow-pipe, with which he was able to fuse platinum—a considerable achievement at that time. Later he received the Rumford Medal of the American Academy of Arts and Sciences.

The Swedish chemist Carl Gustav Mosander (1797–1858) was affectionately known as 'Father Moses' by his friends, including Berzelius, to whom he was assistant. He was also curator of the mineral collections at the Stockholm Academy of Sciences, and carried out long and patient work in the identification of rare earths. He showed first that the earth ceria contained another oxide which he named lanthana, and afterwards discovered that with lanthana there occurred yet another oxide which he named didymia. Later he investigated yttria and found in it two new oxides which he named erbia and terbia, taking these names from Ytterby, the small Swedish town where these rare earth minerals were first discovered. Many years later, Carl Auer, Baron von Welsbach, born in the same year that Mosander died, investigated didymia and discovered that it contained two different elements, which he named neodymium and praesodymium respectively. Von Welsbach is perhaps known better for the incandescent gas mantle which he invented.

The great German physiologist Johannes Müller (1801–58) is renowned both for his researches and for his teaching. He attracted many gifted pupils to his classes, including Virchow, Schwann and Bois-Reymond. Müller's name is particularly associated with the principle of specific nerve energies, but he also carried out important researches in embryology. In later life he studied the ocean fauna, especially plankton.

While modern weather forecasting has done much towards predicting the course of hurricanes, and to prevent by adequate warning some of their damaging effects, little was known about them when William Reid (1791–1858), a Scottish military engineer, was sent to the West Indies in 1831. The information he collected about the paths of hurricanes was published in 1838 as "An Attempt to develop the Law of Storms by means of Facts". This work went through many editions, and numerous translations were made, including one into Chinese. Reid was appointed governor of the Bermuda Islands in 1839, and did much to improve education and agriculture there. Afterwards he was appointed governor of Barbados, and in 1851 of Malta; in both islands he continued his policy of improvement. He was made a vice-president of the Royal Society in 1849, and was knighted two years later.

To be responsible for a major revolution in scientific thought can be the lot of few men, but among them can be numbered Max Planck, the centenary of whose birth on April 23, 1858, is the outstanding one of this year. Born at Kiel, when it was still in Denmark, Planck died at Göttingen in 1947, after passing fifty years of his life at the University of Berlin. His death occurred within a few months of his ninetieth birthday. His law of radiation, which stated that the energy of radiation is emitted and absorbed in integral multiples of certain indivisible 'quanta' of energy, received abundant confirmation in the first decade of this century, and explained many anomalies. He was awarded the Nobel Prize for Physics in 1918, and was elected a foreign member of the Royal Society in 1926.

A mathematician whose early brilliance gained him an international reputation was A. R. Forsyth, born at Glasgow in 1858, who held the Sadleirian chair of pure mathematics at Cambridge and later the principal chair of mathematics at the Imperial College of Science and Technology, London. He was elected a Fellow of the Royal Society at the early age of twenty-seven. Forsyth wrote exhaustively on the subject of differential equations, and developed a theory of invariants. He was also active in introducing to British mathematicians the new developments in pure mathematics which had been made on the Continent towards the end of the nineteenth century. Another mathematician whose work might be reviewed this year was the Italian, Giuseppe Peano (1858–1932), one of the early workers on the logistic development of mathematics, who was also interested in the possibility of a universal language.

Passing from mathematics to astronomy, we come to the American astronomer W. H. Pickering. Born at Boston in 1858, he led several Harvard expeditions to observe total solar eclipses. In 1891 he established the Harvard observatory at Arequipa, Peru, and in 1900 he erected a station for Harvard at Mandeville, Jamaica. This he afterwards took over as a private observatory. Pickering discovered Phoebe, ninth satellite of Saturn, in 1899. He did notable work in planetary photography and published a lunar atlas based on observations made at Mandeville. He did not agree with the view that the Moon was without life and published a paper on seasonal changes occurring in lunar craters. He visited craters in Hawaii and the Azores in order to compare them with those of the Moon. Pickering died at Mandeville in 1938.

Two young graduates who left Britain for Australia towards the end of the nineteenth century rose to the front rank of Commonwealth scientists. One was the geologist Sir T. G. Edgeworth David, born at St. Fagans near Cardiff in 1858, who was appointed as a geological surveyor in New South Wales in 1882. Nine years later he became professor of geology in the University of Sydney. He accompanied the Shackleton Antarctic Expedition of 1907–9 and led the party that reached the south magnetic pole. In the First World War he joined the Australian Tunnellers, and in 1918 was appointed chief geological adviser to the British armies. On his return to Sydney he devoted himself to the preparation of a "Geology of the Commonwealth of Australia". He died in 1934, before it was published. The Australian National Research Council was initiated by the joint efforts of Sir Edgeworth David and his fellow scientist Sir David Orme Masson. The latter, born in London in 1858, graduated in both arts and science at Edinburgh, and became lecturer in chemistry at Bristol under Ramsay. In 1886 he was appointed professor of chemistry in the University of Melbourne. His interests lay in the realm of physical chemistry, but administration made increasing demands on his time. As president of the Australian Association for the Advancement of Science he took a leading part in organizing the visit of the British Association in 1914. Masson died in 1937.

The Dutch physiologist Christiaan Eijkmann, who was awarded a Nobel Prize jointly with Sir F. Gowland Hopkins in 1929, was born at Nyerk on August 11, 1858. His work on dietary deficiencies began with a study of beriberi in Batavia, where he was director of the pathological laboratory. By producing food-deficiency disease in fowls and then curing it by feeding the birds with rice-polishings, he greatly stimulated the development of vitamin research. Eijkmann died at Utrecht in 1930.

Sir Jagadis Chandra Bose (1858–1937) was the first Indian of modern times to achieve distinction through scientific work. Educated at Calcutta and Christ's College, Cambridge, he became professor of physics in Presidency College, Calcutta, in 1884, but is better known as the founder and director of the Bose Research Institute at Calcutta. His work in the field of the physics of plant physiology aroused considerable controversy. He was elected a Fellow of the Royal Society in 1920.

Among other scientists born in 1858 may be mentioned Albrecht Penck, German geologist and geographer, noted for his studies of the Ice Age; E. M. Crookshank, who founded in King's College, London, the first bacteriological laboratory to be established in Britain; and the zoologists F. E. Beddard and G. A. Boulenger.

In the field of applied science, metallurgists can celebrate this year the centenary of the birth of Sir Robert Hadfield, the discoverer of manganese steel; and the contemporary vogue for diesel engines in Britain is a reminder that the first successful diesel engine was built in 1897 by Rudolf Diesel (born 1858). The following year he sold the patents and exclusive manufacturing rights in the United States and Canada to Adolphus Busch of St. Louis for a million gold marks. Diesel died mysteriously in 1913, vanishing overboard from the Harwich mail steamer on his way to consult with the British Admiralty.

Other centenaries of the year include those of the founding of several scientific societies, including the Geologists' Association and the British Ornithologists' Union, and the publication of that landmark in the theory of evolution, the famous Darwin–Wallace essay. The latter will be commemorated at the International Zoological Congress in London in July.

THE TECHNOLOGICAL UNIVERSITY OF EINDHOVEN

By PROF. H. B. DORGELO
Rector Magnificus

ON September 19, the Technological University of Eindhoven, brought into being as a result of an Act of Parliament of June 6, 1956, concerning higher technical education in the Netherlands, was officially opened by H.M. Queen Juliana, in the presence of H.R.H. Prince Bernhard, the Prime Minister, Dr. W. Drees, the Minister of Education, Mr. J. M. L. Th. Cals, other Ministers, the Board of the University, under the chairmanship of Prof. J. E. de Quay, Governor of the Province of Noord-Brabant, the Rectores-Magnifici of all the universities in the Netherlands, and many other distinguished guests.

Preparatory committees under the chairmanship of Prof. G. Holst, who has been a pioneer of applied scientific research in the Netherlands, stressed the need for more qualified engineers, thoroughly grounded in scientific technique, in connexion with the industrialization of the country which is in progress. The Government therefore decided to

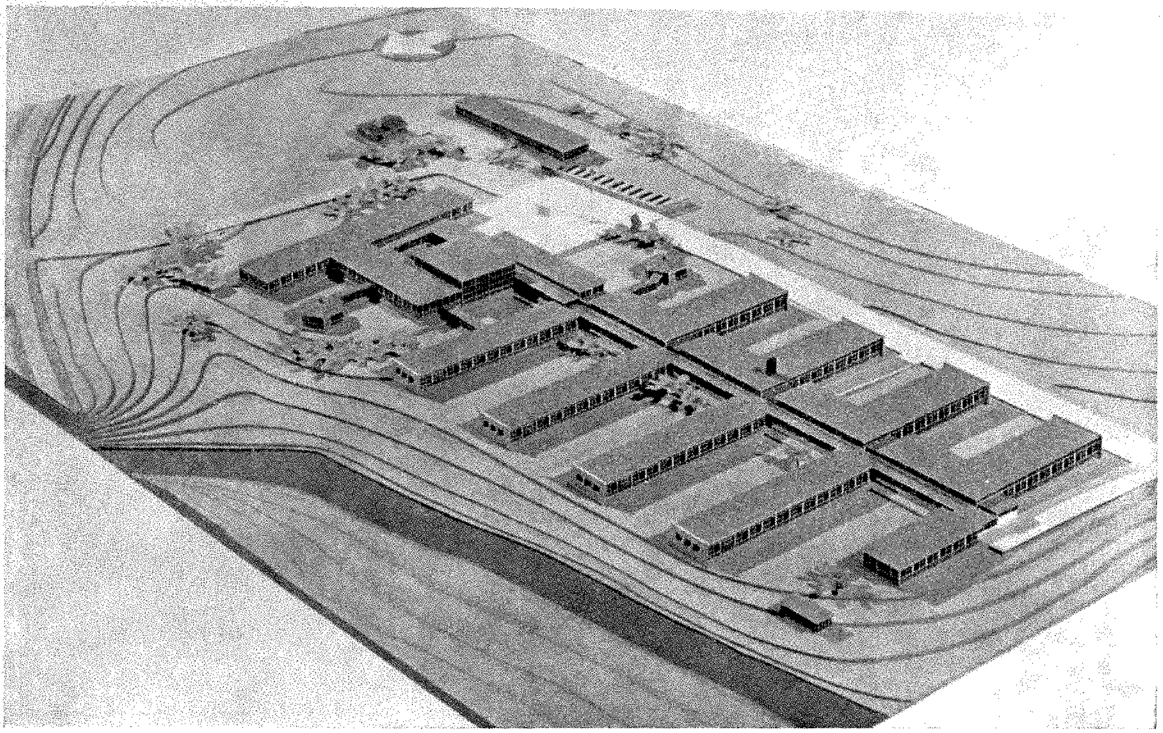
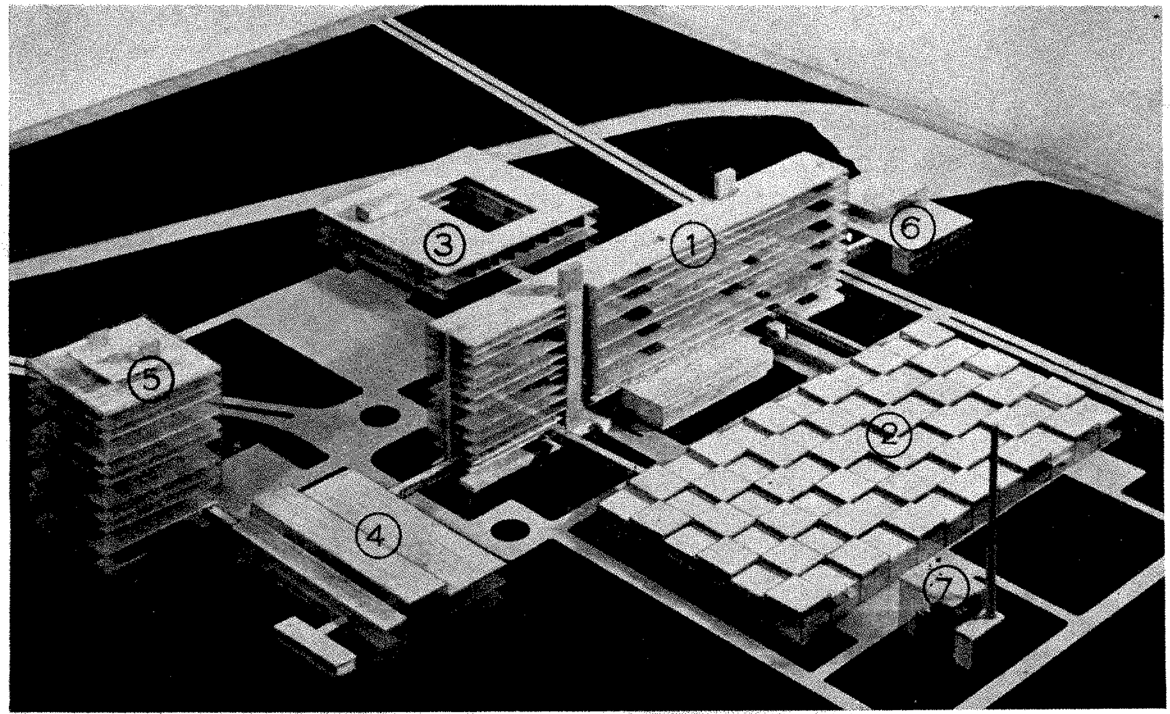


Fig. 1. Model of the provisional buildings

build a new technological university in the southern part of the country, in the hope of making available a new source of technical students. The Act, which made the founding of the new technological university possible, was then prepared by a committee under the chairmanship of Mr. H. L. s'Jacob, Counsellor of the Minister of Education.

Eindhoven, a dynamically developing town, was chosen as the place for the new technological university. The town council generously presented a well-situated site of about 100 acres for the university.

One very important question was thoroughly discussed, namely, whether the new institute should



Copyright Fig 2. Model of the permanent buildings *Martien Coppens, Hoogstraat 312, Eindhoven*

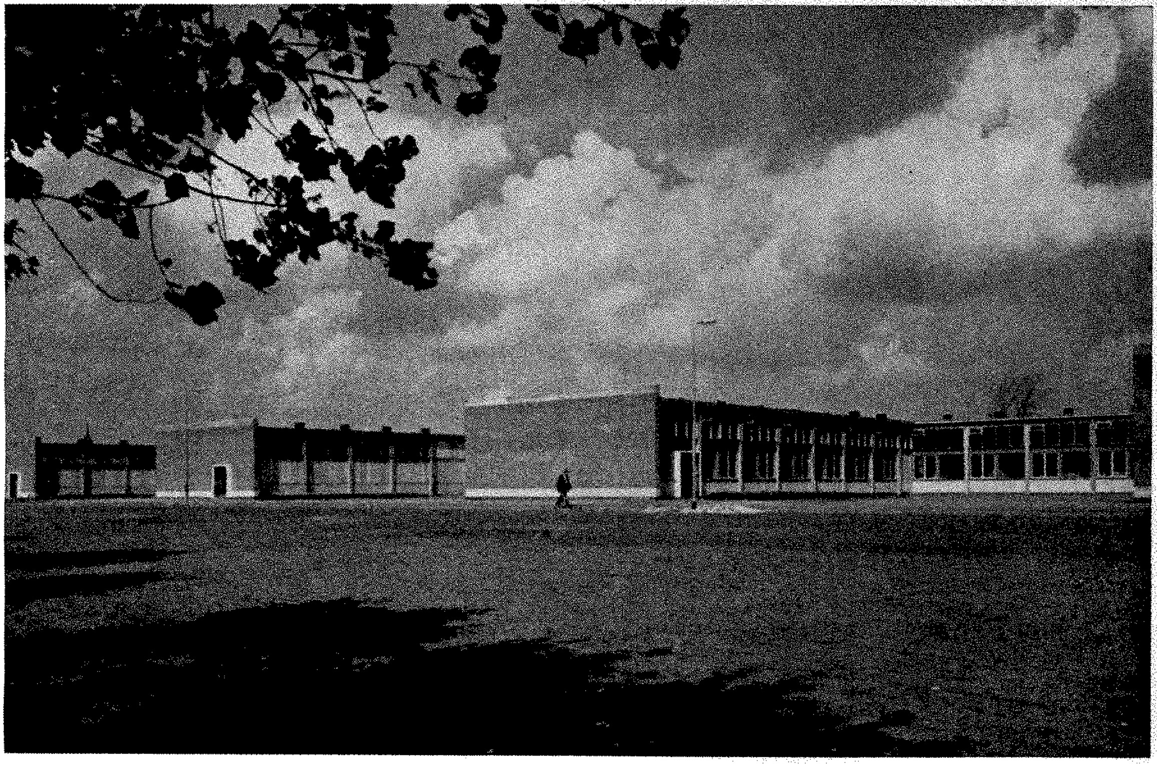


Fig. 3. A part of the building of which the model is shown in Fig. 1

prepare engineers of the same scientific standard as those trained by the Technical University of Delft, or whether the new institute should be something between the existing secondary technical institutes in the Netherlands and that at Delft. Fortunately, the decision was taken that the standard of the Eindhoven Technological University should be the same as that of the Technical University of Delft, but with a different approach to the same goal. A new technological university gives an opportunity, free from traditional bonds, for seeking and finding new ways in scientific, technical and humanistic training, to suit the demands of the technical and ideological age in which the future engineers will have to live and work.

The Technological University of Eindhoven is in the first instance set up with the aim of training three categories of engineers, namely, mechanical, electrotechnical and chemical engineers. It has for that purpose four departments: (*a*) Department of General Sciences (mathematics, physics, philosophy, sociology, economics, etc.). Chairman: Prof. C. Zwikker. (*b*) Department of Mechanical Engineering. Chairman: Prof. W. L. H. Schmid. (*c*) Department of Electrotechnical Engineering. Chairman: Prof. J. L. H. Jonker. (*d*) Department of Chemical Technology. Chairman: Prof. W. van Loon. At the moment the Netherlands urgently need more people with scientific technical training in these branches, therefore the University has started by meeting these requirements.

The secretary of the University is Dr. A. H. M. Wijffels; and the secretary of the Senate is Prof. K. Posthumus.

In developing the programme of study for these three categories of engineers mentioned above, the guiding principles have been: (1) to divide the theoretical and practical courses for the students over eight half-years (semesters); (2) to arrange the examinations to take place as follows: (*a*) an examination at the end of the second semester (the propædeutical examination), as a test for suitability for the studies at a technological university; (*b*) one after the fifth semester (the candidate examination), as a test of achievements, specially concerning the fundamental courses; (*c*) one after the eighth semester (the first part of the final examination), as a test of the achievements in technical science; (3) to ensure that the student should prove his ability to solve a given scientific technical problem on his own, and to make a detailed report of it before obtaining his final degree. It is intended that this work should be done in one or two semesters.

The planning of the buildings for the University was based on the expectation that in the near future the number of students would be about one thousand; should it increase to two thousand, which is likely, extension is easily arranged, because the planning of the main buildings has been arranged with that possibility in view.

In order to start with lectures and practical courses for the students by September 1957, a bungalow-type of building of about 9,250 $m.^2$ floor-area was erected (Fig. 1), provisionally giving accommodation for the theoretical and practicalt raining of students in the first and second years. The number of the students who applied for the first-year courses was 236.

The planning for the permanent buildings of the University is in progress, encouraged by Ir. Th. P. Tromp, member of the Governing Board, and co-ordinated by Prof. P. van der Leeden. Fig. 2 is a photograph of the model of the group of buildings planned by the architect, S. J. van Embden. It will include: (*a*) the main block for the Departments of General Sciences, Electrotechnical Engineering and a part of Mechanical Engineering, with the Library in the centre of the ground floor (Fig. 2, 1), (*b*) a block for the Department of Chemical Technology (Fig. 2, 5), (*c*) a building with the main hall, reception and lecture rooms (Fig. 2, 3), (*d*) a large one-story building to house the heavy equipment of the Department of Mechanical Engineering and the central workshop for the whole University (Fig. 2, 2), (*e*) a laboratory for chemical technology (a similar building is planned for physical technology) (Fig. 2, 4), (*f*) a building for the larger equipment for electrotechnics (Fig. 2, 6), (*g*) a boiler-house for the central heating of the whole University (Fig. 2, 7).

The citizens of Eindhoven have helped and supported the new University in many ways. On the initiative of the Burgomaster of Eindhoven, a committee of leading citizens was formed to help the students in getting accommodation, to build hostels for them, to provide a club-house for the general student society (union building), to promote the possibilities for sport and to found a medical centre. This committee laid the basis for the Eindhoven Technological University Students Welfare Foundation, which is very active in providing the initial necessities for students, and is also stimulating the initiative of the 'freshmen' to build up a new sound student communal life.

The interest of industry in the new University was manifested by founding the Eindhoven University Fund to form a link between the industry in the Netherlands and the new University, this being regarded as of great importance to both. The main purpose of the Fund is to support the scientific work in the Technological University and to promote the contact of the scientific staff of the University with the technical scientific world in the Netherlands and abroad.

The friendly relationship between the Technical University of Delft and its newborn sister found expression in a helpful sharing of ideas during the preparative period and in the token gift of a silver chain of office for the Rector Magnificus of the new University.

The Technological University of Eindhoven has begun its task for the future, a very important task with great responsibilities. As H.M. Queen Juliana said in her opening address: "Technology is the modern mill-stone for our daily bread. It is a gift of God. We have to accept this gift with respect and gratitude, we will not over-estimate it in proud presumption nor abuse it by using it where it will not serve a positive purpose".

FLAMES AND INDUSTRY

THE useful application of science to engineering has nowhere proved more difficult than in the sphere of combustion. In recent years, however, some progress has been made through the work of the International Flame Research Foundation. The main activity of the Foundation has been to establish two experimental furnaces at the Royal Dutch Steelworks at Ijmuiden. These are fully instrumented for fundamental studies and are comparable in size with the smaller furnaces used industrially. One furnace consumes gas or oil and the other pulverized fuel.

The principal object of the work is to provide accurate and usable design formulæ for the types of flame employed in industrial furnaces. It is hoped that in the course of such developments some possibilities of improving current practice may be revealed. The investigations are, however, necessarily concerned with the properties of the flames themselves. The principles governing the transfer of heat from the flame to the work are intimately bound up with the nature of the latter, and advances in this respect must be the responsibility of the industries concerned.

The essence of the work of the Foundation lies, however, in its applicability to the needs of industry. For this reason a symposium was held recently in London, at which papers describing the Ijmuiden investigations were laid beside others from industry dealing with consequential developments. The symposium, which was sponsored by the Institute of Fuel, took place on October 9, at the Institution of Civil Engineers. The presentation of the Ijmuiden papers was presided over by Prof. O. A. Saunders; and Dr. D. T. A. Townend was in the chair for the industrial session.

The experimental methods used at Ijmuiden and the progress made in the understanding of flames were reviewed by Prof. M. W. Thring, assisted by Mr. E. H. Hubbard and Mr. A. E. Pengelly. The work has been almost entirely devoted to turbulent jet diffusion flames, in which a high-velocity jet of fuel, carried by compressed air or steam, entrains air for combustion through its own energy.

The furnaces are both in the form of a tunnel some 2 metres square in section and 6 metres long, with the flame directed along the axis. They have been made large compared with the flames to avoid impingement and to minimize other forms of interference by the furnace walls. As a result of this, recirculation of the combustion products is a prominent feature of the flow pattern. The furnaces are provided with vertical slots down each side for flame radiation measurements, and there are generous provisions for the insertion of probes for sampling, temperature measurement and other purposes. For the essential routine operations of measuring waste gas composition and temperature, paramagnetic oxygen analysers and suction pyrometers respectively are preferred. To estimate air leakage into the combustion chamber the fuel and air input must also be known. Combustion air, gaseous and liquid fuels are measured by orifice meters and pulverized fuel by a constant-feed weighing belt. Air leakage is controlled through furnace pressure by means of conventional dampers, with the aid of draught gauges and a pressure recorder attached to the centre of the furnace roof.

Fuel-air mixing in a turbulent jet diffusion flame is primarily influenced by fuel jet momentum. This is conveniently measured as the reaction thrust on the burner, by means of a counterbalanced suspension system. Radiation from the flame is observed with a total-radiation pyrometer. Radiation and convection are differentiated with the aid of two heat flow meters, differing either in surface temperature or in surface emissivity. Gas velocities are measured with a Pitot tube and the information obtained used to carry out isokinetic sampling at a particular point for flame gases and unburnt solid particles. Gases are analysed in an Orsat type apparatus with Lomchakov absorption vessels. The solid sample is analysed for moisture, volatile matter and ash by micro-methods or by a modified Fenton train for ultimate analysis. Element balances permit calculation of the proportion of fuel burnt at any stage in the flame and its comparison with the degree of mixing on one hand, and with the proportionate heat release on the other.

For gas and oil flames it is found that until about 90 per cent of the total requirement of combustion air has been consumed, relative mixing, reaction and heat release are closely similar. The processes of combustion and heat release can therefore be studied up to this point simply by examining the aerodynamics of the system. This enables aerodynamic similarity criteria to be applied to the scaling-down of industrial gas and oil-fired furnaces for experimental model studies. The similarity condition is that the burner nozzle must be replaced by an equivalent nozzle which gives the same mass flow and momentum, but with the stream density changed to that of the flame gases. At its far end, where the flame is influenced by the re-circulation and re-entrainment of the combustion products, simple similarity relations with cold models do not apply. This is also the case throughout a pulverized fuel flame, for although the combustion of the volatiles may be a rapid process, that of the solid residue is not so. In these circumstances, the physical process of air-fuel mixing is no longer rate-controlling.

The non-luminous radiation and emissivity of the combustion products can be evaluated from a knowledge of the temperature and concentrations of water vapour and carbon dioxide by established methods due to Schmidt and Hottel. Luminous radiation depends mainly upon the particles present in the flame. Emissivity has been successfully related to soot concentration and can be scaled. The soot appears at an early stage in the flame and thereafter decreases, but the laws and mechanism of its formation are not sufficiently understood. The concentration of soot and hence the luminous emissivity is, however, a function of the fraction of the flame length considered, the rate of axial mixing and the carbon–hydrogen ratio of the fuel used.

In the early part of the flame, the edges of the jet form a sheath of high-temperature products while the axis of the flame contains excess fuel at relatively low temperature. Around the hot sheath excess air and recirculated products bring about a considerable reduction in temperature. At a stage where 80–100 per cent of stoichiometric air has reached the centre of the jet, the axial temperature reaches a peak of the order of 1,500–1,700° C. The peak is raised by an increase in fuel input or jet momentum, and by pre-heating. Because a gas flame loses heat less rapidly by radiation than does an oil flame, its temperature is some 100° C. higher throughout.

The Ijmuiden experiments cannot give direct information on the transfer of heat from the flame to the work since conditions in this phase of operations vary so widely. It is here that particular study by each industry becomes necessary. The Ijmuiden investigations have, however, shown how to control flame length, emissivity and coverage. Where there is direct impingement of the flame on the work, heat transfer by convection can be calculated as for a hot gas in contact with a surface. With a cold receiving surface, convection may be responsible for as much as 35 per cent of the total heat transfer.

The relevance of the work of the Foundation to conditions in steel furnaces was discussed by Dr. J. H. Chesters and Mr. R. Mayorcas. In the steel-making industry the Ijmuiden experiments have already stimulated a number of investigations and developments from which production has profited. Cold model experiments have revealed flow and wear patterns. The improved understanding of the mechanism of oil atomization and jet momentum which has resulted from the Ijmuiden work has been employed with great effect on production furnaces. Advantage has also been taken of the function of carbon in increasing flame emissivity, and the output rate of a full-scale furnace has recently been substantially increased by the application of the results of calculations based upon the Ijmuiden and other similar experiments.

The glass industry uses producer gas and liquid-fuel flames of the turbulent jet diffusion type, and has followed the lead of the steel industry in the use of model experiments, some results of which were described by Mr. S. Krusjewski. The luminosity and solid particle radiation of producer gas flames require further study, but the findings of the Foundation and the steel industry on oil flames are applicable to similar flames in glass tanks. Special problems are to obtain good flame coverage without too much loss of access to the walls of the tank, and to limit recirculation so far as possible without exposing the furnace crown unduly to the flame gases. The theory of heat transfer from an oil flame in a glass furnace has been developed by Thring and the problem of heat transfer through the glass itself is to some extent understood in exact terms, but the part played by convection is at the moment appreciated only qualitatively.

The application to boilers was discussed by Dr. W. B. Carlson. The work at Ijmuiden on pulverized fuel flames, which is of particular interest to the boiler industry, has not yet progressed far. Some special factors have to be taken into consideration. Sufficient radiation must be available from flame and furnace to maintain stable ignition. The combustion region must be large enough and of adequate temperature to complete the combustion of the relatively slow-burning particles. This leads to very large combustion chambers, for which an unusually extensive scaling-up of model experiments is necessary. The great height of the boiler results in a large chimney effect within the furnace itself. The size of the flame causes it to become somewhat opaque to its own radiation and this results in a hot flame core from which the heat cannot readily be released. The need to avoid excessive ash deposition within the furnace dictates aerodynamic design to a large extent, and in general precludes compactness. The necessary provisions for ultimate ash retention, either by slagging or collection, still further enlarge the plant. The Ijmuiden pulverized fuel furnace has unfortunately no provision for experiments involving slagging of the ash. The cement industry, represented at the Symposium by Mr. E. Burke and Mr. G. Field, also uses pulverized fuel extensively. Heat transfer to the work would most readily be improved by increase of radiant intensity through control of flame length, temperature and emissivity. The proper distribution of heat transfer throughout the kiln also requires attention.

The problem in gas turbine combustion chambers, as pointed out by Prof. Saunders, is the reverse of that in industrial furnaces—that is to say, to limit the transfer of heat from the flame to the surfaces in order to avoid overheating. The small amount of information at present available suggests that whereas the flames of the lighter fuels used are almost non-luminous, those of the heavier fuels emit considerable luminous radiation. However, the high-rate heat release type of chamber as used in aero-engine design probably minimizes radiation transfer from the flame and for this reason may find favour for industrial use.

J. H. Burgoyne

OBITUARIES

Prof. Léon W. Collet

Prof. Léon W. Collet died peacefully in his seventy-eighth year at Geneva on October 13. His health had been failing sadly of recent years. "Born with a rucksack on my back", he used to say; and he attributed much of his latter-day troubles to previous strenuous exertion.

In his passing, British and American geologists see the end of a career largely devoted to their service; for Collet will long be remembered as an apostle, spreading the nappe theory of the Alps throughout the English-speaking world. Most of the amazing discoveries made since 1893 in regard to the structure of the Alps have been published in French or German. Moreover, as a problem in field-geology, the subject has been bewilderingly confused for outsiders by essential local detail, both geographical and stratigraphical. The findings, too, have been of such an unbelievable nature that to risk an opinion upon their veracity without special introduction and guidance might well seem foolhardy. It was this introduction and guidance that Collet delighted to furnish, by leading excursions, from 1909 onwards, by publishing his "Structure of the Alps" (1927, 1935) and by delivering lectures, especially those at Harvard (1928–29).

Collet's Swiss colleagues may perhaps protest that there are more fundamental reasons for gratitude. There are, for example, many original contributions towards the unravelling of the Alpine story, chief among which stands Collet's description, with Paréjas, of the Jungfrau (1931). Here, indeed, we find work of first-rate geological ability, coupled of necessity with adventurous climbing. There are also his many valuable essays on physical geology and geography, among which must be reckoned his books, "Les Depôts Marins" (1908) and "Les Lacs" (1925).

It so happens that these two books bring us back to the British connexion. In 1904, immediately after taking his D.Sc. at Geneva, Collet joined the temporary, in part international, staff of the Murray–Pullar Survey of the freshwater lochs of Scotland—the Murray concerned was Sir John Murray, of *Challenger* fame. This often brought Collet to Edinburgh, where in two formative years he responded whole-heartedly to the spell cast by Peach and Horne; and their influence remained with him to the end of his days.

Collet at Geneva had been brought up in a die-hard school of Alpine interpretation, still struggling against the new ideas announced by Schardt in 1893; and it is remembered in Edinburgh how, during his sojourn there, he maintained in a lecture that it was possible that his teachers might yet prove correct. Soon after his return, however, to Geneva in 1906 as *Privatdocent* he saw with delight that the new interpretations were irresistible, and he at once joined the happy throng developing the profitable field thrown open to all-comers.

The rest must be put very briefly. During 1912–18 Collet was director of the newly established Federal Hydrographical Survey of Switzerland. During 1918–44 he occupied with great distinction the chair of geology and palæontology at his *alma mater*. He received many honours, but probably none was more highly valued than the foreign membership of the Royal Society of Edinburgh and the LL.D. bestowed on him by the University of Glasgow.

E. B. Bailey

Colonel E. E. B. Mackintosh

Colonel E. E. B. Mackintosh, a former director of the Science Museum, South Kensington, died on November 25. He was the last of a line of distinguished Royal Engineer officers who directed the fortunes of the scientific collections at South Kensington from 1858 until 1945. He and his predecessors, Donnelly, Festing, Abney, Ogilvie and Lyons, brought the Museum to its present fame, as one of the most visited museums in the world.

Mackintosh's contribution to this development was to encourage the organization of special temporary exhibitions, lasting for a few months each, on such subjects as "Noise Abatement", "Very Low Temperatures" and "Science in the Army". These, with their formal opening ceremonies by some public figure, at which Mackintosh was in his element, gave wide publicity to the Museum; and his friendly bonhomie gained much goodwill for the Museum among those who were in a position to support its activities.

Ernest Elliott Buckland Mackintosh was born in 1880 and was educated at Eton and the R.M.A., Woolwich, from which, in 1899, he was commissioned in the Royal Engineers. He served in the Sudan and Egypt before taking part in the First World War in France, for which he was awarded the D.S.O. and appointed to the Legion of Honour. After a period, first in Hong Kong and then as chief engineer, Eastern Command, he was appointed director of the Science Museum in 1933. Almost immediately he became concerned with plans for the proposed new centre block of the Museum, which was to include a planetarium; but all his plans were frustrated by the Second World War and its preliminary crises. From 1939 onwards, except for a short period in 1939 and 1940 when he was commandant of the School of Military Engineering at Chatham, his energies and organizing ability were directed towards the evacuation and preservation of the Museum's collections. The War had only recently ended when, in 1945, he retired on reaching the age limit.

His own collecting instinct manifested itself by an interest in glass, of which he formed a small private collection. In the latter part of 1937 he was instrumental with others, including W. A. Thorpe, of the Victoria and Albert Museum, and John M. Bacon, in founding the Circle of Glass Collectors, of which he became, in 1947, one of the five honorary vice-presidents.

During his time at the Science Museum he was also a governor of the Imperial College of Science and Technology and one of the trustees of the Imperial War Museum.

He is survived by his widow and one daughter. His only son was killed in action in 1944.

H. R. Calvert

NEWS and VIEWS

Psychology at University College, London :

Prof. R. W. Russell

It is now a little more than a year since Prof. Roger Russell resigned from the professorship of psychology at University College to take up an administrative appointment with the American Psychological Association. His decision has occasioned the most lively regret among his many friends and colleagues in Great Britain. In his six years at University College, Prof. Russell transformed his Department into a most active centre of research in experimental and comparative psychology. He will be remembered especially for his work on behaviour disorders in animals and for his more recent studies of the effects of greatly reduced body temperature upon learning and memory in the rat. Prof. Russell also gave devoted service to a variety of bodies concerned with the organization and applications of psychology. In spite of his return to the United States, Prof. Russell hopes to retain his many contacts—personal and scientific—with his psychological colleagues in Britain.

Prof. G. C. Drew

George Drew, who has been appointed to the chair of psychology in University College, went to the Cambridge Psychological Laboratory from the University of Bristol in 1935 as the holder of the Viscount Haldane of Cloan Studentship. He worked there with Sir Frederic Bartlett, finding his main interest in the study of animal behaviour. The award of a Rockefeller Fellowship took him to Harvard, where he worked for two years under Prof. K. S. Lashley. On his return to Cambridge, it was intended that Drew should further develop his animal studies. Unfortunately, the War intervened and he found himself increasingly drawn into the programme of work on human skill and fatigue which became the main war-time preoccupation of the Department. His work with the late Dr. Kenneth Craik on the 'Cambridge Cockpit' is deservedly well known. In 1942 Drew was appointed psychological adviser to the Air Ministry, a post which he successfully held for the remainder of the War. After the War, Drew returned to Bristol as lecturer in psychology. His promotion was rapid; by 1951 he had been appointed professor of psychology with a small independent department. The latter was broadly conceived, embodying genetic and clinical no less than experimental interests. It has also developed as a promising centre of experimental research, some of it undertaken in conjunction with the Road Research Laboratory. Drew has also served as a consultant to the Medical Research Council Applied Psychology Research Unit at Cambridge. To a subject not always noted for its sanity, Prof. Drew brings a resourceful and level-headed approach. By virtue of his background and interests, he would appear particularly well fitted to develop the experimental trend in psychology at University College so courageously initiated by Prof. Russell.

Discovery

The January issue of *Discovery* is the first in the new format. This journal has always been well produced, yet the larger size is a distinct improvement. It allows for the use of bigger type and better spacing. The illustrations are also bigger and the half-tones are consequently most impressive. There is a new lay-out for the page of contents, though this does not seem to show much improvement on the old one. Any scientific journal which has to attract non-scientists must be in itself attractive. *Discovery* is now produced in such a way that many potential readers will be attracted by its illustrations, typography and lay-out. The first issue in the new form contains five articles, all of which are well written and interpret science for the non-specialist in a very desirable way. They are: "Diamond: Fiction, Fancy and Fact", by Prof. S. Tolansky; "The Fascination of Numbers", by W. J. Reichmann; "British Science and Technology for the Brussels Exhibition, 1958", by J. Gardner and Caroline Heller; "A Swiss Guided Missile", by E. Stehli; "The International Geophysical Year: Month by Month", by Angela Croome.

The journal opens up with long notes entitled "The Progress of Science", which deal with recent advances and expression of opinion. They include a well-illustrated account of Marcoule—centre of French atomic power; electronic music; oil under the Sahara (illustrated); Oskar Minkowski (who established the cause of diabetes), and an account of the Symposium on Biological Productivity in Britain which was held under the auspices of the Institute of Biology. The first note under "The Progress of Science" takes the form of a leading article pleading for the need for a strategy of science. This issue also contains a number of useful and authoritative book reviews together with science news. One very useful feature which is being continued is "Science on the Screen".

The Editor and publishers of *Discovery* are to be congratulated on the attractive changes which have been initiated in a very useful journal.

Numbers of Medical Students and Practitioners

The Willink Committee, which was appointed in February 1955, has now reported to Ministers on "the number of medical practitioners likely to be engaged in all branches of the profession in the future, and the consequential intake of medical students required" (H.M.S.O., 2*s*. 6*d*. net). Excluding students from overseas, the present annual output of qualified men from the medical schools of the United Kingdom is 1,855. Allowing for losses due to natural causes, the Committee's view is that from 1962 until about 1975 a smaller number will suffice to meet all estimated needs, and that in consequence the intake of medical students should be reduced by about 10 per cent as soon as practicable. On the other hand, the Committee also believes that by about 1975 more doctors are likely to be needed, and that consequently the student intake should be raised from about 1970. This forecast is necessarily speculative, and the prudent suggestion is made that another review should be made in about ten years time.

In the meantime, it would seem inevitable that the result of these recommendations will be to generate no small measure of despondency and alarm among the scientists in our medical schools. There are 1,200 or so "whole-time university medical teaching and research staff", and the Willink Committee seems to have accepted a quite arbitrary opinion of the Committee of Vice-Chancellors and Principals that these figures should not increase by more than 1 per cent a year. One can only hope that the University Grants Committee will pay little attention to a piece of advice the effect of which can only be to help stifle a body of research workers who number among themselves some fifty Fellows of the Royal Society and two recent Nobel Prize winners.

Department of Scientific and Industrial Research

In reply to a question in the House of Commons on December 17 regarding progress with the five-year plan of the Department of Scientific and Industrial Research, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that the first three and a half years of the plan had been completed and the activities of the Department are developing broadly along the lines planned. At the end of 1957–58 it is estimated that the staff will have increased by 750 out of the 800 planned, although the Department has not been able to recruit all the specialist staff needed. The provision of new buildings has also fallen behind, largely owing to restriction on capital expenditure, and by the end of 1957–58 only half the planned building programme will have been completed. Plans for the period 1959–64 are at present in preparation and are being considered by the Council for Scientific and Industrial Research.

In reply to a further question, Mr. Nicholls said that there are close direct contacts between the nine research associations serving the textile industries. Ten years ago the Department established a Standing Consultative Conference on Textile Research to avoid undesirable duplication and to promote collaboration among the research associations, or equivalent organizations engaged in textile research, whether in receipt of a grant-in-aid from the Department or not. He thought there was no doubt that the Conference, which meets every year, its effective committee meeting quarterly, has justified its existence.

Questioned about the Department's postgraduate training grants, Mr. Nicholls said that the Council has set up a Postgraduate Training Grants Committee under the chairmanship of Sir Eric Ashby consisting of three members appointed after consultation with the Committee of Vice-Chancellors and Principals of Universities; one member representing the technical colleges; and professors of high standing in the main broad fields of science and technology, together with the chairman of the University Grants Committee and a Ministry of Education representative as assessors.

Study of Dentine

Teeth consist of a surface layer of enamel and a core of dentine which also forms the root. The dentinal matrix is permeated by canaliculi which, according to the usually accepted view, contain cytoplasmic strands originating from odontoblasts within the pulp cavity. An alternative view about the contents of the tubules was advanced as long ago as 1879, but the classical description does not appear to have been challenged until 1954 when Dr. W. Warwick James published a preliminary account of work which led him to believe, first, that the dentinal tubules open into the pulp cavity between adjacent odontoblasts; secondly, that they contain tissue fluid; and thirdly, that odontoblasts are concerned with the production of the collagenous fibres and mucopolysaccharides of the dentinal matrix. A full report of Dr. James's observations has recently been published in the *Transactions of the Zoological Society of London* (**29**, Part 1; 1957) in the form of a lavishly illustrated monograph. Introductory sections summarize earlier views about the structure of dentine and lead to descriptions of the histological appearance of the tissue as seen in the conventional type of preparation from the teeth of mammals (twenty-two species at various stages of development); reptiles (seven species); amphibians (one species); and fish (ten species). Dr. James develops the thesis that the dentinal tubules originate as a result of mechanical forces set up as adjacent odontoblasts produce columns of fibrous matrix in a space permeated by tissue fluid and enclosed by the cells of the internal dental epithelium. He concludes with an account of some of the physical properties of dentine, and suggests that the high elasticity of the tissue accounts for its peculiar sensory characteristics.

Biotopes of Ruwenzori

In the second series of monographs on the Exploration du Parc National Albert (fasc. 3. *Inst. des Parcs Nat. du Congo Belge, Brussels*, 1956), J. Heinzelin and H. Mollaret have written an introductory account of the "Biotopes de Haute Altitude Ruwenzori, I". The localities inspected, mostly at an altitude of 4,000 metres and above, are seldom visited, except perhaps by native hunters, the more so as there is no season when good weather, and therefore travelling conditions, can be assured. There are, however, brief periods, for example, during January–February, when for a few weeks mist and rainfall may be such as to admit of travel and observation. The equipment used during the expedition is described, and then follow notes and diagrams on selected biotopes, that is, localities in which particular biological materials are to be observed. The monograph is illustrated by some excellent photographs—some in colour—those of the high mountain lakes being of a particular fascination. The main cartographical observations from the present and from earlier surveys of the high massifs of Ruwenzori have been brought together in a new map. Some brief floristic and faunistic notes are given.

Biochemistry of Antibiotics

The first European symposium on "The Biochemistry of Antibiotics" was held during September 10–13, 1956, in Milan. The second volume of *Giornale di Microbiologia* (pp. 503, 1956) is devoted entirely to the papers given at this symposium and to the discussions which followed. The president, Prof. P. Rondoni, contributed the foreword, but unhappily he was not able to be present and he died shortly afterwards. The papers deal with topics such as the chemical composition and biosynthesis of antibiotics and their mode of action on pathogenic bacteria. There were thirty-four communications, most of them given in English; Sir Howard Florey, A. I. Virtanen and S. A. Waksman were among the contributors.

Veszprém Polarographic Conference

The proceedings of the polarographic conference held in Veszprém, Hungary, in August 1955 have now been published in *Acta Chimica* (Hungary), 9; 1956. Forty-six papers were presented at this conference, covering general procedures, inorganic, organic, biochemical and pharmaceutical applications of polarography. Among the subjects discussed were various new types of polarographic electrodes, oscillographic polarography and the use of kinetic currents for the determination of extremely high rates of reaction. The effect of maxima suppressors on the shape of polarograms was considered and an attempt was made to correlate the molecular weight of a suppressing agent with its concentration and maxima-suppressing ability. Methods were described for the polarographic estimation of magnesium, gallium, oxygen, dithionite and various nitrogen-containing inorganic compounds. In the organic field the polarographic reduction of nitrogen-containing heterocyclic compounds, aromatic nitro-compounds, glucosazones and boric acid derivatives of D-glucosazones were among the subjects studied. In the biochemical applications of polarography, investigations were reported on muscle proteins, proteins in serum obtained from liver lesions and mucoproteins in pneumoconiosis. Work on new methods of evaluation of catalytic protein waves was described, as also were researches on the Brdicka polarographic protein reaction. Various applications of polarography to pharmaceutical problems were recorded. Copies of the proceedings can be obtained from Kultura, Budapest VI, Magyar Ifjúság útja 21. Price 126 forints.

Institute of Information Scientists

A meeting will be held on January 23, at 5.30 p.m., at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2, to discuss terms of inauguration of an Institute of Information Scientists. The aims of the proposed Institute would include the promotion of high standards in scientific and technical information work, the promotion of educational courses, and the establishment of qualifications for those engaged in such information work. Membership of the Institute would be open, in the first place, to graduate (or similarly qualified) members of scientific, technical or economic information departments. Applications for admission tickets may be made to J. Farradane, Torran, Crofton Road, Orpington, Kent. Applicants should indicate briefly their qualifications and enclose a stamped addressed envelope for reply.

University News:

Belfast

Dr. D. T. Elmore has been appointed to a lectureship in biochemistry.

London

Prof. H. Lionel Elvin has been appointed director of the University of London Institute of Education from October 1, 1958. Since April 1956 Prof. Elvin has held the chair of education with special reference to education in tropical areas at the Institute. The title of reader in chemistry in the University of London has been conferred on Dr. C. A. Bunton and on Dr. A. Wassermann in respect of their posts at University College; and that of reader in applied mathematics in the University of London on Dr. E. P. Wohlfarth in respect of his post at the Imperial College of Science and Technology.

Melbourne

Dr. J. A. Pateman has been appointed a senior lecturer in botany.

Sheffield

The Shell Petroleum Co., Ltd., has made a gift of £15,000 to the Development Fund of the University.

Announcements

Medals of the Tokyo Geographical Society have been awarded to Prof. L. Dudley Stamp, immediate past president, and Prof. Hans Ahlmann, president of the International Geographical Union.

Mr. Leonard Rotherham, director of research and development at the Industrial Group Headquarters of the United Kingdom Atomic Energy Authority, Risley, Warrington, Lancs., has been appointed a full-time member of the Central Electricity Generating Board with effect from April 1.

The Institute of Personnel Management is holding a five-day residential study course in "The Employment Function of Management" during January 26–31 at the Prince of Wales Hotel, De Vere Gardens, Kensington, London, W.8. Further information can be obtained from the Courses Secretary, Institute of Personnel Management, Management House, 80 Fetter Lane, London, E.C.4.

A course in "The Use of Statistics in Personnel Management", organized by the Institute of Personnel Management in conjunction with the National Institute of Industrial Psychology, will be held non-residentially at the National Institute of Industrial Psychology, 14 Welbeck Street, London, W.1, during January 20–24. It is intended for those personnel officers and managers who have had no previous training in the use of statistical methods and their application to personnel administration. Further information can be obtained from the Training Officer, Institute of Personnel Management, Management House, 80 Fetter Lane, London, E.C.4.

The British Institute of Management is holding a work study conference on February 6. The fee for attendance is 7 guineas, which includes morning coffee, buffet luncheon and afternoon tea. The conference will be held in the Caxton Hall, Caxton Street, Victoria Street, London, S.W.1. Further information can be obtained from the British Institute of Management, Management House, 80 Fetter Lane, London, E.C.4.

THE RAMSDEN LABORATORY OF ILFORD LIMITED

By Dr. G. B. HARRISON
Research Director

THE silver halide crystal is the basis of the photographic industry, and the scientific and patent literature of this century contains ample evidence of the effort that has been applied to enhance its amazing efficiency as a detector of radiation. The achievement of the highest possible sensitivity to light must be one of the principal aims of a research group in photographic science, and this must be pursued through experimental emulsion-making, as well as by more fundamental studies of the physics and physical chemistry of the process. In the photographic industry it is still only one of many aims, and it is the task of large laboratory units to evolve all those sensitive materials of highly specialized characteristics which are demanded by the different branches of human activity to which photography makes its contribution.

The film production facilities of Ilford Limited are situated at Brentwood in Essex, and the recent opening of a new building there, the Ramsden Laboratory, is a consequence of the rapid expansion of output, the greater variety of product which it is called upon to produce, and the increasing complexity of the problems which are set by the range of applications of film in the modern world.

The Ramsden Laboratory (Fig. 1) has an area of 30,000 sq. ft. on two floors, divided into three sections: emulsion and chemistry, testing, and physics. In it are blended more or less conventional chemical and physical laboratories and workshops, with a large number of laboratories and dark rooms specially designed for the various operations of photographic technology.

The Emulsion and Chemistry Section has responsibility for emulsion production as well as for research and development leading to improved or new emulsions, and its first care is for the quality of raw materials. These present peculiar problems in this industry, for traces of foreign chemicals which may be almost undetectable chemically or spectrographically may produce marked and damaging effects in photographic emulsions, and the processes of routine analysis in the chemical laboratories must be supplemented by tests in emulsions.

Of all the raw materials, gelatin offers the biggest problem and is of the greatest interest. At Brentwood and in the Ilford laboratory of the Company, the application of the techniques of paper chromatography and electrophoresis, and of polarography, has led to the identification and quantitative determination of the traces of sulphur compounds in gelatin which act as sensitizers of silver halide, and work now in progress at Brentwood is throwing new light on the protein itself.

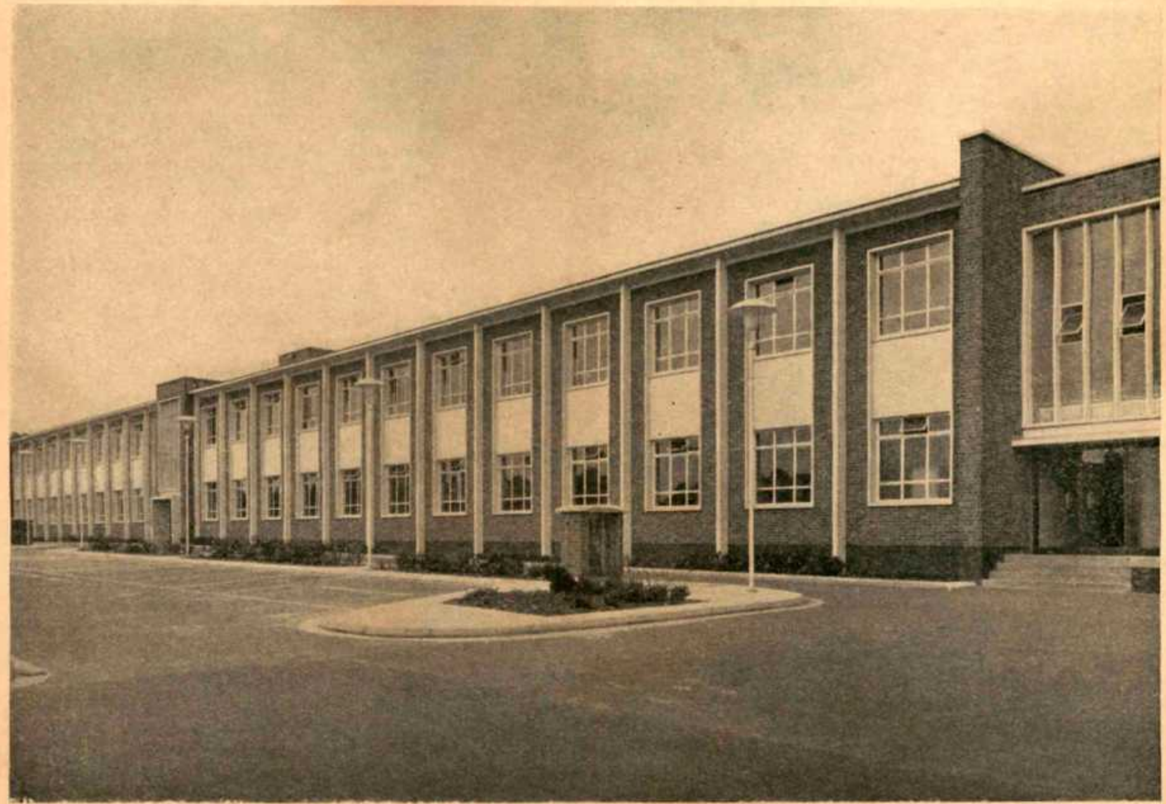


Fig. 1. Front of the Ramsden Laboratory, Ilford Limited, Brentwood, Essex

The eight emulsion-making laboratories are grouped on the ground-floor, and their design has evolved from many years of experience. They are provided with stirring and mixing apparatus for the precipitation of silver halide under closely controlled conditions, and thermostatically controlled tanks for heat treatment. The 'safe-lighting' and ventilation of these laboratories have needed careful planning to achieve the best possible working conditions with the greatest efficiency.

The problems of the emulsion chemist arise in the first place from the variety of films that are nowadays called for. The fast panchromatic films of the miniature camera are closely related to those of the cinema industry, and a little more distantly to the films which meet the needs of aerial photography or oscillograph recording in various forms. The range of emulsions of high contrast used in X-ray work, medical or industrial, are entirely different products. The graphic arts also make their demand on the emulsion makers' time and ingenuity, and the problems met in the development and production of films for colour photography are the most complex of all. Work devoted to the improvement of all these materials is constantly in progress.

The emulsion chemist's task is not by any means limited to production of a material which has the required characteristics of sensitivity, contrast and freedom from fog or from troublesome grain. Besides these and other 'sensitometric' characteristics there are other qualities that the material must possess to give satisfaction under all conditions of handling or mishandling, and these call for a study of such factors as surface hardness, surface friction, wettability, water absorption and the melting point of the swollen emulsion, and the means to modify these qualities. Problems of colloid chemistry arise here, as they do also in the manufacturing process itself. These problems are ultimately technological ones for the emulsion chemist to solve, but the Ramsden Laboratory has a section where rheology and surface chemistry and physics, as they relate to photographic processes, are to be the subjects of basic investigations.

A small department fully equipped for microscopy and photomicrography will provide essential service to all departments of the Laboratory.

The testing of a trial emulsion presents a special problem and covers not only the characteristics of its sensitivity to light but also other features such as resolving power, graininess and physical properties like its susceptibility to scratching or melting point. Nearly all these tests are peculiar to the photographic laboratory, and it is necessary to develop most of the testing equipment within the organization. This is generally part of the work of the physics laboratory which, by the application of physical principles, will first devise the test and then produce at least a working prototype of the final routine test equipment. The physics laboratory is provided with a well-equipped workshop and drawing office which is capable of light precision engineering and can build all kinds of equipment from the odds and ends required in the construction of research 'lash-ups' to a full-scale continuous processing machine for handling cinematograph film. Such a machine is, in fact, being constructed for installation in the processing section and will be capable of processing 35-mm. and 16-mm. colour film. For experimental work a high degree of versatility is required, and the machine will be able to perform any sequence of operations likely to be called for in research on new processes of colour photography, which is one of the chief preoccupations of the physics laboratory to-day. Present-day colour materials start with a more or less conventional black-and-white emulsion having special features which are the product of research in the emulsion laboratories. The problem of introducing colour is one involving both chemistry and physics, and the particular problem of the colour reproduction obtained is very much the concern of the physicist.

Another section of the physics laboratory is concerned with electronics. The use of equipment coming under this general heading is growing rapidly, particularly in testing instrumentation and its progress towards more and more automation. Electronics has in this way played its part in developing colour photography and now it seems to be entering the field of commercial printing of colour materials.

The photographic industry depends more than most industries on its research laboratories, and this new laboratory at Brentwood, which was visited by the Duke of Edinburgh on December 6, is the third new laboratory designed and built by Ilford Limited since the Second World War.

RESIDUES OF PESTICIDES IN FOODSTUFFS

A JOINT meeting of the Pesticides Group of the Society of Chemical Industry with the Association of British Insecticide Manufacturers was held on October 21 to discuss "Residues of Pesticides in Foodstuffs". The chairman of the Pesticides Group, Dr. F. P. Coyne, said that the intention of his committee in organizing the discussion was to give those in the chemical industry engaged in trying to apply current regulations an opportunity to air their views on this rather controversial matter. The Association of British Insecticide Manufacturers had welcomed the proposal and had nominated three speakers who would be recognized as authorities on the particular aspects which they discussed, but none of whom would wish to be taken as speaking for every member of the Association. The presence of 160 in the audience was some indication of the interest aroused, and there would have been at least forty more had seating capacity been available.

The following papers were delivered: "Existing Regulations in the U.K. and Overseas" by Mr. J. I. Hendrie; "Pesticide Residues and Public Health" by Dr. E. F. Edson; and "Determination of Residues" by Mr. J. M. Winchester.

Since the United States and Britain appeared to have progressed more than other countries in providing public safeguards, it was inevitable that the two very different procedures should be compared and contrasted. In the United States no new pesticide can be marketed before the Food and Drug Administration has laid down a tolerance, and if this limit be exceeded the whole of the treated crop is subject to confiscation. In Britain, a voluntary system of notification of new pesticides operates, and there is no provision for enforcement. The principle adopted is to agree on treatments that will result in no toxic hazards to the consumer, and this is considered preferable to any definition of permitted residues. It was stressed that tolerances in the United States do not in themselves indicate basic toxicity to humans, since the Food and Drug

Administration is charged by Congress to prevent unnecessary contamination of food, and its tolerance always takes into consideration the minimum biologically effective dosage—which may differ for different pests on different crops and which relate only to conditions in the United States.

It would be surprising if two such systems had evolved along exactly the same lines, and the factor of legal enforcement probably tends to make the Food and Drug Administration more meticulously precise in its demands. None of the speakers suggested that its requirements were in any way fallacious, but doubts were expressed as to whether all the routine requirements were essential. A recent report from the United States, that the combination of two organo-phosphorus pesticides at residue levels within the permitted tolerance for each caused effects on experimental animals greater than could have been anticipated as normally additive, raised the question of 'potentiation'. This could mean that any new pesticide must be tested in combination with all others to prove its absence of hazard and, while no objection could be made were the case for such action fully proved, the greatest care was needed in ensuring that any such requirement was justified to the full, because of the implications. Theoretically, the possibility of such a happening could not logically be restricted to chemically similar compounds.

Some fear was expressed that the superficial attractiveness of stated tolerances would tend to make other countries favour the United States system, and that without the excellent facilities and high standards of operation in the Food and Drugs Administration there could arise a series of uncoordinated demands on industry, many of them quite unjustified. The analytical side is completely dependent upon the methods available, about which there is frequent disagreement even at national levels. This is one of the reasons why British officials are not enthusiastic about stated tolerances.

Toxicological work presents even more complications, not only in the choice of techniques but also in the interpretation of findings, and Dr. E. F. Edson advocated caution at this early stage, although he was satisfied that there are no grounds for active apprehension. He suggested, and was supported by Mr. J. M. Winchester, that consideration should be given to more extended feeding tests as alternatives to exhaustive chemical investigations into possible metabolites of pesticides. Both speakers agreed with Mr. J. I. Hendrie that closer collaboration between Government and industry is necessary in order to define more accurately the essential requirements. A Board of Trade investigation into demands of overseas countries is being carried out and should elaborate the position reviewed by the first speaker. Efforts to draw up an agreed scheme of testing are at present being made by official and industrial toxicologists in Britain, and such a contribution could well form the basis for discussions with other countries.

Emphasis was laid on the sense of responsibility of the industry and on its desire to do all that is necessary to protect the public ; but it was pointed out that if the difficulties of development of a pesticide became so onerous that the prospects of adequate commercial return appeared to be too remote, finance in the chemical industry will undoubtedly be directed into other channels—as a simple duty to shareholders. Even to-day it is widely agreed, both in the United States and Great Britain, that it is not worth while to attempt to develop a new speciality product with very limited markets, no matter how important the problem involved may be to the branch of agriculture or horticulture concerned. This applies whether the potential pesticide be highly toxic or relatively harmless to humans, since the same procedure must be followed and the same order of expenditure incurred.

In attempting to summarize the three papers, the chairman pointed out that all three contributors were making a case for co-ordination of international standards, in principle at least. It seemed possible, however, that if Britain desired some general international agreement, she may have to be the first to modify current practice. Already in Britain there are tolerances for a limited number of preservatives of foodstuffs, which include fungicides. It would not require any fundamental change to extend these to insecticides, weedkillers, etc. If some such action could be taken there would probably be a much better chance that the system operating in Britain would be acceptable elsewhere.

Opening the discussion, Sir Solly Zuckerman paid a tribute to British industry, not only for its highly developed sense of responsibility, but also for its most co-operative attitude on the voluntary notification scheme. He refused to be perturbed by the present situation, and considered that the essential costs must be shared by government, industry and the user of pesticides. Since Britain, as well as being a leading importer of foodstuffs is also a considerable exporter of chemicals, it was doubly important that we should take a lead in this matter. He advocated caution, however, in making an approach to United Nations agencies, such as the World Health or Food and Agriculture Organizations, which could ultimately be important and helpful, until more progress had been made in settling Britain's own admitted difficulties in chemical and toxicological testing and interpretation. If the collaboration already existing between industry and government were continued in the same spirit he was hopeful that the chief difficulties could be overcome.

An animated discussion followed with views and comments from chemists, toxicologists and administrators in government and in industry. It was clear that everybody concerned was well aware of the difficulties, but there was less unanimity on how to overcome these. A tendency to generalize rather too freely from particular examples was perhaps excusable with such a complex issue, particularly in view of the short period during which current regulations have been operating, either in the United States or Britain. The papers and discussions will be published in full elsewhere.

F. P. Coyne

PHYSICS IN INDIAN UNIVERSITIES

UNDER the auspices of the Indian University Grants Commission, the University of Calcutta arranged a seminar on physics which was held during September 9–11. The conference was attended by Dr. W. W. Buechner, professor of experimental physics in the Massachusetts Institute of Technology, and by delegates from almost all the universities in India at which physics is taught at a postgraduate level, together with representatives from a number of other research institutes. The second and third days of the seminar were devoted to papers on nuclear physics and cosmic rays.

The morning and afternoon sessions of the first day were allotted to a discussion of the teaching of postgraduate physics in Indian universities. While welcoming the guests, Dr. P. C. Bhattacharya, head of the Department of Physics, University of Calcutta, gave a brief account of his Department, first established in 1916, in which such eminent scientists as Sir C. V. Raman, Dr. D. M. Bose, the late Dr. M. N. Saha, Dr. S. K. Mitra and Prof. S. N. Bose worked and inspired the younger generation. Dr. D. M. Bose, director of the Bose Institute, in his presidential address, first gave a description of the teaching of physics in his college days in the Presidency College, Calcutta (1905–6), in Cambridge (1907–11), in London (1911–12) and Berlin (1914–18), under J. C. Bose, J. J. Thomson, C. T. R. Wilson, Jeans, Watson, Rubens, Max Planck and others. He also mentioned the methods of teaching of Einstein and Nernst. As a professor of physics, Dr. Bose revised the M.Sc. syllabus in physics for the University of Calcutta in 1920 on the lines adopted by Planck. Dr. Bose discussed the feasibility of devising a satisfactory syllabus for teaching postgraduate physics in all the universities in India. Young men after getting the degree of M.Sc. generally take up (1) the teaching of physics in high schools and colleges, (2) research work in the universities, government laboratories and industry, (3) administrative work in government, technical and commercial services; and Dr. Bose stressed the importance of the first category to the economic and technological development of India.

Finally, Dr. Bose dealt with the importance of encouraging nuclear research through non-governmental agencies. Like Brookhaven National Laboratory for research and training in nuclear physics which is managed by nine United States universities, he pleaded that similar laboratories should be established in India on a regional basis.

Dr. Buechner gave an impression of his two months tour of India, visiting various universities and institutions. He remarked upon certain similarities between India and the United States as regards the type of student who undertakes postgraduate studies and the lack of financial support for universities. One striking difference is that in the United States, although there are a number of laboratories managed by the government or by industry, the prime centre of research is the university. This is not the case in India, where Dr. Buechner had the impression that the universities are steadily declining in importance, being overshadowed by government and other research institutions. Without government support research cannot flourish, and without research any programme of postgraduate teaching will fail. It is the responsibility of the Indian universities to put forward their claims to the authorities and to make them understand the place of research in the university and in postgraduate teaching.

Sixteen other speakers, mostly heads of departments of physics in various universities, also gave accounts of the methods of postgraduate teaching prevailing in their respective universities, with suggestions for improvements.

The teachers of physics present at the seminar, representing almost all the universities of India, finally resolved (*inter alia*) that:

"As the main burden of the training of future physicists must be borne by the universities, the University Grants Commission is requested to ensure that the emoluments, research grants and other facilities available to the university teachers are adequate and in no way inferior to those available to people in similar positions in the National Laboratories or elsewhere."

The conference viewed with concern the general tendency for men with the best university qualifications to leave their universities for more lucrative jobs elsewhere, including the administrative services in which a knowledge of physics is not necessary, when their knowledge is urgently required for teaching work in the universities. "The best tools must be retained for manufacturing the tools themselves, for this in turn will produce better and better tools."

P. C. BHATTACHARYA

WATER QUALITY PROBLEMS IN THE UNITED KINGDOM

At a meeting of the Society for Visiting Scientists held on October 22, under the chairmanship of Mr. H. W. Cremer, there was an interesting discussion on "Water Quality Problems in the United Kingdom" following short papers on different aspects of this subject by Dr. G. Carter (Metropolitan Water Board), Dr. A. Key (Ministry of Housing and Local Government), and Dr. B. A. Southgate (Water Pollution Research Laboratory).

There is a growing demand for water of good quality, not only for domestic use, but also for industry—in some processes of manufacture the specifications to which the water must conform are more stringent than for drinking water—and for agriculture, particularly for drinking water for attested cattle. To produce water of this high quality from surface supplies a wide range of treatment processes is used; the Metropolitan Water Board, for example, treats Thames water by storage, filtration through rapid and slow sand-filters, and chlorination; industrial supplies may be treated in plants resembling those of municipal water undertakings, and for some purposes may be de-ionized by exchange processes; drinking water for cattle is often chlorinated before use.

At the same time the total volume of water asked for is also rapidly increasing. Usually, whether used for domestic or industrial purposes, the volume returned to a stream is substantially the same as that extracted, the problem being so to treat it that it can, if necessary, be used again farther downstream. For sewage, satisfactory methods of treatment are available, and by taking special precautions—as, for example, by passing the treated sewage effluent through sand-filters—the liquid finally returned to a river may be brought to a high standard of quality, and indeed would often be suitable, after chlorination, for some industrial purposes. Waste waters from industrial processes, having a much wider range of composition, present more difficult problems in treatment.

The large amount of research on these problems now being undertaken, or sponsored, by industry was widely recognized in the discussion. Several speakers referred to the difficult situation which may arise if there is any great increase in the practice of irrigating farm crops in the drier parts of Britain; water used in this way is lost from the cycle of use and re-use, being, of course, evaporated or transpired by plants.

STUDENT SCIENTIFIC EXPEDITION TO GHANA

UNDER the auspices of the Imperial College Exploration Board, seven students from the Imperial College of Science and Technology, London, organized an expedition to Ghana in the summer vacation, 1957. One of the seven, G. A. Matthews, made a detailed and restricted study of the infestation problems of ships' cargoes. The remaining members, including two women students, led by N. D. Jago (a third-year entomologist), undertook ecological research which centred upon soil conservation, one of the most important and fundamental problems in the tropics.

The main body was based in the Bobiri Forest Reserve near Kumasi, where two suitable areas were selected for examination. One was a strip transect containing a stream, thick forest and swamp, and the second a river area now drained and deforested, supporting a rice crop. Rice has only recently been introduced into this district, and the selected areas provided the opportunity for comparative studies.

The usual method of farming in Ghana away from the coastal plain is to clear the mature forest and to plant crops. The humus is immediately dried by the sun, and the soil nutrients, no longer held by an extensive root-system, are leached away by rain and the area is soon allowed to degenerate into secondary bush vegetation. The focal point of the investigation was the factors affecting formation and destruction of humus. In addition, associated problems were studied by individual members of the party.

During the eight-week period in the forest region several trips were made by the students in order to extend the work and see different peoples and places. B. M. Gerard went as far as Agades, on the southern fringes of the Sahara, accompanied by D. H. Barry, lecturer in botany in the Kumasi College of Technology. Together they began an analysis of leaf-hopper associations in different grasslands in the various savannah regions.

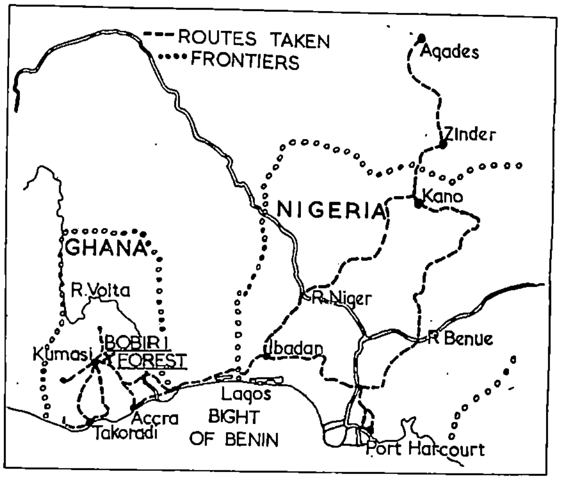


Fig. 1

Just before the party returned, an area of forest was completely cleared of vegetation and it is hoped that other expeditions from the College will be able to study this region and thus continue the work which has had so successful a beginning.

Generous financial support was provided by a number of firms and institutions and invaluable help was also given by several departments of the Ghana Government and of the University College of Ghana, Achimota.

B. M. GERARD

FLAVONOIDS OF THE PRIMULACEAE

Distribution of Flavonoids in Genotypes of *Primula sinensis*

THE Chinese primrose, *Primula sinensis*, a plant of which a wide range of colour mutants is available[1], provides excellent material for investigating the biochemical genetics of the flavonoid plant pigments. Earlier, Scott-Moncrieff[2] showed that red flowers (*K*-genotypes) contained malvidin-3-monoside which was dominant to pelargonidin-3-monoside in coral flowers (*kk* genotypes). A Mendelian factor *Dz* controls the independent production of pelargonidin in the presence of *K*. Other genes present influence flower colour by controlling production of an unidentified flavone co-pigment, by altering the *p*H of the cell sap and by regulating the concentration of anthocyanin.

A re-investigation of the flavonoid pigments of this plant was prompted by the facts that the stocks used by Scott-Moncrieff were still available and that better methods of identifying these pigments had been developed since her investigations. The flavonols and anthocyanidins produced by acid hydrolysis of direct plant extracts have been examined in both the floral and foliar parts of the different genotypes of *P. sinensis*. Identifications have been based on comparisons with authentic compounds using paper chromatography in several solvent systems[3], and spectrophotometry[4]. The results show that all the six common anthocyanidins and also the three flavonols, kæmpherol, quercetin and myricetin, are present in various forms of *P. sinensis*.

The distribution of these pigments, which are all closely related chemically, is as follows. Flowers of *K*-genotypes which are coloured contain mainly malvidin, some petunidin and traces of delphinidin; in the leaves and stems, there is much more of petunidin than of the other two pigments. In the flowers, kæmpferol is the predominating flavonol and lesser amounts of quercetin and myricetin are present. In the leaves and stems, quercetin is present in greater amount than myricetin and kæmpferol. *K*-genotypes which bear white flowers have the same pigment pattern, except, of course, that there are no anthocyanidins in the flowers. In addition, pelargonidin occasionally appears in both floral and foliar parts since, even in the absence of *Dz*, *K* is incompletely dominant in some genetic backgrounds[5]. In the presence of *Dz*, large amounts of pelargonidin are present in the flowers of *K*-genotypes, but the foliar parts only contain traces of this compound.

Flavonoids with hydroxyl (or methoxyl) groups in the 3′, 4′ and 5′ positions, for example, myricetin and delphinidin, are absent from the recessive *kk* genotypes, namely, *kkdzdz* and *kkDzDz*. The latter genotype has the higher absolute content of pigment in the flowers. Both contain mainly pelargonidin, together with a small amount of peonidin (about 10 per cent) and traces of cyanidin in their petals. The foliar parts, however, contain equal amounts of pelargonidin and cyanidin. Kæmpferol and quercetin occur in all parts of the plant. In the flowers, the former predominates, and quercetin is often absent. The situation is reversed in the leaves, where again quercetin is found most abundantly.

Other related polyphenolic compounds are also present in *P. sinensis*. An unidentified flavanone glycoside, sinensin[6], occurs in large quantities in the flowers of *kkDzDz* forms, from which it has been isolated. The aglycone, sinensetin, does not correspond in its properties with any of the commonly occurring flavanones and therefore its structure is under investigation.

The co-occurrence under gene control of anthocyanidins and flavonols having the same hydroxylation pattern was first noted by Geissman *et al.*[7] in *Antirrhinum majus* and *Dianthus caryophyllus*, where the pairs of pigments, cyanidin and quercetin, and pelargonidin and kæmpferol, co-occur in different genotypes. The co-occurrence of anthocyanidins and flavonols at all three levels of hydroxylation of the *B* ring was first observed by one of us[8] in *Solanum* species. *P. sinensis* thus provides a fourth example, the situation being very similar to that in the *Solanum* series. This work, then, supports the theory that flavonols and anthocyanidins are derived from a common precursor, have a similar biosynthetic pathway and only diverge at a very late stage in pigment synthesis.

It is also apparent that in *P. sinensis* the effects of some genes controlling pigment metabolism differ in different parts of the same plant. The only other known case of this phenomenon is that of plants of the tuberous *Solanums*, where tuber and flower contain different anthocyanins[9]. It is hoped to publish full details of this and other work elsewhere.

J. B. HARBORNE
H. S. A. SHERRATT

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Anthocyanins in the Flowers of *Primula sinensis*

STUDIES were made previously of the biochemical genetics of the flower pigments of *Primula sinensis*[1]. A crystalline anthocyanin from red flowers, 'primulin', was stated to be malvidin 3-galactoside on the basis of its distribution number between pentanol and water[2], and more recently the pelargonidin derivative present in orange flowers (genotype *kkDzDz*) was stated to be a 3-galactoside[3].

As part of a re-investigation of the polyphenolic components of *P. sinensis*[4], the anthocyanins of *KKdzdz* and *kkDzDz* flowers were examined by paper chromatography. Extracts of flowers in methanolic hydrochloric acid were banded on Whatman No. 3 paper and developed with *n*-butanol/2*N* hydrochloric acid 1/1 (upper layer). The separated anthocyanin bands were cut out and eluted with 5 per cent acetic acid in methanol and purified by re-running in *n*-butanol/acetic acid/water, 4/1/5 (upper layer), and then 15 per cent aqueous acetic acid on washed paper. The purified pigments were hydrolysed and the aglycone and sugar components identified[3].

The anthocyanins in *KK* flowers were found to be malvidin 3-glucoside with an appreciable amount of petunidin 3-glucoside. Orange (*kkDzDz*) flowers contained pelargonidin 3-glucoside, smaller amounts of peonidin 3-glucoside (about 10 per cent) and much smaller amounts of a cyanidin 3-hexoside (about 1 per cent); they also contained two other pelargonidin glucosides which did not correspond in their chromatographic behaviour in five solvent systems with any known pelargonidin derivative.

No galactose was detected in the hydrolysates of any of the anthocyanins. It was, however, readily confirmed by these methods that cyanidin 3-galactoside was present in the leaves of the copper beech, *Fagus sylvatica*[5,6]. A few milligrams of the crystalline anthocyanin, 'primulin', isolated from red flowers of *P. sinensis*, and also a crystalline anthocyanin isolated from magenta flowers[1], were kindly made available by Miss V. C. Sturgess. These were both found to yield only glucose on hydrolysis and to consist of malvidin 3-glucoside containing about 15 per cent of petunidin 3-glucoside. This material would therefore be expected to give a different distribution number from that of malvidin 3-glucoside, which might explain the earlier incorrect identification of 'primulin' as the 3-galactoside.

Anthocyanins which have been isolated so far from flowers of other members of the Primulaceae are all glucosides, namely, malvidin 3-glucoside from *P. polyanthus*[7], malvidin 3 : 5-diglucoside from *P. viscosa* and *P. integrifola*[8], delphinidin 3 : 5-diglucoside from *P. obconica*[9] and hirsutidin 3 : 5-diglucoside from *P. hirsuta*[8]. It is no longer necessary to retain the name 'primulin'[1] for the supposed malvidin 3-galactoside from *P. sinensis*.

H. S. A. SHERRATT

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Anthocyanidins of the Primulaceae

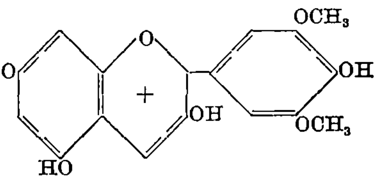
IN connexion with detailed chemical and genetical investigations of the flavonoid pigments of *Primula* species, a brief survey of the anthocyanidins present

Table 1. VISIBLE SPECTRA AND R_F VALUES OF ANTHOCYANIDINS AND ANTHOCYANINS

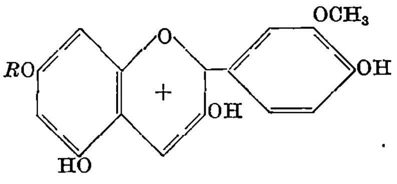
Anthocyanidins	$\lambda_{max.}$ (mμ) Solvent: ethanol/0·01 per cent conc. HCl	R_F values on Whatman No. 1 paper		Colours	
		Acetic/water/ conc. HCl (30 : 10 : 3)	Formic/water/ conc. HCl (5 : 3 : 2)	Visible	Ultra-violet
Hirsutidin	545	0·78	0·36	Purple	Mauve
Malvidin	554	0·66	0·27	,,	,,
Petunidin	558*	0·46	0·20	,,	,,
Delphinidin	557*	0·32	0·13	,,	,,
Rosinidin	534	0·76	0·39	Pink	Magenta
Peonidin	542	0·62	0·30	,,	,,
Cyanidin	545*	0·49	0·22	,,	,,
Pelargonidin	530	0·68	0·33	Orange	Orange-red
Anthocyanins		Butanol/acetic/ water (4 : 1 : 5)	Acetic/water/ conc. HCl (15 : 82 : 3)		
Rosinidin glycoside	524	0·30	0·70	Pink	Bright orange fluorescence
Peonin	527	0·24	0·55	,,	,, ,,
Cyanin	533*	0·21	0·42	Red	Dull red ,,

* Only the spectra of these pigments were affected by adding alcoholic aluminium chloride to the cell solution (a test for free vicinal hydroxyl groups)

in the flower petals of a number of wild and cultivated plants of the Primulaceae has been carried out, using modern techniques[1]. The results show that a greater variety of pigments are present than was apparent from an earlier survey carried out using the Robinson tests[2]. All the six commonly occurring anthocyanidins have been detected in one or other of the *Primula* species examined. The rare 7-methylated anthocyanidin, hirsutidin (I, $R = CH_3$), first isolated from *P. hirsuta*[3], has been found in several other species, namely, *P. auricula*, *P. denticulata*, *P. polyanthus* and *P. purpurea*. In addition, a new anthocyanidin has been discovered in *P. rosea*, where it occurs with peonidin, and in a blue form of *P. polyanthus*. This anthocyanidin, for which the name rosinidin is proposed, has not yet been obtained in sufficient amounts for chemical analysis, but from spectral and chromatographic evidence it may well have the structure of 7-methyl peonidin (II, $R = CH_3$):



I



II

Rosinidin occurs in *P. rosea* as a glycoside, probably as a 3 : 5-diglycoside, and is prepared from it by acid hydrolysis. The R_F values and visible maxima of both glycoside and aglycone are listed in Table 1, together with those of known pigments. Rosinidin, while showing all the characteristic colour reactions and solubility properties of an anthocyanidin, differs in its spectral and chromatographic data from any of the known anthocyanidins, all of which have been available for direct comparison.

The following facts suggest that rosinidin is 7-methyl peonidin (II, $R = CH_3$). (1) In its properties, it most closely resembles peonidin rather than any of the other anthocyanidins. The glycoside in particular possesses the bright orange fluorescence in ultra-violet light previously shown only by peonidin 3 : 5-diglycoside. (2) The R_F values of both aglycone and glycoside are higher than those of the known pigments. It is well known that stepwise masking of the hydroxyl groups in anthocyanidins by methylation correspondingly increases the R_F value in aqueous solvents (*cf.* the series delphinidin, petunidin, malvidin and hirsutidin in Table 1). (3) The hypsochromic shift of 9 mμ caused by introducing a 7-methyl group into malvidin (I, $R = H$) to give hirsutidin (I, $R = CH_3$) is exactly paralleled by the difference of 8 mμ in the spectra of rosinidin ($\lambda_{max.}$ 534 mμ) and peonidin ($\lambda_{max.}$ 542 mμ). (4) The occurrence of rosinidin in Primulaceae, a genus known to make a 7-methylated anthocyanidin, that is, hirsutidin, is significant. There is indeed a striking parallel between the occurrence of hirsutidin and malvidin in *P. hirsuta*, and rosinidin and peonidin in *P. rosea*. Furthermore, all four anthocyanidins occur in *P. polyanthus*.

The presence of two rare anthocyanidins, hirsutidin and rosinidin, in Primulaceae fits in with earlier studies of the flavonoid pigments present in this genus. For example, certain *Primula* species are quite exceptional in exuding flavone and, in some cases, 5-hydroxy, or 5 : 8-dihydroxy flavone, as a white dust or 'farina' on their leaves and stems[4]. Several other unusual flavonoid pigments have been detected during this survey and it is hoped to characterize them in due course.

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RELATION BETWEEN PEROXIDASE AND 'CYTOCHROME *dh*' IN WHEAT ROOTS

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PEROXIDASE is present in most non-chlorophyllous plant tissues[1–3]. The main source of this hæmin enzyme is wild horseradish[2], but roots of spring wheat, too, contain considerable quantities, amounting to 10–20 µmoles per litre of root tissue[1]. The peroxidase may be extracted from roots treated with cold acetone. It shows the same spectrum as peroxidase from horseradish, namely, a high band at 404 mµ, which after reduction in dithionite moves to 437 mµ, and a more indistinct broad elevation at about 500 mµ, sloping toward 600 mµ, which at reduction is substituted for a sharp band at 556 mµ. All these bands, as also the complexes with CN^- and F^-, are excellently recorded in living roots[1].

Peroxidase is the quantitatively dominating hæmin enzyme in wheat roots. The concentration commonly exceeds that of the sum of the cytochromes $a + a_3$, $c + c_1$, and b, which are all present in the lower 0–60 mm. of wheat roots from 2–3 week-old seedlings[4]. Peroxidase is claimed to oxidize various substrates, including phenols and polyphenols, quinone compounds, etc., at the expense of hydrogen peroxide[3]. These experiments *in vitro*, however, have not contributed much to knowledge of the role of peroxidase in the cell metabolism. From measurements on horseradish I concluded that peroxidase may conduct at most 10–15 per cent of the total aerobic respiration of wheat roots[4c]. Accumulating evidence in the literature points to the co-operation of manganous ions and complexes between peroxidase and organic compounds in the oxidizing activity of peroxidase. Long ago I showed[5] that the basal respiration of wheat roots is stimulated by manganous ions. Kenten and Mann[6] showed that the oxidation of certain dicarboxylic acids is catalysed by peroxidase systems in the presence of manganous ions. Ray and Thimann[7], studying *Omphalia flavida*, claim that indole-3-acetic acid is oxidized and destroyed by a peroxidase which forms an intermediate, possibly with a skatol compound. Stutz[8] mentions an enzyme with similar properties which, in *Lupinus albus*, requires a phenolic activator and is stimulated by manganous ions. These studies were not supported by spectrophotometric observations on living tissues, however.

During spectrophotometric investigations on wheat roots I observed[4] a band at about 571 mµ appearing under prolonged complete anaerobiosis in a non-streaming medium (aqueous solutions of phosphate or neutral salts). Observations of the time-course of increasing reduction showed that this band may be clearly distinguished from the α-band of cytochrome *b* at 560–562 mµ (cytochrome *b* in plants has bands moved about 1–2 mµ toward the violet, as compared with cytochrome *b* from animals or yeast; it also reacts much more slowly on antimycin *A* than the yeast enzyme). As the formation of the new compound was inhibited by urethane, a complete spectrum of it could be calculated[9a] as the difference: ε(oxygen-free water) minus ε (oxygen-free 10 per cent urethane). Because the compound showed γ-, β-, and α-bands (at 424, 540, and 571 mµ respectively) quite similar to those of the cytochromes and also behaved similarly to cytochromes at reduction and reoxidation it was called 'cytochrome *dh*' [9a–c]. Continued investigations now showed that 'cytochrome *dh*' is probably not a true cytochrome but a peroxidase complex, appearing only under extreme anaerobiosis. An important step to the identification of the complex nature of '*dh*' was the observation that it does not, as a rule, appear either in the mitochondria or in the microsome fractions of root homogenates[10]. The mitochondria show excellent spectra of cytochrome *b*, whereas peroxidase together with fractions of cytochrome *c* and flavoprotein go into the supernate.

The high band of peroxidase at 404 mµ as a rule dominates the γ-spectrum of aerated roots (Fig. 1). The cytochromes *c* and *b*, which according to the 60–85 per cent oxidation normally prevailing[4b] are present mainly as bands at 406 and 418–420 mµ respectively, move the peak of the peroxidase band somewhat toward the red, but the true concentration of peroxidase can generally be calculated from the difference 404–380 mµ.

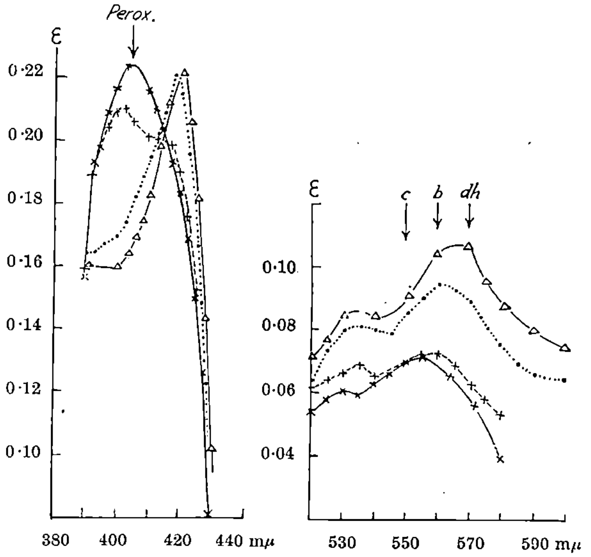

Fig. 1. Direct spectrograms (with 10 layers of Munktell No. 3 filter paper as reference) of a bundle of wheat roots 14 mm. thick (0–20, 20–40 mm. from the tips, packed together; seedlings 2–3 weeks old). Stages of increasing suffocation in non-streaming water (closed tube, containing 6 ml.). ×—×, start from aerated water; +—+, 15 min.; ○—○, 45 min.; △—△, 110 min. from the closure of the tube. The spectrograms show the disappearance of peroxidase and the appearance of the joined γ-bands of cytochromes c, c_1, b, and the peroxidase–*dh* complex (links), and the appearance of joined α-bands of the latter compounds in the time-order $c > b > dh$ (to the right)

The peroxidase is not reduced if the roots are exposed to complete anaerobiosis, but the bands at 404 and 500 mμ nevertheless more or less disappear (Fig. 1). The disappearance of the elevation in the blue-green is conveniently measured from the difference ε(580–520 mμ), the rise of which is the main cause of the rising extinction in the yellow-red part of the root spectrum under anaerobiosis.

Continuous records of the spectral changes occurring in roots which are exposed to states of increasing suffocation now show that the bands of 'cytochrome *dh*' appear synchronously with the disappearance of the peroxidase band at 404 mμ (Fig. 1). Concomitantly a synchronous increase is observed of the difference 580–520 mμ and of the band at 571 mμ (Fig. 2). These observations support the conclusion that '*dh*' is a reduced peroxidase complex. The spectrum of aerated roots gives no clear indication as to the existence of such a complex in an oxidized state. Against the existence of measurable quantities of an oxidized complex is the fact that the quantity of free peroxidase in aerated roots, calculated from the height of the 404-mμ band, tallies with calculations from the peroxidase–CN^- band and from the bands of pyridine hæmochromogen appearing after the addition of cyanide, or pyridine + dithionite, respectively (refs. 1,4c). The direct observations at increasing suffocation, furthermore, clearly show the simultaneous disappearance of free peroxidase and formation of the '*dh*'-complex.

The problem of the nature of the peroxidase acceptor is a difficult one, because the enzyme is apparently able to combine with a variety of substances, which are known to occur in the root tissue, and which may serve as hypothetical acceptors, such as flavone derivatives, ascorbic acid, C_4-acids, and so on. The following observations may be mentioned here.

The aerated roots frequently show a pronounced elevation, or broad band, between about 530 and about 570 mμ, which may only partly be explained from a combination of 60–85 per cent oxidized and 40–15 per cent reduced bands of the cytochromes *c*, c_1, and *b* (cf. ref. 11). This elevation or broad band slowly disappears on prolonged washing of the roots. It was shown several years ago that cut roots exude pigments with a spectrum very similar to that of certain flavone derivatives[12]. The effect of removing the exudate from the roots is spectral changes of *dh*.

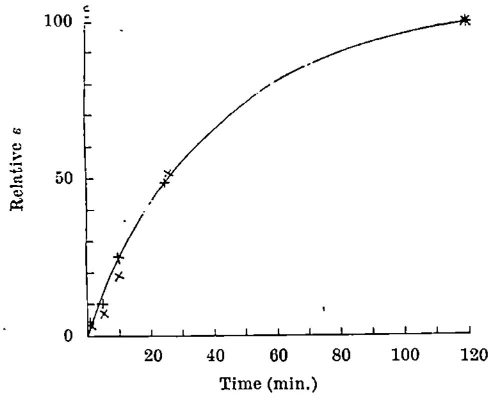

Fig. 2. Curve showing the synchronous disappearance of peroxidase (+—+), measured as the difference ε (580–520 mμ), and the appearance of the peroxidase-*dh* complex (×—×), measured as the height of the band at 571 mμ. The experimental conditions correspond to those in Fig. 1

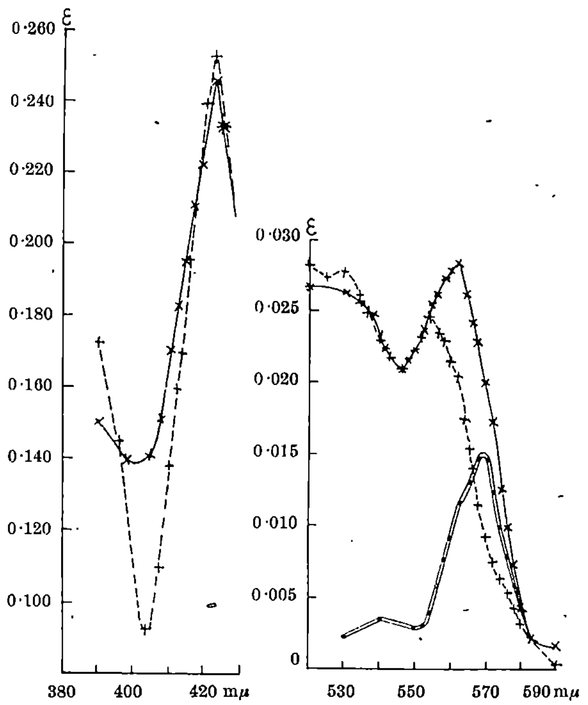

Fig. 3. Links: difference spectrograms of a bundle of roots 18 mm. thick, enclosed in a 6-ml. quartz tube, provided with inlet and outlet. ×—×, ε (non-streaming oxygen-free water) minus ε (aerated streaming water); +—+, ε (non-streaming oxygen-free water) minus ε (streaming oxygen-free water). Peroxidase 404 mμ reappears in the streaming oxygen-free medium, whereas the reduced band of cytochromes $c + c_1$ at 420 mμ remains unmoved. To the right: direct spectrum (cf. Fig. 1) of roots in non-streaming oxygen-free water (×—×) and in streaming oxygen-free water +—+. The difference between them (=) shows the spectrum of the peroxidase-*dh* complex (see the text)

The '*dh*'-complex appears only in non-streaming oxygen-free media. If the oxygen-free medium starts streaming, '*dh*' disappears. An excellent spectrum of '*dh*' can thus be computed as the difference between non-streaming and streaming oxygen-free water (Fig. 3). The cytochromes hereby remain reduced. The possibility cannot be excluded, however, that the streaming solution supplies minute quantities of oxygen sufficient for oxidation of '*dh*'. If roots are homogenized the pigments are recovered in the last supernatant. This has a yellow or light brown colour which deepens on prolonged exposure to oxygen. Dithionite decolourizes the red-brown fraction of the pigments, leaving bright yellow pigments, probably flavone derivatives together with certain quantities of carotene. The reddish pigments are precipitated from the supernatant by 50 per cent ammonium sulphate. Which of these pigments act as peroxidase acceptor cannot yet be decided.

That the acceptor substance is present in the supernatant from centrifugation of homogenized roots is shown by the fact that the combination of an oxygen-free peroxidase preparation with the oxygen-free supernatant shows spectral bands similar to those of '*dh*'. These bands disappear on reoxidation. Bands also appear in the absence of oxygen if a preparation of wheat peroxidase is combined with indole-3-acetic acid + ascorbic acid (bands at 390–400 and 560 mμ) or catechol (bands at 420, 543, and

568 mμ). An interesting effect, which was touched upon in a previous communication[9c], is exerted by fumarate (*p*H 3·6). The bands of '*dh*' are 50–100 per cent stronger in the presence of fumarate. Theoretically fumarate could act as a peroxidase acceptor. Because the development of '*dh*' is positively promoted by adenosine triphosphate[3c] there is a possibility, however, that fumarate acts indirectly by 'internal oxidation' of cytochrome-*b* (cf. refs. 4,*b* and *c*). The '*dh*'-complex acts in the opposite direction from cytochrome-*b* : it is reduced in fumarate and disappears in urethane and partly in succinate, too, whereas cytochrome-*b* is oxidized in the presence of fumarate and reduced in the presence of urethane. This fact may possibly indicate a relation between the peroxidase complex and the cytochrome system ; but the situation is more complicated than that because the formation of the '*dh*'-complex is obviously exposed to competitive exchange reactions. Urethane may thus be presumed to shield the acceptor from the peroxidase enzyme. Similarly cyanide rapidly removes the '*dh*' acceptor and forms peroxidase–CN^-. This is the reason why '*dh*' disappears in the presence of cyanide both aerobically and anaerobically without leaving visible CN-bands other than those of peroxidase–CN^-. Fluoride acts in a similar way, but considerably more slowly, because the reaction between peroxidase and fluoride proceeds fairly slowly[1,2].

More experimental work is needed for elucidation of the mechanism which controls the activity of peroxidase in wheat roots. No direct observations support the idea that hydrogen peroxide co-operates as an oxidant. The relative velocity[9c] of reoxidation of the hæmin enzymes in the roots is $dh > b > c > a + a_3$ and the velocity of reduction is the reverse (cf. ref. 11). The '*dh*' complex is thus operating in a manner which is in full agreement with the assumption that the oxidation of '*dh*' is mediated by the cytochrome system. On the other hand, the fact that '*dh*', formed *in vitro* from a peroxidase preparation and a mixture of root pigments (see above), is reoxidized in the absence of cytochromes points to a certain autoxidation. Because peroxidase is extremely sensitive to cyanide[1,4] the '*dh*' complex cannot co-operate in the 'basal respiration', in which cytochrome *b* is probably acting as an auxiliary oxidase[4b]. From a kinetical point of view peroxidase is probably a slow-acting oxidant. The first step of its activity is obviously the formation of the acceptor complex '*dh*'. This formation, however, proceeds fairly slowly and thus controls the process. The second step, the oxidation of '*dh*' and the liberation of peroxidase, proceeds rapidly. As a consequence very little is seen of the peroxidase–'*dh*' complex in aerated roots. According to the scheme outlined here the formation of a peroxidase complex is an intermediate step in the oxidation of the acceptor and not a complex enzyme, as claimed by others[7,8]. This question needs further elucidation, however.

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SPECTROPHOTOMETRIC, LIGHT SCATTERING, AND TITRATION STUDIES UPON THE INTERACTION OF POLYADENYLIC AND POLYURIDYLIC ACIDS

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IN a previous paper we reported the presence in polyadenylic acid of a hydrogen ion binding group with a *pK* in the vicinity of *p*H 6·0, which we identified as the 6-amino group of adenine[1]. In the present communication we include some of our preliminary findings as to the role of this group in the interaction between polyadenylic acid and polyuridylic acid described by Warner[2] and by Felsenfeld *et al.*[3].

Polyadenylic and polyuridylic acids were prepared as described previously, with particular care being taken to remove all traces of protein[4]. Two different preparations of polyadenylic acid of molecular weights $5·7 \times 10^5$ and $1·5 \times 10^6$ and two different preparations of polyuridylic acid of molecular weights $5·3 \times 10^5$ and $2·1 \times 10^6$ were employed.

The reaction between the two polymers was followed spectrophotometrically by observing the drop in optical density at $\lambda = 259$ mμ over the mean optical density for the non-associated species. At *p*H 7 in 0·1 *M* potassium chloride and 0·05 *M* phosphate the optical density decreases linearly with mole fraction of uridylic acid, reaching a minimum at an adenylic : uridylic mole ratio of 2 : 1, and thenceforth increases linearly, the maximum drop in optical density being about 40 per cent.

Table 1. LIGHT-SCATTERING RESULTS FOR POLYADENYLIC ACID–POLYURIDYLIC ACID (POLY A–POLY U) INTERACTION IN 0·5 M POTASSIUM CHLORIDE*

Solution	Concentration	Treatment	M_W† × 10^{-6}	$< r_g^2 >^{1/2}$‡	Time
Poly A IX*m*	0·120		0·568	258 A.	
Poly U I*e*	0·158		0·580	472	
Poly U II*a*	0·103		2·13	648	
Poly A IX′*p*	0·095	2 per cent HCHO for 48 hr. at 25° C.	0·866	299	
A IX*m*–U I*e*	C_A = 0·060 C_U = 0·079	Equal volumes of A IX*m* and U I*e* mixed (t = 0)	3·49	709	200 sec.
			3·57	1020	3,000 sec.
	C_A = 0·048 C_U = 0·095	To above was added additional U I*e* at t = 4,200	6·93	1330	300 sec.
			6·47	1710	24 hr.
	C_A = 0·048 C_U = 0·095	pH of above adjusted to 10·3	0·763	660	200 sec.
	C_A = 0·048 C_U = 0·095	pH readjusted to 8·0	2·77	930	2,000 sec.
1 IX′*p*–U II*a*	C_A = 0·057 C_U = 0·044	A IX′*p* and U II*a* mixed	1·28		1,800 sec.

* The pH is 7·6 unless otherwise specified.
† Weight average molecular weight.
‡ Radius of gyration.

Light-scattering has been employed to follow the interaction between polyadenylic acid and polyuridylic acid at neutral pH. In 0·5 M potassium chloride at pH 7 the change in optical density reaches completion within the period of mixing. The molecular weight also reaches a value close to its final one very rapidly. However, a slow change in molecular configuration without an important further change in molecular weight appears to proceed for a much longer period, as Table 1 shows. This corresponds to an increase in radius of gyration, and probably reflects a rearrangement of the initial imperfect configuration to form a more regular doubly or triply stranded structure, in which 'loops', etc., have been eliminated.

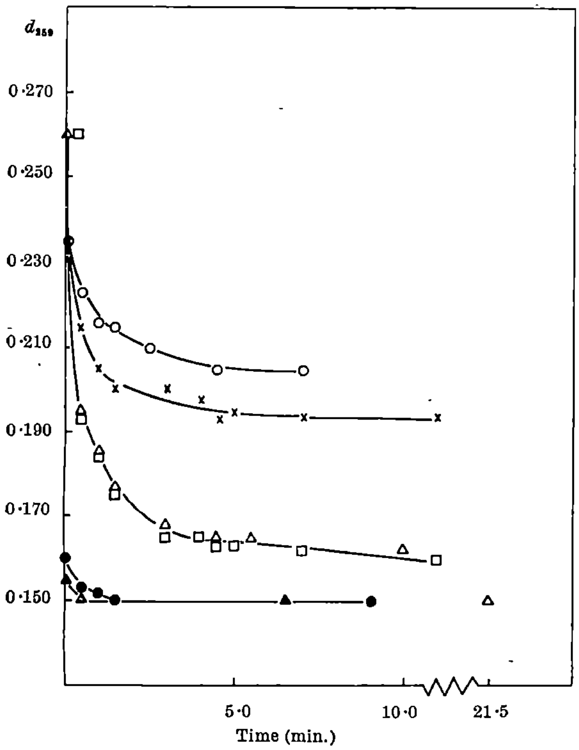

Fig. 1. Fall in optical density at λ = 259 mμ with time for polyadenylic acid IX (molecular weight 5·7 × 10^5) and polyuridylic acid I (molecular weight 5·3 × 10^5) in an adenylic : uridylic mole ratio of 1 : 2 at several pH's. All measurements are in 0·03 M NaOAc.
△, pH 6·5; □, pH 6·1; ×, pH 5·8; ○, pH 5·65; ▲, pH 6·5; 0·002 M Mg⁺⁺; ●, pH 5·65, 0·002 M Mg⁺⁺

The rate of reaction, as followed spectrophotometrically, falls off very rapidly in the region of titration of the 6-amino group of adenine in polyadenylic acid, as Fig. 1 shows. This effect is suppressed by addition of magnesium ions, which likewise suppresses titration of this group in the pH region 5–6[1].

Direct evidence for the involvement of the 6-amino group of adenine has been obtained by treating polyadenylic acid with formaldehyde under the conditions described in the previous paper[1]. In the present instance the 6-amino group is selectively blocked. Polyadenylic acid thus treated gave no evidence of any interaction with polyuridylic acid, both the extinction coefficient at λ = 259 mμ and the weight average molecular weight of equimolar mixtures of the two corresponding closely to the mean values for the two components, as Tables 1 and 2 show.

Table 2. SPECTROPHOTOMETRIC RESULTS FOR MIXING OF POLYURIDYLIC ACID AND FORMALDEHYDE-TREATED POLYADENYLIC ACID*

Solution	Treatment	λ	Optical density
Poly A IX′*q*	2 per cent HCHO for 48 hr. at 25° C.		0·424
Poly A IX*r*	Native poly A	259	0·379
Poly U II*c*	Native poly U	259	0·381
A IX*r*–U II*c*	Equal vols. mixed	259	0·273
A IX′*q*–U II*c*	Equal vols. mixed	259	0·408

* In 0·1 M potassium chloride, 0·001 M NaOAc, pH 7·0.

Further evidence for the involvement of the adenine 6-amino group has been obtained from titration and spectrophotometric data for the complex. The addition of increasing amounts of polyuridylic acid results in a suppression of H+ binding by polyadenylic acid in the pH region 5–6 and a displacement of the region of maximum binding to lower pH's (Fig. 2). This effect reaches its limiting extent at a mole ratio of uridylic : adenylic of 2 : 1.

The extinction coefficient of equimolar mixtures of the two acids is, in contrast to that of polyadenylic acid alone, constant between pH's 5 and 9 in 0·1 M potassium chloride. Below pH 5 a rapid rise in extinction coefficient with decreasing pH occurs, approaching as a limit the mean for the non-associated mixture, as Fig. 2 shows.

We interpret the above results as indicating a lowering of the effective pK of the adenine amino-group as a result of its involvement in an intermolecular linkage with uridine. Binding of a hydrogen ion appears to be accompanied by a dissociation of the complex.

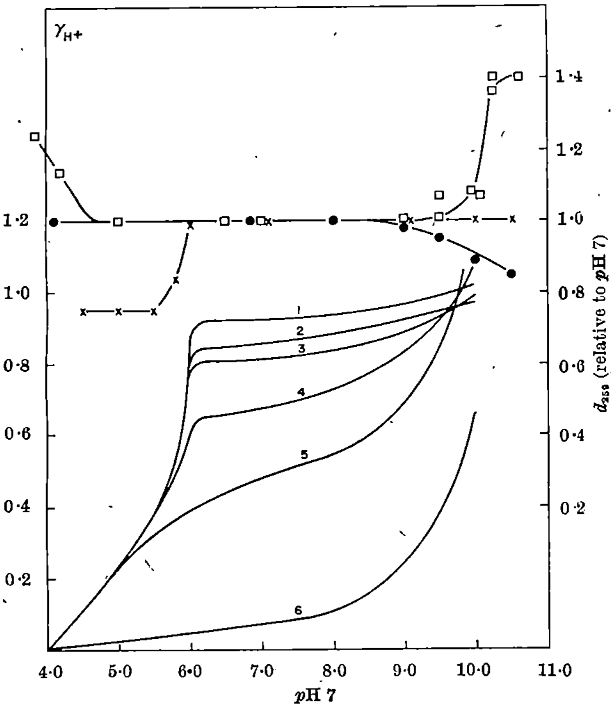

Fig. 2. Spectrophotometric and titration data for polyadenylic acid (molecular weight $1·5 \times 10^5$) and polyuridylic acid (molecular weight $2·1 \times 10^6$) in 0·1 *M* potassium chloride, and 23° C. In all cases the components were mixed at *p*H 7·5 and allowed to stand for 1 hr. before altering the *p*H. The left ordinate is the number of protons released per monomer unit. The right ordinate is the ratio of optical density at the given *p*H to that at *p*H 7.

×, Relative optical density for polyadenylic acid alone; ○, relative optical density for polyuridylic acid alone; ●, relative optical density for 1 : 1 mole ratio of adenylic : uridylic.

Curve 1, titration data for polyadenylic acid alone; Curve 2, uridylic : adenylic = 0·33; Curve 3, uridylic : adenylic = 0·56; Curve 4, uridylic : adenylic = 1·11; Curve 5, uridylic : adenylic = 2·38; Curve 6, polyuridylic acid alone

Polyuridylic acid, like its monomer, possesses a *pK* in the vicinity of *p*H 9·5. Dissociation of a hydrogen ion is accompanied by a decrease in extinction coefficient at λ = 259 mμ (Fig. 2). The equimolar complex with polyadenylic acid shows a sharp rise in extinction coefficient beginning at about *p*H 10. At higher *p*H's the extinction approaches the mean for the two components. The change is reversible if reneutralization is carried out within five minutes. Thus, loss of a hydrogen ion from the pyrimidine base of uridine appears to result in dissociation of the complex.

A direct confirmation of the latter conclusion has been obtained by light scattering (Table 1). Upon adjusting the *p*H of a solution of the complex from neutrality to 10·3, a very pronounced drop in molecular weight occurs. Upon reneutralization after a short interval at *p*H 10·3, most of the drop in molecular weight was recovered.

It appears probable that either the 6- or the 2-carbonyl group, or both, of uracil can exist in an enol form, and loses a proton in the vicinity of *p*H 10. As the source of the latter is the 1-nitrogen, the capacity of this group to serve as a proton donor for a hydrogen bond, as postulated by Felsenfeld *et al.*[3], would thereby be eliminated.

It is desirable to point out that the preceding results refer explicitly to polyadenylic acid and polyuridylic acid of quite high degrees of polymerization. Further work will be necessary to ascertain the lower limits of molecular weights for which the preceding observations are applicable. For these preparations in any event the linear variation of ε_{259} with adenylic : uridylic mole ratio would appear to make any abrupt transition from a doubly to a triply stranded structure unlikely. It appears to be entirely possible that it is the triply stranded structure which is formed at all adenylic : uridylic ratios under these conditions.

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INDUCED POLYPLOIDY IN EGYPTIAN AND INDIAN CLOVERS

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EGYPTIAN clover or berseem (*Trifolium alexandrinum* L.) and Indian clover or senji (*Melilotus indica* All.) are the important fodder plants of north India under irrigated and rain-fed conditions respectively. Both are cross-pollinated and have the somatic chromosome number 16. Four different strains of berseem and two of senji were treated with colchicine in 1954 and plants with $2n = 32$ were thus obtained. The techniques which gave the highest percentage of tetraploids in berseem and senji were the immersion of shoots of one-week-old seedlings in 0·1 per cent colchicine for 8 hr. and the immersion of whole seedlings of a similar age in 0·05 per cent colchicine for 4–8 hr. respectively. The treatments were carried out at room temperature (75–80° F.). The tetraploid plants showed all the characteristic features usually associated with chromosome doubling such as increase in size of cells, stomata, pollen and seed, and reduction in pollen and seed fertility. Seeds were collected from the tetraploid plants in April 1955, and two subsequent generations were raised during the winter seasons of 1955 and 1956. The following is a summary of the observations made in them.

Berseem. The tetraploids were consistently superior to the diploids in growth and yield (Fig. 1). In randomized row trials, the tetraploids gave 2–3 times more yield of green fodder per cutting than the corresponding diploids. The average percentage dry matter content in the fodder was 25·71 in the diploids

Table 1. CELL SIZE IN DIPLOIDS AND TETRAPLOIDS OF BERSEEM AND SENJI

Species	Somatic chromosome No.	Average size of epidermal cells in microns from					
		Stem		Petioles		Leaves	
		Length	Width	Length	Width	Length	Width
T. alexandrinum	16	19·33	13·45	17·94	13·11	29·98	19·32
	32	26·91	17·60	30·02	19·32	43·47	24·84
M. indica	16	25·19	16·91	25·88	23·12	46·23	21·39
	32	34·16	20·01	37·26	29·88	56·93	31·05

and 17·57 in the tetraploids. There was, however, a wide variation among the tetraploids in dry matter content and several tetraploid plants with 25–27 per cent dry matter also occurred. Nodule and root development was found to be better in the tetraploids. Chemical analysis showed that the diploids and tetraploids did not differ in the content of nitrogen and phosphorus per unit weight of fodder. Lime content was, on the other hand, much higher in the tetraploids, the average value being 3·06 per cent as against 1·54 per cent in the diploid. The study of meiosis in microsporocytes showed that a maximum of 6 quadrivalents per cell occurred at diakinesis and metaphase I in tetraploids, the mean frequency being 2·8 per cell. At metaphase II, ·39 per cent of the gametes had unbalanced chromosome numbers. Seed setting as measured by the number of seeds per inflorescence was 17·8–55·7 per cent of that found in the diploids. The tetraploids had, however, nearly twice as many inflorescences per plant as the diploids; thus, some tetraploid plants produced more seeds per plant than the diploids. Among the seeds obtained from tetraploid inflorescences some were small in size. These were also very hard and did not germinate when sown either in Petri dishes or in the soil. Chromosome numbers were determined in 421 C_2 and 1120 C_3 plants in oxyquinoline-orcein root tip squashes[1]. The number was found to be 32 in most and 24 in a few. In controlled pollinations, it was found that tetraploids and diploids were cross-compatible and this would account for the occurrence of triploids. Since all tetraploid plants had $2n = 32$, there obviously exists some mechanism for the elimination of aneuploid gametes and zygotes. It is possible that the small, inviable seeds found in tetraploids have aneuploid embryos.

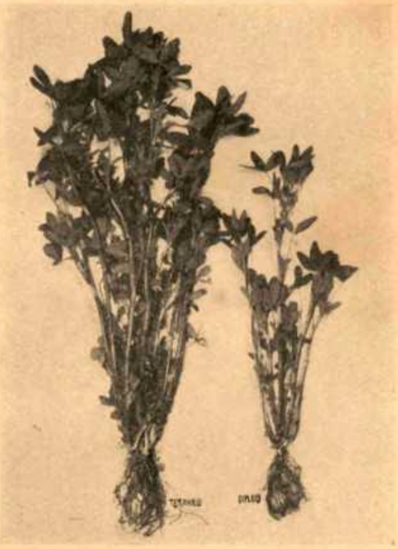

Fig. 1. Eight weeks old seedlings of diploid and tetraploid berseem

Senji. The tetraploid plants were compact and uniformly slow in growth. The yield of fodder was low owing to poor tillering and vigour. The tetraploids were further found to be preferentially disposed to the attack of aphids and downy mildew. There was a mean quadrivalent frequency of 3 per cell at diakinesis, and seed-setting ranged from 25·2 to 45·5 per cent of that found in diploids. The tetraploids and diploids were found to be capable of crossing with each other.

From the results so far obtained, the outlook for evolving tetraploid strains of berseem, superior in yield to the existing diploid varieties, is hopeful. The improvement of seed fertility and the selection of cultures with a good fodder yield as well as a high percentage dry-matter content would be the chief problems requiring attention in future generations. In red clover (*Trifolium pratense*), Julen[2] has stated that no tetraploid strain has yet been released to the market in spite of the pronounced superiority of the tetraploids over diploids in vegetative growth, because of the low seed-setting ability of the tetraploid. In berseem the tetraploids fortunately show an increase in the number of inflorescences per plant and also a low coefficient of realization of multivalents. The ability to cross with each other would, however, necessitate the growing of diploid and tetraploid strains in isolation.

Berseem being an important fodder crop in many sub-tropical regions, the results of the present study may be of interest to several individuals and institutions and we would be glad to supply small quantities of tetraploid seeds to interested workers.

The reasons for the differential growth pattern observed in tetraploids of berseem and senji are not clear. Among the many factors known to condition individual crop response to chromosome doubling, berseem and senji differ prominently only in cell size (Table 1). From the results in Table 1, it is clear that diploid senji has nearly the same cell size as tetraploid berseem. An examination of the available strains of senji for cell size did not reveal any significant intra-specific variability with reference to this character. These results would, thus, support Schwanitz's[3] view that once a species has attained an optimum cell volume, any increase in it would only lead to a depression in growth.

We are grateful to Dr. B. P. Pal for his interest and encouragement and to Dr. N. B. Das for carrying out the chemical analysis.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Effective Magnetic Meridian for Cosmic Rays

RECENT latitude surveys of cosmic-ray intensity made with neutron intensity monitors appear to confirm an earlier suspicion that the dipole approximation to the Earth's magnetic field fails to account accurately for the observed distribution of cosmic rays over the Earth's surface[1-3]. This has been revealed as a result of the much greater latitude variation observed with these instruments compared with charged-particle detectors. The Lemaître–Vallarta theory of the geomagnetic effect predicts a minimum in the cosmic-ray intensity coincident with the geomagnetic equator. Simpson *et al.*[2] have collected the available observations of the equatorial minimum and conclude that the 'cosmic ray equator' fits more accurately the equator of a dipole rotated about the Earth's axis 40°–45° to the west of the 'best fit' dipole. Rothwell and Quenby[3], on the other hand, find the magnetic dip equator fits adequately, and suggest that the Earth's real field rather than the dipole approximation accounts for the observed distribution.

New evidence can be obtained from a determination of the 'cosmic-ray meridian' or line on the Earth's surface along which the rate of change of cosmic-ray intensity is greatest. Depending on which theory proves most acceptable, this might be expected to coincide with the geomagnetic meridian, the meridian of Simpson's rotated dipole, or with the magnetic declination. A determination of the cosmic-ray meridian through Melbourne has been carried out at the University of Tasmania using a monitor counting the disintegration-product neutrons from the local production of stars in lead. The monitor uses two counters and follows closely the design proposed by Simpson. It was installed in a Lincoln bomber provided for the work by the Royal Australian Air Force.

The cosmic-ray meridian was determined by flying the aircraft in a triangular circuit with a vertex at Melbourne (lat. 38° S., long. 145° E., geomagnetic lat. 47° S.) and the base to the north. The aircraft flew at a pressure altitude of 20,000 ft. and completed the circuit twice on June 4, 1957.

If θ is the bearing of the cosmic-ray meridian and r the rate of change of intensity along the meridian then θ and r are related to θ_1 and r_1, the bearing of the first leg of the flight and rate of change along the leg respectively, by the equation: $r_1 = r\cos(\theta - \theta_1)$.

From the six legs, six independent equations in the two unknowns r and θ were obtained. The method of least squares gave the following best values for r and θ: $r = 2{\cdot}4 \pm 0{\cdot}2$ per cent deg.$^{-1}$ latitude; $\theta = 10° \pm 4°$, east of north. The errors are standard errors.

This value of θ can be compared with the following magnetic data for Melbourne: magnetic declination, 10° east of north; geomagnetic meridian, 9·5° east of north; meridian of dipole rotated 45° to west, 14·5° east of north.

It is clearly not possible to choose between the magnetic declination and the geomagnetic meridian; but the experiment suggests the rotated dipole theory may be wrong. It is unfortunate that nowhere in Australia does the difference between the declination and the geomagnetic meridian exceed 2°, and it will be necessary to repeat the experiment elsewhere in order to distinguish between the rival theories. In order to obtain a sufficient rate of change of intensity with latitude, observations should be made between geomagnetic latitudes 30° and 50° north or south. Within these bands suitable localities can be found in the northern hemisphere over the Mediterranean, while Cape Town seems promising in the southern hemisphere. Even more suitable, but rather inaccessible, is the region to the west of the south tip of South America, represented by the point (90° W., 50° S.) in Table 1, which compares the merits of selected localities.

Table 1

	Magnetic declination	Geomagnetic declination	Rotated geomagnetic dipole declination
Melbourne	+ 10°	+ 9·5°	+ 14·5°
Rome	− 2·5	− 16	− 14·5
Istanbul	+ 2	− 15	− 8·5
Cape Town	− 24	− 14	− 12
90° W., 50° S.	+ 24·5	+ 5·5	− 6

Declinations to the east of north are positive.

The experiment described here seems capable of providing new evidence on the influence of the Earth's magnetic field on cosmic rays, and although it cannot be fruitfully pursued in Australia there is every reason to expect valuable results if it is performed in more suitable localities.

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Single-Hop Propagation of Radio Waves to a Distance of 5,300 km.

IT has been established that radio waves can be propagated between Ottawa in Canada and Slough in England by a single ionospheric reflexion. The one-hop mode of propagation is seen on the accompanying ionogram (Fig. 1) at frequencies between 27 and 33 Mc./s. This ionogram was recorded at 1800 G.M.T., September 11, 1957. The low-angle part of the one-hop mode is intercepted by the Earth. The high-angle portion is associated with reflexion at apparent heights of 600 to more than 900 km. The other traces correspond to two- and three-hop propagation.

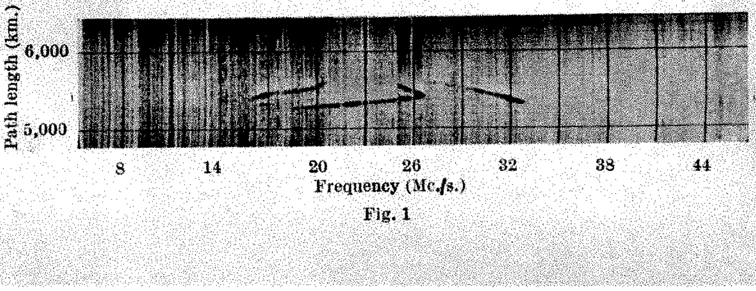

Fig. 1

The identity of the second- and third-hop modes was established by computing the vertical incidence *h'f* curves from the oblique incidence record, a process which involves making a tentative identification of the modes of propagation indicated by the oblique record. If these identifications are correct, the vertical incidence *h'f* curves from the different traces will be congruent; otherwise not.

The possibilities which remain for the mode between 27 and 33 Mc./s. are one-hop, *M*- and *N*-type propagation paths. The *M*- and *N*-type paths involve a reflexion from the *E* layer. Because of the curvature of the Earth, the greatest angle of incidence a radio wave can make with the *E* layer is 81 degrees. The maximum critical frequency for the *E* layer at these latitudes on September 11 was 4·0 Mc./s. As a result, the maximum frequency that could have been reflected from the *E* layer was 25·6 Mc./s. The possibility of the *M*- and *N*-type paths is therefore eliminated. Further, the vertical incidence curve computed from the one-hop is continuous with that from the second- and third-hop modes.

Although one-hop propagation over this distance was known to be a possibility, it was thought to be unlikely, and the greatest distance for one-hop propagation was set[1], for prediction purposes, at 4,000 km. Since the records obtained to date indicate that the one-hop mode occurs with the same reliability as the two- and three-hop modes at times between about 1200 and 2020 G.M.T., a revision of the prediction method for long circuits may have to be considered.

Because predictions at present are made on the assumption of at least two hops for these distances, the frequencies for which regular reflexion from the ionosphere occurs are considerably greater than those anticipated. The maximum usable frequencies run almost daily above 49 Mc./s. at the present time. The mutual interference problem can become serious for users of scatter and other very-high-frequency circuits on frequencies less than 50 Mc./s.

This investigation of propagation modes was made possible by the efforts of the other members of the Applied Propagation Section of the Defence Research Telecommunications Establishment, Canada.

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Nov. 25.

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[1] Circular 462, National Bureau of Standards, U.S. Dept. of Commerce.

Ionospheric Drift in the *F*2 Region near the Magnetic Equator

It has been suggested recently[1] that the drift of ionization in the *F*2 region of the ionosphere, known to exist from measurements made at middle latitudes[2], is caused directly by the electric field associated with the *S* system of currents in the 'dynamo' region of the atmosphere. The presence of these currents was originally invoked to explain the daily variations in the geomagnetic elements; recent ionospheric analysis[3,4] and direct experiments using rockets have shown that this dynamo region corresponds in height with the ionospheric *E* region. According to Martyn, magnetic lines of force linking the *E* and *F* regions represent directions of high electric conductivity and can be considered as equipotentials. Thus a horizontal north–south electric field in the *E* region can give rise to a vertical component of electric field in the *F*2 region which is greatest at the magnetic equator, where it may exceed by several times the horizontal *E* region field. If this field exists it must give rise to a horizontal drift of ionization in the *F* region in an east–west direction. Martyn[5] has proposed on theoretical grounds that, except in the immediate vicinity of the magnetic equator, the eastward drift velocity resulting from the diurnal potential in the dynamo region should be given approximately by

$$v = [27 \sin\theta(1 - 3\cos^2\theta)\cos\varphi]/H \text{ m./sec.}$$

where θ is the geomagnetic co-latitude of the point in the *F* region, φ is longitude measured positively eastward from the midnight meridian and H is the vertical geomagnetic field component. This equation predicts for high and middle latitudes a drift toward the east by day and to the west by night, which is in agreement with observations. At geomagnetic latitudes less than 35°, however, a phase reversal of this drift should take place, and near the magnetic equator the westward drift by day should reach large values of the order of 200 m./sec.

Results are now available from over a period of years to test these predictions. Drifts in the *F*2 region of the ionosphere have been measured in Singapore (geographic lat. 1·4° N., long. 103·7° E.), 10·0° south of the magnetic equator, over the period September 1953–August 1956. The method used was that originated by Mitra[6] using a pulse transmitter and three receiving aerials, the latter being spaced roughly a wave-length apart along two directions. Records of the variation of the three signal amplitudes in time were obtained on film moving across a display tube at a speed of 10 cm./min. These records were analysed by the method of identifying similarities in the fading patterns[7] and, providing that the fading was of a suitable irregular type, mean time displacements of the signals relative to one another were interpreted as revealing a constant drift of irregular patches of ionization in the *F* region, at or near the height of reflexion of the pulsed signal. A frequency in the range 5·5–6·5 Mc./s. was used according to conditions: records taken when a sporadic *E* echo was present on the same frequency are not included in the present analysis. Measurements were made mostly on three selected days each month over the three-year period, and during this time some 1,000 film records were obtained of average duration ten minutes each. Extreme difficulty was experienced in obtaining results during the midday period from about 10 to 14 hr. local mean time (105° E.) owing to inadequate transmitter power (300 watts peak) and to high absorption in the lower regions of the ionosphere. Of these records only 172 showed irregular fading of a suitable rate ranging from 5 to 25 maxima per minute: many were rejected for showing a very slow fading-rate, indicating uniform horizontal conditions in the ionosphere. The useful ones were reasonably well distributed throughout the year as shown in Table 1, but the number of results in each seasonal grouping itself is insufficient to permit a search for seasonal variations. Consequently the mean annual diurnal variation of drift was examined by grouping the results in hour intervals, centred upon each hour of local mean time. The resultant of each group of drift vectors was found by vector

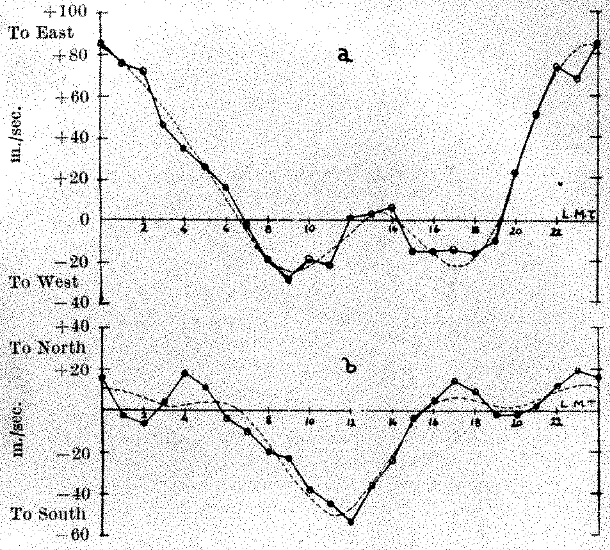

Fig. 1. Diurnal variation: (*a*) east–west drift; (*b*) north–south drift. —⊙—, Experimental results, 3-hr. smoothed values; – – – –, 3-term harmonic approximation (see text)

addition and the mean diurnal variations were plotted of the drift magnitude and direction, and of the east–west and north–south components, following the convention that drifts toward the east and the north are considered positive. The latter two curves were then smoothed by taking a 3-hr. running mean, the value at hour t being averaged with those at $t - 1$ and $t + 1$. This process removes short-period variations and makes the longer-period trends more obvious.

Table 1. Seasonal Distribution of Data

Winter solstice (Nov., Dec., Jan., Feb.)	44
Summer solstice (May, June, July, Aug.)	61
Equinoxes (Mar., Apr., Sept., Oct.)	67

The resulting diurnal variations of the easterly and the northerly components are shown in Fig. 1. The east–west component shows a predominant 24-hr. period, with drifts of up to about 90 m./sec. directed toward the east during the night-time period of 20–06 hr. (ground local mean time) and a smaller drift to the west during daylight hours and up to about an hour after ground sunset. A tendency for the westward drift to be reversed for a short period of 12–14 hr. is shown, although great reliance cannot be placed on this finding due to the shortage of data during this part of the day. Harmonic analysis of the data in terms of 24-, 12- and 8-hr. components yields the following representation:

$$v(E - W) = 18 + 45 \sin \frac{\pi}{12}(t + 5\cdot6) + 22 \sin \frac{\pi}{6}(t + 2\cdot5) + 10 \sin \frac{\pi}{4}(t + 4\cdot1) \text{ m./sec.}$$

with t in hours ($\varphi = 15t°$). The dominant periodicity is thus in phase with the dynamo S field within a few degrees.

The north–south component is much smaller at all times than its east–west counterpart and its daily trend is less well defined. The results for the part of the day containing the most reliable data, from about 14 hr. through midnight to 10 hr., shows no marked trend except for a tendency for northward drifts at night and southward ones by day, each of the order of only 20 m./sec. This is confirmed by the harmonic analysis of the results which yields:

$$v(N - S) = -7 + 23 \sin \frac{\pi}{12}(t + 6\cdot9) + 12 \sin \frac{\pi}{6}(t + 9\cdot9) + 8 \sin \frac{\pi}{4}(t + 2\cdot7) \text{ m./sec.}$$

The results strongly suggest that, subject to statistical uncertainties, the drift of ionization in the $F2$ region at Singapore is predominantly in an east–west direction with consistent easterly drifts during the night of up to about 90 m./sec. and less consistent westerly drifts during the day of up to about 30 m./sec. These movements are in clear phase opposition to those determined at higher latitudes[2] and provide a confirmation, at least in qualitative terms, of the predictions of Martyn[1] concerning the electromagnetic coupling between the E and F regions of the ionosphere.

Fuller details of this work will be published elsewhere. I am indebted to Mr. B. W. Osborne for some of the earlier observations and to Dr. Thong Saw Pak for assistance in maintaining a continuous period of observation.

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Aug. 22.

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A New Spectral Characteristic in Solar Radio Emission

The intense radio emissions from active areas on the Sun have been studied since 1942 on 'single' fixed frequencies; but the first 'spectral' or sweep frequency observations were not initiated until 1949, when Wild and McCready[1] at Sydney commenced observations with equipment sweeping the band 70–130 Mc./s. These observations, which were later[2] extended to 40–240 Mc./s., marked a notable advance in solar radio techniques, and greatly simplified the classification of solar radio phenomena.

The purpose of this communication is to describe briefly a new sweep-frequency experiment, brought into operation at the beginning of September 1956 at the Harvard Radio Astronomy Station, and to discuss a new type of solar burst which has recently been observed.

The equipment covers the band 100–580 Mc./s. Its antenna comprises a 8·55 m. (28 ft.) diameter paraboloid, equatorially mounted, with three broad-band primary arrays coaxially mounted at its focus; the collecting area is 41 sq. m. at 100 Mc./s. and 45 sq. m. at 500 Mc./s. The primary arrays are individually connected to three sweep-frequency receivers covering the bands 100–180, 170–330 and 300–580 Mc./s. The receiver noise figures are respectively 6, 7 and 8 db., their bandwidths 0·3, 0·5 and 1·0 Mc./s., and each sweeps its respective octave band three times per second. The receiver outputs are displayed on three intensity-modulated cathode-ray tubes of high resolving power, and are photographed by a continuous-motion 35 mm. camera in which the film moves at approximately 12 mm. per min. Time marks are inserted on the film every minute, and the absolute timing is accurate to ±1 sec. The antenna tracks the Sun automatically, and the equipment records the solar emissions daily from sunrise to sunset[3].

The films record the intensity of the solar radio emissions as a function of frequency and time. It is possible to interpret the frequency co-ordinate in terms of height in the solar atmosphere, if the assumption is made that, for the band 100–580 Mc./s., the radio emission from the Sun at a given frequency originates near a level in the solar atmosphere where the plasma frequency corresponds to that of the emitting frequency. At the present maximum of the solar cycle the frequency band 100–580 Mc./s. is thus transformed to a height-range of approximately 500–50 thousand km. above the photosphere. However, it must be remarked that above an active area the exact heights which are to be assigned to given plasma frequencies are at present uncertain.

Analysis of the records so far obtained reveals the common phenomena of noise storms caused by localized disturbances in the solar corona above sunspot areas: the isolated fast bursts at present attributed to disturbances moving outward through the solar atmosphere with velocities of the order of 30,000 km./sec.; and slow bursts, at present attributed to disturbances moving with velocities of the order of 1,000 km./sec. The radio data recorded during the past twelve months at Fort Davis have been correlated with the occurrence of flares, sprays, and other optical phenomena on the solar disk as recorded at the Sacramento Peak Observatory. It has been found, for example, that the fast bursts, which were previously unassigned to any optical phenomena, are quite commonly associated in time with minor flares. Detailed results of this comparison will be published elsewhere[4].

Fig. 1 shows a remarkable new type of burst, which appears on the records in the form of an inverted U. The essential characteristics define it as a fast burst, and it is typical of 43 such bursts which were recorded during the first 12 months observations. This particular example covers a period of 8 seconds, its turning frequency is 130 Mc./s. and it shows a noticeable broadening on the return path. Of the remaining 42 U bursts, 32 had turning points between 100–150 Mc./s., 6 between 150–250 Mc./s., and 4 between 250–580 Mc./s. The duration of all the bursts was between 3 and 10 sec. Broadening on the return path is rare, and may be caused by dispersion in the velocity components of some fast travelling disturbance which gives rise to the bursts.

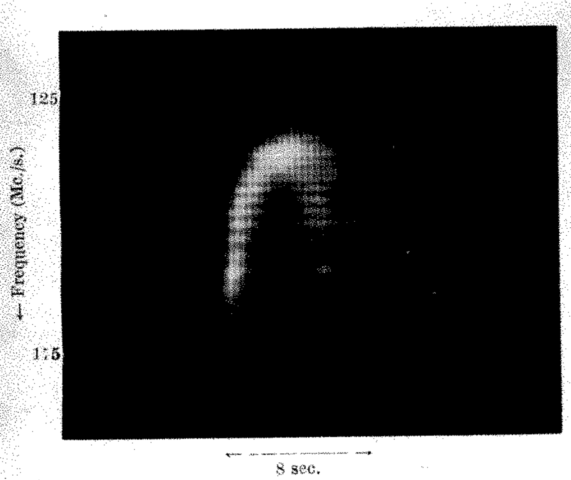

Fig. 1. Inverted U burst: November 29, 1956, 23h. 17m. U.T.

The occurrence of the U bursts has been correlated in time with flares on the solar disk. The radio observations covered 95 per cent of the possible observing time, with one photographic record taken every $\frac{1}{3}$ sec., whereas the optical observations covered approximately 50 per cent of the possible observing time, with photographic exposures in H_α light made on the average once every 2·5 min. Of the 28 U bursts that were recorded during periods of optical observations, 19 coincided with class 1 and 1 − flares, 2 with class 2 flares, and 1 with a class 3 + flare; in 75 per cent of these cases the U bursts occurred not more than 5 min. after the commencement of the flare and within 3 min. of its maximum phase. Six of the bursts had no apparent optical counterparts.

In considering the origin of the fast U bursts it is useful first to examine the possible mechanisms which may give rise to the ordinary fast bursts. Wild, Roberts and Murray[5] have attributed the latter to the motion of a corpuscular stream outward through the corona at a velocity of 30–100 thousand km./sec. (0·1–0·3 c). They tentatively identified such streams with cosmic rays of solar origin, although the velocities are very low compared with those deduced by cosmic ray investigators. The U bursts, on this basis, would require the motion of the stream to be reversed, presumably by a magnetic field. A new theory recently suggested by M. Krook (private communication) considers the problem in terms of fast-travelling shock waves. This theory, which we now briefly outline, neither denies nor precludes the existence of fast-travelling corpuscular streams, although it may be noted that there is no direct experimental evidence confirming the existence of such streams. There is, indeed, as yet no direct evidence showing that the frequency drifts are definitely caused by travelling disturbances—that is, that the change in frequency is associated with a systematic change in position—but at present this is the most plausible interpretation.

The new theory assumes that the prime origin of radio bursts is some gross instability or explosion at a low level in the solar atmosphere near, but not in, an active area. Such areas have strong magnetic fields extending into the chromosphere and corona. The explosion gives rise to large-amplitude waves the actual mode of propagation of which through the solar plasma depends on the strength and configuration of the magnetic field. In considering the propagation of these waves in terms of non-linear theory, Krook shows that an initial transverse disturbance in the region of the magnetic field gives rise to large-amplitude waves propagated along the direction of the field. In this case electron plasma and certain 'transverse' shock waves are associated with large velocities of propagation. These disturbances are strongly coupled with the radio-frequency field because of the presence of the magnetic field, and this coupling gives rise to electromagnetic radiation which can escape, if it is above the plasma frequency. The fast radio bursts are thus associated with the propagation of the electron plasma or transverse shock waves. The U bursts are caused by these waves being guided around the magnetic field lines between regions of opposite polarity.

One would therefore predict that the U bursts should originate from activity in the region of bipolar sunspots. This prediction is confirmed by the observations, which show that 80 per cent of the U bursts were associated with flares, and of these flares 80 per cent occurred over bipolar areas. (This latter result, however, is not unexpected, as nearly 80 per cent of all flares occur over bipolar areas[6].)

This work forms part of a research programme which is supported by financial assistance from the Geophysics Research Directorate of the United States Air Force. We wish to thank Dr. M. Krook for permission to refer to his unpublished work and for many valuable discussions, and Prof. D. H. Menzel for his interest in the experiments. One of us (A. Maxwell) gratefully acknowledges the award of a Fulbright travel scholarship.

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G. Swarup

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Nov. 22.

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Electron Emission from Silicon *p–n* Junctions

It is well known that silicon *p–n* junctions emit infra-red radiation when operated in the forward direction[1] and visible light in the breakdown region of the blocking direction[2,3]. The experimental study of non-thermionic electron emission from solids showed that there is often a correlation between the electron emission and the luminescence, as was stressed particularly in the work by Bohun[4,5]. The question now arises whether the electroluminescence in *p–n* junctions is accompanied by emission of electrons.

The experiments were carried out with grown silicon *p–n* junctions of about 0·2 cm. × 0·2 cm. cross-section cut from a single crystal and etched in a hot mixture of concentrated nitric acid (1 part) and hydrofluoric acid (2 parts). The junctions had a breakdown voltage of about 100. The point of a Geiger counter, operated at normal air pressure (as described in refs. 4, 6), was placed at a distance of 2–7 mm. from the junction; the voltage was about 2,000. With the current flowing in the forward direction we failed to observe any electron emission. This is not surprising, as it is scarcely possible to imagine how the electrons could gain an energy of several electron volts necessary for them to escape from the crystal. However, in the breakdown region of the blocking direction, we did observe emission of electrons. It was accompanied by the usual emission of light. First, it was necessary to ascertain whether the electron emission observed was not caused by the ionizing action of the light emitted from the junction. That this is not the case was shown by covering the emitting junction with a thin sheet of lithium fluoride transparent to visible and ultra-violet light, which immediately stopped the emission. Further, it was verified that the electron emission is not caused by the rise in temperature of the junction when electric current is flowing, but is connected with the current flow itself. Finally, it is considered improbable that the effect is caused by an external gas discharge across the junction, as the voltage was below the sparking potential of air[7].

In the exploratory experiments reported here, no simple relation was found between the intensity of the light emitted and the number of electrons emitted per unit time. The electron emission seems to arise from the spots situated on the surface which emit white light. When only red spots are observed, emission of electrons is either small or is not detectable. However, when the junction breakdown was made 'soft' by slightly working the surface, bright white spots appeared at a low voltage (cf. ref. 2), which were often poor electron-emitters. Maximum emission was observed on freshly etched junctions with 'hard' characteristics operated in the avalanche breakdown region, when the whole junction appeared as an almost continuous bright white line.

In the blocking direction, the electrons in the conduction band can gain considerable excess kinetic energy from the electric field. From the point of view of energies involved, it is plausible that some electrons can leave the crystal if one compares the depth of the conduction band as determined by Esaki[8] (3·47 eV.) with the light emission spectrum from silicon *p–n* junctions, which, according to Chynoweth and McKay[3], extends over photon energies greater than 3·2 eV.

I thank Z. Trousil for preparation of the silicon *p–n* junctions, A. Bohun for his generous help with advice and measuring set and A. Abrahám for his help with the experimental work.

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Vacuum Breakdown in Dielectric-loaded Wave-guides

A slow wave structure suitable for an electron linear accelerator or a high-power travelling-wave tube can be obtained by loading a metal wave-guide with a dielectric, either in the form of a coaxial tube or a series of disks.

A low-loss dielectric must be used, and it is also advantageous for the dielectric constant to be high. To meet these and other requirements a most promising material is a titanium dioxide ceramic which has a loss tangent of about 0·0003 and a dielectric constant of about 90 at a frequency of 3,000 Mc./s. In principle it is possible to design structures[1,2] using this material which have a higher efficiency and better frequency characteristics than can be obtained by the conventional method of loading by means of metal disks.

Experimental work at Malvern[1] indicated that when operated at electric field strengths of the order

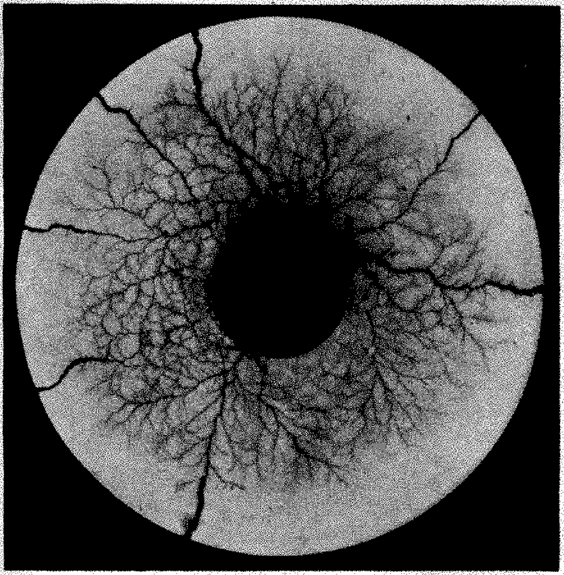

Fig. 1. The disk shown is 3 in. in diameter

of 10^4 V./cm., wave-guides loaded with dielectric disks tended suddenly to develop very high losses. This was thought to be due to a multipactor effect and appeared to occur more readily if vacuum-pump oil were present in the system.

Further experiments have been carried out at Queen Mary College using a resonant cavity 20 cm. long loaded with four dielectric disks arranged at half-wave intervals, power being fed to the cavity by a 2-MW. magnetron operating at a frequency of 3,000 Mc./s. The dielectric disks were of thickness 0·25 in., outer diameter 3 in. and each had a central hole $\frac{7}{8}$ in. in diameter. The cavity was excited in an *E*-mode, the electric field being most intense along the axis. The field was approximately normal to the plane surfaces of the disks, the maximum value of the radial component occurring inside each disk at its mid-plane.

At an axial electric field strength of less than 10^5 V./cm. and at a pressure of about 10^{-5} mm. mercury it is found that a breakdown is liable to occur. This is accompanied by a sudden increase in X-ray output from the cavity; by reducing the field strength the incidence of this breakdown is delayed, but even at an intensity of 10^4 V./cm. it is not entirely eliminated.

The disks sustain an entirely superficial damage, a reduction of the titanium dioxide to a lower, semiconducting oxide taking place. In some cases heavy black tracks containing copper deposits, indicating intense local heating, radiate from the copper wall, ending in a diffuse tree-like formation. Quite distinct from this, more diffuse tracks occur around the central hole, and whereas on some disks these two patterns merge (Fig. 1) on other disks they are found to occur separately. Similar discharge lines were also observed in the work at Malvern.

To avoid poor contact between disk and wall (which could give rise to intense local fields) tests were carried out with disks which had been silvered on their outer edge, but breakdown was not greatly affected.

In recent experiments the disks were coated with a layer of glaze, and a most remarkable breakdown strength resulted. The glaze is a well-known green resistor enamel consisting mainly of lead borate. It is sprayed on and then baked, giving a final thickness of a few thousandths of an inch. Tests carried out with the cavity loaded with such glazed disks gave no breakdown at an electric intensity of 3×10^5 V./cm., the limit attainable with the available power source. Further tests, using two glazed and two unglazed disks in the same cavity, showed no change in the glazed disks despite intense bombardment accompanying the breakdown of the unglazed pair. This field strength is higher than that used in any electron linear accelerator, to our knowledge.

The investigation was supported by a grant from the Atomic Energy Research Establishment.

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Absorption Spectra of Rare Earths in Glasses

ABSORPTION spectra of rare-earth ions have been increasingly studied over recent years because of their presentation of band and line absorption in the visible region. Much work has been carried out in both aqueous and non-aqueous solutions, with and without the presence of complexing ions, which demonstrates the influence of these complexing or hydrating ions upon the absorption spectrum and hence upon electron transitions involving the partially filled, lower-lying (4*f*) electron shell to which the band absorption is attributable[1]. Few studies have, however, been reported upon variations in absorption spectra of rare-earth compounds in glassy compositions.

Use of rare earths in optical filters has long been exploited, but the consensus of hitherto known results has indicated that the presence of anions or cations in the glassy state has relatively little effect upon the position, intensity, etc., of neodymium or praseodymium absorption bands in the visible region[2]. Wiedert[3] and Fedotieff and Lebedeff[4] examined the absorption spectra of silicate glasses containing neodymium and found the position and intensity of the main absorption band to be affected by alkali and divalent ions. The effect produced being to some degree dependent upon the ionic size of these ions, band-shifts were attributed partially to inhomogeneities produced in the glass, but Weyl[5] concluded that ionic size of these alkali and divalent ions could not be the only factor influencing the electronic perturbation or transition responsible for the absorption spectra.

In the process of fundamental research on the effect upon physical properties of the inclusion of rare earths in glasses, we have examined, on a preliminary basis, the absorption spectra of a phosphate glass containing varying concentrations of the rare earths. The glass was 'Corning 4600', containing: P_2O_5, 77·6; Fe_2O_3, 2·52; B_2O_3, 8·26; CaO, 5·07; Al_2O_3, 3·98; MgO, 0·91.

As shown in the accompanying spectrograph (Fig. 1), it is evident that, in the phosphate environment, both dissection and wave-length shift occur for the neodymium 576 and 522-mμ bands, absorption

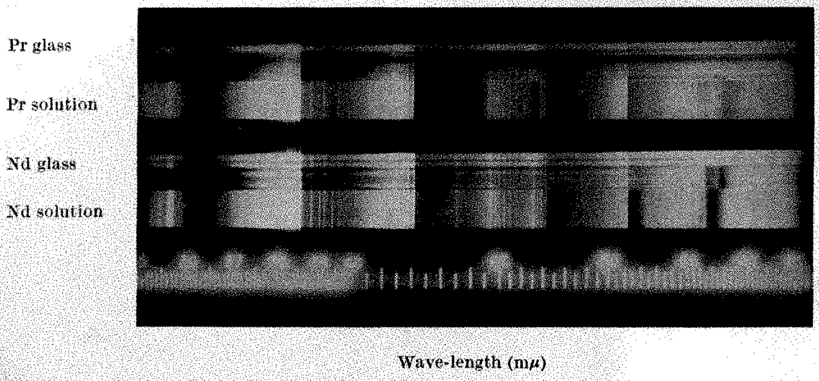

Fig. 1. Absorption spectra of Pr^{3+} and Nd^{3+} in phosphate glass

peaks being shifted to longer wave-lengths. The praseodymium 480-mμ band shifts to a lower wave-length and, while the 440-mμ complex also shows evidence of shift and dissection, both bands are decreased in intensity. Loci and density are compared in both instances with aqueous solutions of the same concentration of rare-earth ion. By analogy with known effects of complex formation upon lanthanon absorption spectra it may be considered, therefore, that in phosphate glasses evidence is obtained indicating the possible existence in this environment of complexed ions of the type $[Ln(PO^4)_x]^{y+}$. Primary comparative evidence correlating band-shift and dissection with thermodynamic stability of complexes suggests that the spectrophotographic data now obtained indicate appreciable difference in the stabilities of the phosphate complexes formed. Application of the simple de Broglie–Schrödinger equation to the wave-length shifts found show the praseodymium and neodymium complexes to differ by some $4 \cdot 55 \times 10^{-5}$ volts in thermodynamic stability, and it is significant that, where phosphate complexes have been employed in rare-earths separation, appreciable separation factors have been obtained[6].

The lanthanons are known to function as network modifiers in phosphate glasses[7], that is, the lanthanon ions are enclosed in PO_4 tetrahedra, but do not play any part in the development or breaking of oxygen bridges. Complex formation would suggest, therefore, the development of a structure such as is shown in Fig. 2.

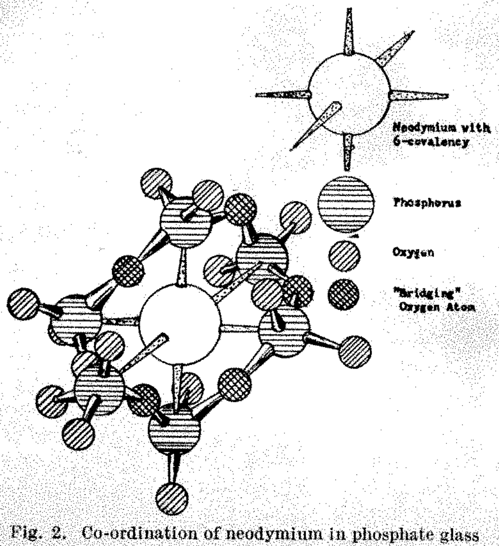

Fig. 2. Co-ordination of neodymium in phosphate glass

It is hoped to extend this preliminary evidence for complex formation in phosphate glasses to the wider field of rare-earth phosphate complexes generally, but any further observations cannot be expected to be available for some time. This communication is therefore presented for the immediate interest of workers in this and allied fields.

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Structure and Density of Glass

FROM the chemical composition and density of several hundred glasses[1] the volume v associated with an oxygen ion has been calculated in $A.^3$ or 10^{-24} cm.^{3} units. This volume amounts in simple glass-forming oxides, that is, SiO_2, B_2O_3, P_2O_5, to $21 \cdot 1$–$22 \cdot 7$ $A.^3$.

SiO_2–B_2O_3 mixed glasses show a linear relation between v and R, which is the number of oxygen ions per network-forming atom:

$$R = \frac{O}{Si + B + Al + \ldots} \tag{1}$$

where the chemical symbols stand for the gram atoms present in a given quantity of glass (for example, 100 gm.) of the respective elements. For SiO_2–B_2O_3-glasses the equation

$$v = 3 \cdot 8\,R + 15 \cdot 25 \tag{2}$$

holds with a maximal error of $0 \cdot 3$ per cent.

Sodium silicate glasses yield the equation

$$v = 3 \cdot 8\,R + 14 \cdot 9 \tag{3}$$

with R between $2 \cdot 051$ and $3 \cdot 053$ with a maximal error of $0 \cdot 65$ per cent.

For potassium silicate glasses

$$v = 12\,R - 1 \cdot 2 \tag{4}$$

(maximal error $0 \cdot 7$ per cent). Similar equations have been found for calcium silicate and strontium silicate glasses. The volume v in lead glasses can be approximated with three linear equations for different ranges of R.

If we introduce another network-forming oxide, for example, BeO, Al_2O_3, in sodium silicate glass, the equation (4) remains valid, only the additive constant being modified to a small extent; for sodium silicate glasses containing alumina

$$v = 3{\cdot}8\,R + 15{\cdot}1$$

and for those containing BeO

$$v = 3{\cdot}8\,R + 14{\cdot}6$$

The equation for sodium silicate glasses containing boron trioxide is somewhat more complicated.

Three-component glasses containing network-modifiers such as CaO, MgO, etc., are contracted by ions of smaller size and higher charge and this can be accounted for in a simple way. If we denote the number of moles present in 100 gm. of glass of a network-modifying oxide by Mg*, Ca*, etc., then the contraction brought about by them is proportional to Mg*, Ca*, etc. For soda–lime glasses

$$v = 3{\cdot}8\,R - 5\,\mathrm{Ca}^* + 14{\cdot}9$$

for soda–barium oxide glasses

$$v = 3{\cdot}8\,R - 0{\cdot}5\,\mathrm{Ba}^* + 14{\cdot}9$$

and so forth. If the glass contains also alumina, it must be considered when calculating R. The maximal error is 0·9 per cent.

The case of three-component glasses derived from potassium silicate is similar, only the coefficients of Ca*, etc., being different. For potash–lime glasses an equation derived from (4)

$$v = 12\,R - 12\,\mathrm{Ca}^* - 1{\cdot}1$$

holds with a maximal error of 1·1 per cent. Similar equations have been found for potassium glasses containing other network-modifying oxides.

Calculations for four-component glasses are being made with good results and it is proposed to extend them for five- and multi-component silicate, borate and other glasses.

This makes it possible to calculate the densities of glasses from the composition with an accuracy much greater than the equations proposed earlier allow. Standard errors of the above equations are of course much smaller than maximal errors.

It is evident that the volume of the non-periodic tetrahedral network in glasses is extended when R increases, because R is the measure of the bridging of tetrahedra; the greater R, the fewer corners of tetrahedra are bridged, that is, connected with other tetrahedra. Therefore with increasing R the network expands. Our results show that this expansion is linear, therefore each 'molecule' of Na_2O expands the SiO_2-network by the same amount, but the introduction of a K_2O causes a different amount of expansion. Network-modifying ions contract the network according to the size and charge; the factors are different for sodium glasses and potassium glasses:

Ion	Factor for sodium glasses	Factor for potassium glasses
Mg^{2+}	5	13
Ca^{2+}	5	12
Ba^{2+}	0·5	9
Zn^{2+}	2	—
Ti^{4+}	10	—
Zr^{4+}	10	—

A detailed account of this work is to appear in *Acta Physica*, Budapest.

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Large Sand Waves near the Edge of the Continental Shelf

Trains of large ridges, made mostly of sand and orientated normal to tidal streams, occur at many places in the shallow waters around Britain and in other parts of the world. The largest features of this form have recently been found by echo-sounding during cruises of R.R.S. *Discovery II* and R.V. *Sarsia* near the edge of the continental shelf, in depths of about 90 fathoms. It may be useful to describe the work carried out by the former ship on La Chapelle Bank in the neighbourhood of 47° 41′ N., 7° 13′ W.

The patch of sand waves, about 12 miles long, ended abruptly at the edge of the continental shelf (Fig. 1) while the eastern limit was rather ill-defined. The patch extended laterally for 5 miles, but was probably rather more extensive than this for the ridges were large at the limits of the region sounded.

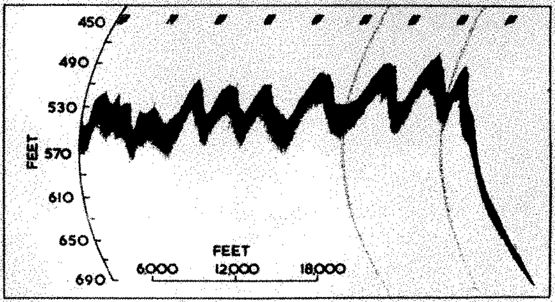

Fig. 1. Sand waves on La Chapelle Bank showing their abrupt termination at the edge of the continental shelf. Section is approximately normal to the crests. The slopes are distorted by the curvature and exaggeration of the depth scale

The crests have an average height of about 25 ft., 40 ft. being the maximum value observed. The mean separation of the crests was about 2,800 ft., although there was considerable variation. The survey consisted of seven lines arranged in a star-like pattern over the ridges. From the differences in the apparent separation of the crests, on sounding lines of different orientation, it was possible to derive the direction giving a true profile. The orientation of the crests was about 110° true, and so the ridges were parallel to the general line of the edge of the shelf.

A large sample taken from a ridge and from a trough, by conical dredge, showed that sand together with some shell gravel were the chief components (median diameter about 0·5 mm.).

These sand waves are of interest for a number of reasons. Their crests have a separation about three times greater than for similar ridges in shallower water. Their presence suggests that the tidal streams on La Chapelle Bank, even at 90 fathoms, are strong enough to transport sand and gravel along the floor. From a study of the slight asymmetry of the profiles of the ridges it was inferred that there must be a net westward transport of sediment. The abrupt western limit of the ridges at the edge of the shelf may mean that the material, once it reaches the top of the continental slope, is carried away (perhaps periodically) into deeper water.

We shall be pleased to hear of other places where such features occur, since we hope to make a more general study.

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Absorption Spectrum of the OBr Radical

USING the flash photolysis technique of Norrish and Porter[1,2] I have discovered a spectrum consisting of a series of roughly equidistant diffuse absorption bands which is attributed to the OBr radical. This spectrum was observed when mixtures of the vapours of bromo-substituted methanes and oxygen were irradiated by a flash discharge. Chloro-bromo-methane provided the most intense absorption bands, but they also appeared with the following compounds: CCl_3Br, CCl_2HBr, CBr_2H_2, CBr_4; the strongest bands were also weakly visible in mixtures of oxygen and ethyl bromide.

The intensity of the absorption decayed with a half-life of ½–1 msec., which falls into the range observed for radicals and metastable states. About fifteen diffuse absorption bands have been observed; the maxima, accurate to about 1 A., are given in Table 1.

Table 1

Wave-length (A.)	Frequency	Intensity	$\delta\nu$
3547	28,190 cm.$^{-1}$	weak	
3484	28,700 cm.$^{-1}$	weak	510 cm.$^{-1}$
3435	29,110 cm.$^{-1}$	weak	410 cm.$^{-1}$
3383	29,560 cm.$^{-1}$	strong*	450 cm.$^{-1}$
3336	29,975 cm.$^{-1}$	medium	415 cm.$^{-1}$
3291	30,385 cm.$^{-1}$	medium	410 cm.$^{-1}$
3250	30,770 cm.$^{-1}$	medium	385 cm.$^{-1}$
3209	31,160 cm.$^{-1}$	medium*	390 cm.$^{-1}$
3170	31,545 cm.$^{-1}$	strong*	385 cm.$^{-1}$
3138	31,870 cm.$^{-1}$	medium	325 cm.$^{-1}$
3105	32,205 cm.$^{-1}$	weak	335 cm.$^{-1}$
3070	32,575 cm.$^{-1}$	weak	370 cm.$^{-1}$
3041	32,885 cm.$^{-1}$	weak	310 cm.$^{-1}$
3015	33,165 cm.$^{-1}$	weak	280 cm.$^{-1}$
2990	33,445 cm.$^{-1}$	weak	280 cm.$^{-1}$

* Fairly sharp limit on the short wave-length side.

It is surprising that this band system has never been observed during explosions sensitized by the flash-photolysis of bromine. In an investigation on the emission spectrum of flames to which bromine or methyl bromide had been added, Coleman and Gaydon[3] observed some unidentified faint bands. They mention that the strongest heads appear to be at 3333 and 3384 A. These wave-lengths coincide with two of the strongest bands given in Table 1.

The presence of oxygen, either as a mixture component or as an impurity in the added gas, is a prerequisite for the occurrence of the spectrum. The participation of bromine in the absorbing radical may be inferred from the fact that all the compounds from which the spectrum can arise must contain bromine. An absorber, consisting of more than two atoms, will probably result in a more complex spectrum, and it is difficult to see which common substance, other than BrO·, can result from the various mixtures of substituted bromomethanes and oxygen. Consequently, the radical OBr has been identified as the absorbing species although it is realized that no definite proof has been given.

The assignment of the spectrum to OBr also gives an explanation for the diffuseness of the bands, since it may be expected that the O—Br bond is very weak and thus easily dissociated. Predissociation from the high energy-level of the upper state is very probable. The fact that no absorption spectrum was observed when bromine was flashed in the presence of oxygen (in contrast to the corresponding case of Cl_2–O_2) can also be due to the weakness of the O—Br bond, which makes the reaction:

$$O_2 + Br\cdot \rightarrow BrO\cdot + O$$

energetically impossible. This is also an indication that BrO_2, which is unstable at room temperature, is not the absorbing species. On the other hand, oxygen atoms will not react with bromine atoms in the formation of OBr radicals, since they cannot lose their energy. Indeed, no OBr bands were observed in an experiment in which a mixture of bromine and nitrogen dioxide was flash-irradiated.

It is believed that the formation of the OBr radical is possible in the present experiments as a result of the following occurrence. The flash dissociates the bromo-compound (RBr) into a bromine atom and a radical ($R\cdot$). This will occur only if the bromo-compound has a sufficiently strong absorption. The introduction of more halogen atoms into the molecule increases the extinction coefficient, but decreases the vapour pressure. The maximum concentration of OBr will be greatest for that compound for which the product of extinction coefficient and vapour pressure is optimal. This is the case with $CBrClH_2$ and CBr_2H_2. The radical $R\cdot$ formed reacts with oxygen in the formation of $ROO\cdot$ in which the O—O bond is weakened to a large extent. On a subsequent collision with a bromine atom the OBr radical is formed.

My thanks are due to Prof. R. G. W. Norrish for his interest in the investigation and for the facilities provided in his laboratory, and to the management of the Koninklijke/Shell-Laboratorium, Amsterdam, for the opportunity given to me to undertake this investigation.

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Effects of Nuclear Irradiation upon the Decomposition of Lead Styphnate Monohydrate

THE thermal decomposition of lead styphnate monohydrate has been re-investigated prior to a study of the effects of gamma-ray and reactor irradiation upon the decomposition. The two previous studies[1,2] of this decomposition gave quite divergent results.

A decomposition apparatus similar to those employed by other workers[3] was used. Lead styphnate monohydrate was found to decompose reproducibly in the range found by the other investigators, that is, 197–228° C. Because of this small range of temperature available it was controlled to 0·1° C.

The decomposition curves of the present study fell into group *C* described by Garner and Haycock[3]; this group of decompositions is characterized by an initial small, fast gas evolution. This is followed by a linear period which develops into the acceleratory period. The initial gas evolution in lead styphnate monohydrate corresponded to about 1 per cent of the total gas evolved; this phase was followed by a linear region which developed into a parabolic acceleratory period. The inflexion point corresponded to 29 per cent reaction and was followed by a first-order deceleratory period. Rate constants for the acceleratory period were calculated from

$$(P - P_0) = k(t - t_0)^2$$

P_0 was close to the pressure at the end of the linear period and was determined exactly by the method described by Garner *et al.*[3]. The activation energy for $k^{1/2}$ was 36·0 kcal./mol.; this is close to the value of 33 kcal./mol. determined by Tompkins and Young[2]. Many of the present results were similar to those of Tompkins and Young, that is, the general shape of the curves, the location of the inflexion point, the nature of the acceleratory period and its activation energy. However, the initial small gas evolution and linear period were absent in their curves. This discrepancy may be due to the small size of the crystals used in the present work; the average particle size was 7·7μ.

A series of cobalt-60 gamma irradiations (25° C.) up to $1\cdot 8 \times 10^8$ r. did not significantly alter the subsequent thermal decomposition curves. Negligible gas was evolved during an irradiation of 3×10^7 r.; this agrees with a recent finding[4], namely, the total gas evolved from lead styphnate monohydrate was 1/50 that of lead azide after a 3×10^7 r. room temperature irradiation from the 0·41 MeV. gamma-rays of gold-198. The stability of lead styphnate monohydrate towards ionizing radiation as reflected in its subsequent thermal decomposition curves is in marked contrast to lead azide; Groocock[5] has found that X-ray doses of 10^7 r. double the maximum decomposition-rate of α-lead azide. He also found that smaller doses altered the decomposition-rates.

Reactor irradiation greatly affected the subsequent decomposition curves (Fig. 1). Small samples of lead styphnate monohydrate were irradiated in a water-cooled hole of the Brookhaven National Laboratory reactor. Negligible difference was found in the decomposition curves of samples irradiated *in vacuo* and in air; consequently most samples were irradiated in air. A sample decomposed 8 days after irradiation gave a decomposition curve nearly identical with one stored for 49 days and then decomposed; this indicates that the radiation damage which affected the decomposition curves was not removed by storage at room temperature. Negligible decomposition occurred during irradiation; less than 1 micron of gas (Fig. 1) was evolved during irradiation of the sample used for curve *C*.

The maximum rate of decomposition for the longest irradiation period (curve *A*, Fig. 1) is nearly three times that of the unirradiated sample. It is of interest that the maximum decomposition-rate of irradiated samples which did not detonate or show evidence of self-heating was almost twice that of an unirradiated decomposition which showed no tendency to self-heat or detonate. The irradiated material is decomposing at a large number of evenly distributed sites formed from fast-particle damage in the crystal; the unirradiated decomposition is proceeding at a smaller number of more localized regions, for example, cracks, grain boundaries, and other imperfections. Evidently at a given overall reaction-rate the probability of detonation or self-heating is much greater in the latter case.

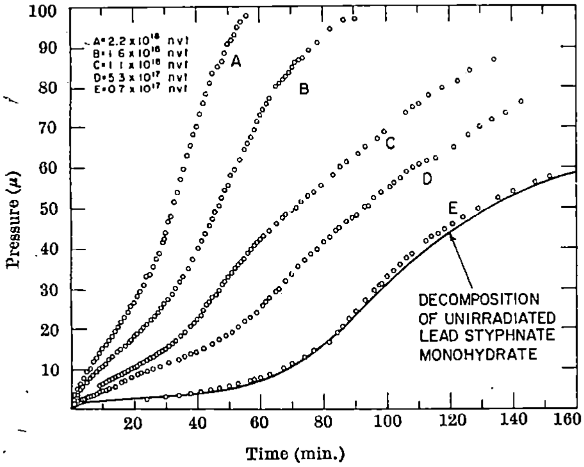

Fig. 1. The thermal decomposition curves of reactor-irradiated lead styphnate monohydrate (222·5° C.)

Further details of this work will appear elsewhere. This work was done at Brookhaven National Laboratory and was supported jointly by the U.S. Atomic Energy Commission and Picatinny Arsenal. I am indebted to Drs. P. W. Levy and J. V. R. Kaufman for their advice and interest.

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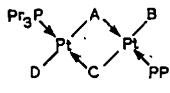
Isomerism among Binuclear Thiocyanato-bridged Complexes

WE earlier described[1] two isomeric platinous complexes of the general formula $(PPr^n_3)_2Pt_2(SCN)_2Cl_2$, which we designated α (melting point, 144–152° C.) and β (melting point, 173–174·5° C.). These were shown to have *trans*-symmetrical structures of type (I), where *A*, *B*, *C* and *D* represent the thiocyanato- and chloro-groups.

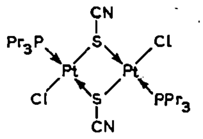
Later, an examination of their infra-red spectra[2] showed that the SCN groups were in bridging positions in both isomers, and hence that both isomers had formula (I) with $A = C =$ SCN and $B = D =$ Cl. It was then suggested that the isomerism must be geometrical and depended upon whether the SCN groups were in a *cis* or *trans* relationship to each other about the PtS_2Pt ring in a molecule of structure (II). This seemed probable because it had always been assumed that the SCN group bridges only through the sulphur atom in platinum(II) and palladium(II) complexes, and because the difference between the frequencies of the SCN stretching modes of vibration in the two isomers is only 7 cm.$^{-1}$.

The possibility that our isomers might be structural, depending upon the structural arrangement of the SCN groups in the bridge as in formulæ (II) and (III), or geometrical as in (III) and (IV) also arose however, together with other less probable possibilities.

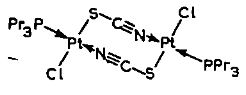
Recently, Lindqvist[3] has found that silver thiocyanate consists of infinite chains of structure $\cdots Ag{-}S{-}C{\equiv}N{\rightarrow}Ag{-}S{-}C{\equiv}N{\rightarrow}Ag\cdots$, in which



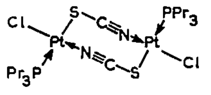
(I)



(II)



(III)



(IV)

the thiocyanate bridge is formed through both the sulphur and nitrogen atoms. We have therefore examined its infra-red spectrum and find that the SCN stretching vibration frequency (2,149 cm.$^{-1}$) is closely similar to those observed in our isomers (α, 2,162 cm.$^{-1}$; β, 2,169 cm.$^{-1}$). This supports the possibility of bridging by $Pt—S—C\equiv N\rightarrow Pt$ in our isomers, and if they have structures (II) and (III) we might expect (III) to be the unstable α-isomer.

We have now examined the structure of the α-isomer by X-rays and do indeed find that it has structure (III). Until we know the structure of the β-isomer, which is now under investigation, the exact nature of the isomerism is uncertain, but it is not a geometrical isomerism of the type previously proposed[2].

We have sought this type of isomerism in other similar complexes and find that the tetrathiocyanate (I; $A = B = C = D =$ SCN) also exists in two isomeric forms. In this case the unstable form is too labile to be isolated in a pure condition.

Full details will be published elsewhere.

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A New Superstructure in Gamma-Ferric Oxide

Since 1935 it has been generally accepted that gamma-ferric oxide has the structure of magnetite (spinel structure) with cation vacancies[1]. The vacancies were assumed to be randomly distributed on *all* octahedral iron sites of magnetite. Magnetite contains 8 molecules of Fe_3O_4 in the face-centred cubic unit cell and has the space group $Fd3m$. Gamma-ferric oxide contains $10\frac{2}{3}$ molecules of Fe_2O_3 in the unit cell. Due to the occurrence of a number of extra reflexions in the X-ray diagram of gamma-ferric oxide also occurring in the diagram of ordered lithium ferrite $Fe_8[Li_4Fe_{12}]O_{32}$, and to the fact that the material he used contained some water, P. B. Braun[2] of this Laboratory suggested that in these gamma-ferric oxide specimens the same superstructure occurs as in ordered lithium ferrite. The ideal composition for ordering would be $Fe_8[H_4Fe_{12}]O_{32}$. For compositions between $Fe_8[H_4Fe_{12}]O_{32}$ and $Fe_8[(Fe_{1\frac{1}{3}}\square_{2\frac{2}{3}})Fe_{12}]O_{32}$ the same superstructure reflexions were observed. (The square brackets [ ] denote the cations on octahedral sites, the ordinary brackets ( ) those on the Li-sites in ordered $LiFe_5O_8$.)

If the $1\frac{1}{3}$ Fe-atoms and the $2\frac{2}{3}$ vacancies are randomly distributed on the positions of the four lithium atoms in ordered lithium ferrite the space group of gamma-ferric oxide would be the same as that of ordered lithium ferrite, namely, $P4_13$ (or $P4_33$). This is a sub-group of $Fd3m$. The extra reflexions found by Braun are compatible with a primitive cubic unit cell, but not with the face-centred cubic cell of spinel.

In the X-ray diagrams of a number of commercial samples of gamma-ferric oxide of different origin and in the diagrams of a number of our own preparations we have found a faint reflexion between $\Sigma h^2 = 6$ and $\Sigma h^2 = 8$. In order to be certain that this reflexion is not caused by an impurity we prepared[3] gamma-ferric oxide by decomposing very pure ferrous oxalate dihydrate in an atmosphere of steam and nitrogen followed by oxidation with a mixture of nitrogen and air at 250° C. The water content is less than one-half weight per cent.

In the X-ray diagram made of this material on a 'Norelco' diffractometer with cobalt K_α radiation, even the strongest reflexion of alpha-iron oxide could not be detected. Beside the superstructure reflexions found by Braun, the reflexion between $\Sigma h^2 = 6$ and $\Sigma h^2 = 8$ mentioned above and fourteen others between 12° and 46° (2θ) have been found.

It has been possible to assign indices to all the reflexions using a tetragonal unit cell having $c/a = 3$ and $a_0 = 8{\cdot}33$ A. Absence of the reflexions $00l$ with $l \neq 4n$ points to a fourfold screw axis with a translation of $\frac{1}{4}$ c. There are no indications of a non-primitive unit cell.

On the assumption that the structure is still practically that of spinel, the new unit cell must contain 32 molecules of Fe_2O_3, and the space group is $P4_1$ (or $P4_3$). This is a subgroup of $P4_13$.

The position of the $3 \times 1\frac{1}{3} = 4$ iron atoms and the $3 \times 2\frac{2}{3} = 8$ vacancies distributed on the $3 \times 4 = 12$ lithium sites is determined by the fourfold screw axis. (Iron at $4a$: x,y,z; $\bar{x},\bar{y},\frac{1}{2} + z$; $\bar{y},x,\frac{1}{4} + z$; $y,\bar{x},\frac{3}{4} + z$.) A verification of the proposed structure by calculation of the intensities is in progress and will be published in detail.

In the course of the present work a paper by R. Collongues came to our attention[4]. He found a number of superstructure lines compatible with a tetragonal unit cell with $c/a = 2$. The discrepancy between his and our results is due to the fact that he has observed a smaller number of extra reflexions and because his samples contain alpha-ferric oxide.

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Mineralogy and Crystal Structure of Greenalite

Greenalite, a hydrous ferrous silicate, was first described in detail by Leith[1]; heavy contamination by other constituents of the iron-ore in which it occurred made analysis difficult. Discrepancies between analyses of the mineral by Leith and by Jolliffe[2] were ascribed by Gruner[3] to different methods of correcting for insoluble silica. Gruner found the X-ray pattern to be very similar to that of chrysotile, but different from chlorite, micas and chamosite. Gruner ascribed to greenalite a unit cell similar to chrysotile, although he found it impossible to tell whether the β-angle differed from that of chrysotile, 93° 16′. Gruner's analysis corresponded to a structural formula of $Fe^{2+}{}_{4\cdot5}Fe^{3+}{}_{1\cdot0}(Si_4O_{10})(OH)_8$.

Recent research[4] on chamosite from sedimentary ironstones, also a hydrous ferrous silicate, has shown it to be a member of the kaolin–antigorite group with an orthohexagonal unit cell, and layers stacked in an orthohexagonal, monoclinic or disordered sequence[5]. Since greenalite and chamosite were similar in composition, Gruner's finding that their X-ray patterns differed was unexpected, and a re-examination of greenalite was made with a Brindley powder camera. The greenalite diagram closely resembled chamosite, much more so than chrysotile. Contaminants gave sharp lines, while the greenalite gave broader lines which were due to the principal orthohexagonal indices. In particular, the clarity of the $20l$ series showed that, unlike many chamosites[6], greenalite has little or no a-disorder. No monoclinic form was observed.

In comparing cell dimensions, the a_0 and c_0 values for chrysotile have been transposed, but the double b_0 and c_0 dimensions have not been altered (Table 1).

Table 1

	Chrysotile (Gruner)	Greenalite (Gruner)	Greenalite (present work)	Lateritic chamosite (Brindley)	Ironstone chamosite (Brindley and Youell)
a_0	5·32	5·32	5·54	5·38	5·40 kX.
b_0	18·6	18·6	9·59	9·31	9·36 kX.
c_0	14·5	14·5	7·19	7·03	7·10 kX.
β	93° 16′	? 93° 16′	90°	90°	90°

The hydrous ferrous silicates vary considerably in chemical composition, giving rise to differences in unit cell dimensions even among specimens of the same mineral. Two factors are important in comparing the unit cells of greenalite and chamosite. Greenalite has very little replacement of tetrahedral Si by Al, compared with chamosite. This factor by itself would produce a reduction of a_0 and b_0 by the same fraction, and a c_0 increase of about twice this fraction. The octahedral sites in the greenalite structure are nearly all filled by the large ferrous ion, whereas in chamosite appreciable substitution by the smaller Al ion occurs. Greenalite would be expected to have larger values of a_0, b_0 and c_0 due to this factor, with the effect about four times as great for a_0 and b_0 as for c_0. Combination of these two factors in greenalite produces a structure in which all parameters are greater than in chamosite, the increase being 3 per cent for a_0 and b_0 and 2·3 per cent for c_0.

Greenalite oxidizes and becomes dehydrated to a high-temperature ferric form, but this is not so well defined as in chamosite. The oxidized and sometimes partially leached form of chamosite occurs extensively in weathered sedimentary ironstones. It seems likely that a similar phenomenon occurs with greenalite in the field, giving rise to Jolliffe's 'Mineral X'. Despite the similarity of the two minerals, greenalite is virtually free from alumina, whereas in most chamosites, the ratio Al/Si is very nearly 1. In view of the differences in environment and deposition of greenalite and chamosite, resemblance in all respects would not be expected. In both cases, however, the low iron content of the hydrous silicates relative to iron oxides and siderite, and the high silica content, render rocks containing a high proportion of these minerals unworkable as iron ores, and intractable to beneficiation processes based on physical methods.

A full account of this work will be published later.

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Rapid Sedimentation of Proteins through Starch

Packed potato starch, which has been widely used for zone electrophoresis, offers certain advantages when employed as a supporting medium in the ultracentrifuge. Boundaries are stabilized, making recovery of fractions easier, and the proteins thus far studied sediment at least twice as rapidly in starch as in free solution. This has been shown in experiments with rat hæmoglobin (1 per cent) or bovine serum albumin (1–5 per cent) stained with bromphenol blue centrifuged in starch and in free solution under identical conditions. Centrifugation was done in the 'Spinco' Model *L* centrifuge by use of an *SW* 391 swinging-bucket rotor at approximately 20°. A 0·1 ionic strength *p*H 7·5 phosphate–sodium chloride buffer was used in each instance. The 'Lusteroid' centrifuge tubes were completely filled with a slurry of starch–protein mixture and accelerated briefly to 20,000 r.p.m. After deceleration, excess fluid was removed and more starch slurry added. The packing procedure was repeated a second time and excess fluid again removed. It is important that the starch suspensions be freshly made, since part of the starch appears to dissolve slowly with time, destroying the effect observed here.

In the experiment shown in Fig. 1, tube *a* was filled with 5 per cent bovine serum albumin and tube *b* with 5 per cent stained bovine serum albumin in starch. After 5 hr. at 37,000 r.p.m., the rotor was decelerated without braking and the tubes gently removed. The distance the protein sedimented in free solution was measured by a method previously described[1]; the sedimentation distance in starch was estimated visually. Comparison of tubes *a* and *b* reveals that the protein moves through starch with a fairly well resolved trailing edge at about twice the rate observed in free solution. Tubes *c* and *d* contain uncentrifuged stained bovine serum albumin in starch and starch in buffer for comparison with tube *b*. No colour was observed in the upper fourth of tube *b*. Sectioning of the tube showed that the

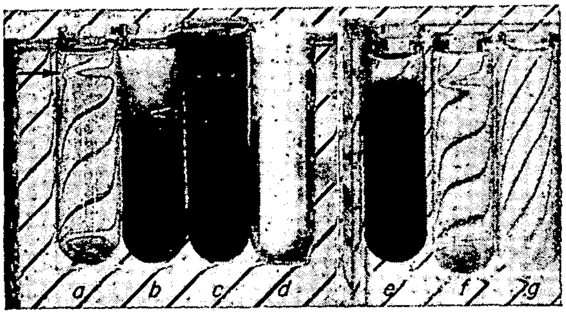

Fig. 1. 'Lustcroid' centrifuge tubes containing (*a*) 5 per cent albumin sedimented 5 hr. at 38,000 r.p.m.; (*b*) 5 per cent stained albumin in packed starch after 5 hr. at 38,000 r.p.m.; (*c*) 5 per cent stained albumin in starch after brief centrifugal packing; (*d*) starch in buffer for comparison with upper portion of tube *b*; (*e* and *f*) 5 per cent albumin centrifuged 6 hr. at 37,000 r.p.m. Presence of stain in tube *e* does not change sedimentation-rate appreciably. Tube *g* contains water

sedimentation was not confined to the edges. Staining the bovine serum albumin does not alter its sedimentation noticeably, as is shown in a separate experiment (tubes *e* and *f*). Further refinements will be required for more accurate measurements, since, in these observations, the effect of reversible packing of the starch during centrifugation could not be measured and has been neglected. One effect of such packing would be to increase the distance the boundary must sediment through free solution before entering the starch. This could decrease the sedimentation-rate observed because of slower sedimentation in free solution, or could increase the observed rate because fluid expressed from the starch during centrifugation would fill a greater length of the tube while in starch than when overlaying it. We checked the latter point by sedimenting the protein all the way to the bottom. The results confirm the finding of a more rapid sedimentation-rate in starch by at least a factor of 2. Experiments are now in progress to adapt the analytical ultracentrifuge cell to the solution of the problem of reversible packing.

The presence of the starch granules might be expected to decrease the sedimentation-rate by increasing the length of the path the protein must travel and by interacting weakly with it. The opposite effect observed (an increase in sedimentation-rate) is believed to be caused by the presence of a local increase in protein concentration on the centripetal side of the starch grains caused by collision of the sedimenting protein molecules with the starch particles. Since the average velocity caused by Brownian movement of the proteins studied here (and actually up to a molecular weight of several million) exceeds the sedimentation velocity obtainable in the 'Spinco' Model *L* ultracentrifuge, the protein molecules would not be held firmly against the starch, but would form small zones or caps of slightly higher concentration. These zones would tend to decant off the starch grains and flow or stream down between them until collision with another starch grain or randomization by diffusion occurred. Flow of this type may be termed 'microdecantation'. The experiments reported were originally carried out to see whether such flow could be exploited. Microdecantation offers a number of rather unusual possibilities, since it appears that an optimum particle-size exists the sedimentation-rate of which in starch will be faster than those of either larger or smaller particles. The application of these findings to equilibrium centrifugation, to continuous preparative ultracentrifugation, and to the sedimentation of larger molecules such as deoxyribonucleic acid will be discussed elsewhere.

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The Anionic Polyelectrolyte, Polyethylene Sulphonate, as a New Anti-neoplastic Agent

Heparin and related sulphomucopolysaccharides have been recognized as mitotic inhibitors for many years. Although heparin has been shown to inhibit cell division in many biological systems, including animal tumours[1,2], its anticoagulant activity diminishes the likelihood of its producing anti-neoplastic activity in man at safe dose-levels.

The pharmacological properties of several potential substitutes for heparin have been explored in man. Alopecia, ulceration of the gastro-intestinal tract, and finger-nail alteration observed as toxic manifestations in some patients who received these compounds may have been evidence of antimitotic effects on normal rapidly growing epithelium[3]. Screening studies of anti-neoplastic activity of several of these anionic polyelectrolytes, originally synthesized as heparin substitutes for their anticoagulant or lipolytic activity *in vivo*, have been undertaken in this Institute.

This communication concerns the polyethylene sulphonates (provided through the courtesy of the Upjohn Company, Kalamazoo, Michigan), sodium salts of polymers of ethylene-sulphonic acid. For equivalent anticoagulant activity, many of the polymers of polyethylene sulphonate have greater lipolytic activity than heparin (Coleman, L. L., personal communication). These same polymers, active in lipolysis, have been shown in our work to produce substantial suppression of growth in mouse tumours. Several such polymers with molecular weights ranging between 15,000 and 35,000 have the same anti-neoplastic activities, and are considered here as one compound.

Ehrlich ascites tumour clone 2 and Krebs 2 carcinoma in ascitic form have been maintained and studied in Swiss mice. Uniform saline suspensions of ascites tumours were transplanted subcutaneously along the chest wall. Leukemias *L* 1210, and strains of *L* 5178, sensitive and resistant to amethopterin, were maintained in *dba* 2 mice in ascites form and transplanted subcutaneously. Carcinoma 755 in *C* 57 black mice and sarcoma 180 in Swiss mice were maintained and transplanted as solid tumours. Tumour transplantation into mice of one sex was performed; the mice were then allocated 3–5 to a cage at random. Treatment began one day after tumour inoculation, except with *Ca* 755, where there was an interval of seven days after inoculation. Solutions of polyethylene sulphonate, maintained in the frozen state until use, were injected in 0·5 cm.^{3} saline into the dorsal subcutaneous tissue. Volume of injected material and distance from tumour site were such that local effect of the drug from high concentration in the vicinity of the tumour transplant was improbable. Subcutaneous tumours were excised and weighed one day after termination of drug treatment, on the

Table 1. PERCENTAGE INHIBITION OF SUBCUTANEOUS TUMOURS BY POLYETHYLENE SULPHONATE ADMINISTERED SUBCUTANEOUSLY

Tumour	Mouse strain	Dose							
		100 mgm./kgm. once daily				200 mgm./kgm. once daily			
		Percentage inhibition tumour weight*				Percentage inhibition tumour weight*			
		No. of experiments	Range Min.	Range Max.	Average of all experiments	No. of experiments	Range Min.	Range Max.	Average of all experiments
Ca 755†	*C* 57 *B*1	1	—	—	55	1	—	—	88
L 1210	*dba* 2	3	9	57	36	1	—	—	71
S 180	Swiss	3	47	59	53	3	63	72	66
L 5178R	*dba* 2	3	40	62	50	—	—	—	—
L 5178S	*dba* 2	3	26	58	47	—	—	—	—
Krebs 2	Swiss	4	−6	59	26	5	31	57	41
Ehrlich 2	Swiss	10	−6	54	27	17	4	75	35

* Percentage inhibition = (control weight − treated weight)/control weight × 100

† *Ca* 755—Treatment began seven days after tumour inoculation

sixth or eighth day. Treated and control groups numbered 10–20 mice. Sex of the host was apparently not a factor influencing response to administration of the drug.

A total of sixty-two consecutive experiments using polyethylene sulphonate at dose-levels of 100–200 mgm./kgm./day in one subcutaneous injection were performed. Eight of these were considered unsuitable for analysis because of deaths from hæmorrhage in excess of 33 per cent. The degree of observed inhibition in these eight experiments, however, was comparable with the other fifty-four. The results of the remaining fifty-four experiments are shown in Table 1. The overall survival-rate for controls was 98 per cent and for treated mice 88 per cent (range 67–100 per cent). In forty-eight of the fifty-four experiments average loss in weight of treated animals did not exceed 10 per cent of their initial weight. Intraperitoneal injection of polyethylene sulphonate produced inhibition of tumours of similar extent to subcutaneous administration, but at greater cost in toxicity. The inhibition of Krebs 2 and Ehrlich 2 tumours, although moderate, is highly significant on statistical analysis. The observed suppression of growth in the other five tumours is substantially greater. Increase of dose to 200 mgm./kgm. inhibited growth more than treatment at 100 mgm./kgm. in all tumours studied, although usually at greater cost in toxicity (93 per cent survival at 100 mgm./kgm./day versus 83 per cent survival for 200 mgm./kgm./day). Further increase in dosage caused greater tumour inhibition, but the greater mortality from hæmorrhage was prohibitive.

The anti-neoplastic effect of polyethylene sulphonate can be recognized without encountering anticoagulant properties of the compound. In fifteen of the fifty-four experiments in Table 1, inhibition of tumour growth up to 50 per cent (average 33 per cent) was seen without hæmorrhagic deaths.

Survival studies involving Krebs 2 tumour in the ascites form were considerably foreshortened by intraperitoneal hæmorrhage from drug toxicity. Studies of combinations of polyethylene sulphonate with protamine, and with other polycations which can reverse the anticoagulant properties of the drug, are in progress.

At equivalent weights of drug administered, polyethylene sulphonate produces tumour inhibition of greater degree with less toxicity than does heparin in unpublished studies of our own. In addition to inhibition of tumour growth, anticoagulant effect and lipolysis, polyethylene sulphonate has also been shown to share certain physiological properties with heparin: the production of diastolic cardiac arrest in isolated frog-heart preparations, reversible by calcium, production of bone disease resembling osteoporosis and gastro-intestinal ulceration on chronic administration (Coleman, L. L., personal communication). Studies could reasonably be extended by others to establish whether polyethylene sulphonate shares other characteristics of heparin: diminishing the activities of hyaluronidase[4], fumarase[5], ribonuclease[6], deoxyribonuclease I[6], and antagonism by adenosine triphosphate in several biological systems[3,7]. Polyethylene sulphonate and heparin in low concentrations have already been shown to inhibit deoxyribonuclease II of human leukæmic leucocytes and mouse tumours (Tunis, M., Regelson, W., Weinfeld, H., and Sandberg, A., unpublished work).

Pathological study of treated mice, aside from hæmorrhages, showed only reticuloendothelial hyperplasia in the spleens of animals which received the polymers of polyethylene sulphonate with higher molecular weights. There are no apparent histological differences between treated and non-treated tumours as seen with hæmatoxylin–eosin or Sudan III staining.

We have observed that polyethylene sulphonate, a polymer with many chemical and physiological properties similar to heparin, has produced inhibition of growth in seven transplanted mouse tumours. This activity can be separated from the lethal anticoagulant effects of the compound by adjustment of dose. Exploration of the possible anti-neoplastic activity of other anionic polyelectrolytes has begun in this Institute, and is indicative of a new class of anti-neoplastic agents.

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α-Amino*iso*butyric Acid, β-Hydroxyleucine, and γ-Methylproline from the Hydrolysis of a Natural Product

We have been examining the structure of an antibiotic supplied to us by the Pharmaceuticals Division of I.C.I., Ltd.; but the work has now had to be suspended for lack of material. As there will be a considerable delay before it can be resumed, some of the results, which may have a wider interest, are recorded here.

The antibiotic (I.C.I. No. 13959), which is unusually active against infections of *Trypanosoma congolense* in mice, was produced by a strain of *Paecilomyces*. It was extracted by ethyl acetate and purified by chromatography on silica and then on magnesium carbonate. The second column separated two non-crystalline fractions with antibiotic activity, eluted by benzene and methanol respectively. Most of our work has been done with the former; but a cursory examination suggests that the latter has similar structural features to those reported below.

Several neutral amino-acids were produced from the antibiotic by hydrolysis with 6 *N* hydrochloric acid at 100° for 48 hr. They were separated by ascending two-dimensional paper chromatography with butan-1-ol (10) : ethanol (10) : water (5) : propionic acid (2) and then butan-1-ol (10) : acetone (10) : water (5) : di*cyclo*hexylamine (2)[1]. Five spots were produced with the following ninhydrin colours and R_F's in the two systems: *A*, blue, 0·60, 0·65; *B*, blue appearing only on heating to 100°, 0·50, 0·36; *C*, yellow, 0·45, 0·42; *D*, grey–green, 0·49, 0·86; *E*, greenish blue, 0·33, 0·35. On a semi-micro scale these amino-acids were separated almost completely by a 61-cm. column of 'Dowex'-50 × 2 cation-exchange resin[2]. They were eluted by *N* hydrochloric acid in the order *E*, *B*, *D*, *C*, *A*, and then recovered from their hydrochlorides with the aid of a short column of 'Dowex'-1 × 2 anion-exchange resin; amino-acids *A*, *B*, and *D* were obtained crystalline.

The identification of *A* with L-leucine was made by elementary analysis, infra-red spectrum, optical rotation and paper chromatography in six solvent systems. Likewise, *B* was found to be α-amino*iso*butyric acid. This amino-acid has not previously been obtained from natural sources; its closest relatives are α-methylserine, also a component of an antibiotic[3], and 1-amino*cyclo*propane carboxylic acid, which has recently been found among the free amino-acids of pears and cowberries[4].

Like proline and hydroxyproline, amino-acid *C* gave a yellow colour with ninhydrin and a blue one with isatin, but was clearly differentiated from them by paper chromatography. It was partly crystalline but could not be recrystallized satisfactorily; the crystalline reineckate had an analysis (C, 25·4; H, 4·4; N, 21·9 per cent) not far from that required for a homologue of proline ($C_6H_{11}O_2N.Cr(SCN)_4(NH_3)_2H$ requires C, 26·8; H, 4·0; N, 21·8 per cent). As amino-acid *C* was distinguished from pipecolic acid by paper chromatography and the ninhydrin colour, the most likely structure was that of γ-methylproline, which has previously been found among the free amino-acids of apples[5]. Indeed, it appeared on paper chromatography to be identical with one component of a partially purified extract from apple juice, generously supplied by Mr. L. F. Burroughs of Long Ashton, Bristol. We therefore regard *C* as γ-methylproline; but proper identification must await comparison with a synthetic sample. Synthesis, which we are undertaking, may also answer the problems of diastereoisomerism and optical activity.

The conversions of amino-acid *D* into leucine by hydriodic acid and into glycine by sodium hydroxide[6], and its rapid destruction by periodate, were consistent with its formulation as β-hydroxyleucine. The DL-*threo* and *erythro* isomers of this amino-acid were synthesized by a method similar to one devised for the threonines[7]. As they were readily separable by paper chromatography in butan-1-ol saturated with 10 per cent aqueous diethylamine[8], it was possible to assign the structure D- or L-*threo*-β-hydroxyleucine to the natural product; its infra-red spectrum resembled that of the DL-*threo*-amino-acid but they were not identical. This is the first time that β-hydroxyleucine has been obtained from natural sources. Amino-acid *E* was shown to be β-alanine by paper chromatographic comparison and by the mixed melting point (140–141°) of its β-naphthalenesulphonyl derivative.

Hydrolysis of the antibiotic also produces basic substances; but discussion of their structures and of that of the antibiotic itself would be premature.

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3β-Methoxy-5-androsten-16β-ol: a Cytostatic and Fungistatic Steroid

In our search for a superior 'androgenic' steroid for use in human cancer of the breast, we have submitted many such steroids to study in the zebra fish-egg test[1]. Using this bioassay method for determination of cytostatic activity, intensely cytostatic compounds in the C-19 or 'androgenic' steroids are difficult to find. To date, our most active compound is 3β-methoxy-5-androsten-16β-ol[2], this steroid having *LD*50 of 1–2 parts per million. It is very interesting that this compound is the exact analogue of the steroidal œstrogen 3-methoxyœstra-1-3,5(10)-trien-16β-ol[3], which had been previously selected by us for use against cancer of the prostate, based on fish-egg cytostasis[4]. Also of much interest in steroidal cytostasis is the fact that methyl ether formation at C_3 of 5-androstene-3β,16β-diol[2] so strongly enhances the activity of this diol, which itself is virtually inactive (*LD*50 > 10 p.p.m.). Methyl ether formation at C_3 of 1,3,5(10)-œstratrien-3,16β-diol[3] had also caused an enhancement (100 per cent) of cytostatic activity in the fish-egg test.

We have also found 3β-methoxy-5-androsten-16β-ol to be among the strongest of fungistatic steroids so far tested by us. It is particularly active against

Table 1. COMPARATIVE FUNGISTATIC ACTIVITY OF 3β-METHOXY-5-ANDROSTEN-16β-OL AND STILBAMIDINE DI-ISETHIONATE AGAINST THREE STRAINS OF ***Histoplasma capsulatum***

	Test dilutions								Control dilutions	
	3β-Methoxy-5-androsten-16β-ol				Stilbamidine di-isethionate				Acetone (per cent)	
	Parts per million				Parts per million					
	1·0	0·5	0·25	0·125	1·0	0·5	0·25	0·125	0·4	0
H. capsulatum Strain 1	0	+	++	++++	+	++	++++	++++	++++	++++
	0	+	++	+++	+	++++	++++	++++	++++	++++
Strain 2	0	+	++++	++++	+	+	++	+++	++++	++++
	0	+	+++	++++	+	+	++	+++	++++	++++
Strain 3	0	+	++++	++++	0	+	++	+++	++++	++++
	0	+	+++	++++	0	+	+	+++	++++	++++

0, maximally inhibited growth ; ++++, maximal growth

Histoplasma capsulatum tested in 'Difco' Sabouraud's dextrose agar in culture plates[5], having a fungistatic effect equal to that of stilbamidine di-isethionate.

Table 1 summarizes the comparative effect of 3β-methoxy-5-androsten-16β-ol and stilbamidine di-isethionate, assayed simultaneously against *H. capsulatum*.

Curiously, 3-methoxyœstra-1,3,5(10)-trien-16β-ol is relatively ineffective against *H. capsulatum* in the culture plate, producing only partial fungistasis at 10 parts per million.

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A Colour Reaction of Vitamin E with Vitamin K and Cysteine

A FEW crystals of vitamin K (2-hydroxy-3-methyl-1,4-naphthoquinone) and of cysteine (chlorhydrate) are added to a solution containing 7–20 µgm./ml. of vitamin E (sodium phosphate of alpha-tocopherol). The solution is heated up to boiling point. About one minute after boiling the solution takes a blue tint. The intensity of colour is proportional to the content of vitamin E and increases during the following three minutes, finally rendering the solution opaque.

The reaction was not obtained when we tried to replace cysteine by the following substances : cystine, ascorbic acid, sodium hydrosulphite, glutathione, glucuronic acid, methionine, and thiourea.

Nor was the reaction obtained, moreover, when we tried to replace vitamin K by the following compounds : 1,4-naphthoquinone, 2-methyl-1,4-naphthoquinone, sodium-beta-naphthoquinone-4-sulphonate ; 2,4-dinitro-1-naphthol-7-sulphonic acid, 2-methyl-1,4-dipropyl-1,4-naphthoquinone, 1,8-dihydroxy-naphthalene-3,6-disulphonic acid, dimethyl-alpha-naphthylamine, alpha-naphthol and beta-naphthol.

The colour reaction is completely inhibited by *p*H 2 (hydrochloric acid) or *p*H 11 (sodium hydroxide).

If cysteine or vitamin K is added not as crystals but as a solution, even when recently prepared, only an indefinite tint is produced and the solution immediately becomes opaque.

Vitamin E must be the first substance present in the solution and the crystals of cysteine and vitamin K must be added simultaneously before heating. This sequence is fundamental.

Raising the temperature accelerated greatly the completion of the colour reaction, but the latter is produced also without heating.

The solution containing vitamin E, vitamin K and cysteine exhibits a yellow fluorescence, the intensity of which is not apparently proportional to the concentrations of any of the three ingredients. The same fluorescence is produced without vitamin E, but not in the absence of vitamin K.

Extraction with organic solvents added to the solution of the three compounds was tried. Ether takes a red tint ; the intensity of the colour is apparently proportional to the quantity of vitamin E present in the solution. The red ether solution gives a blue fluorescence. Petroleum-ether or acetone do not influence the results with ether. A drop of $N/10$ sodium hydroxide extinguishes the red tint of the supernatant ether almost completely, whereas the blue tint of the original solution takes on a colour between green and yellow, depending on the amount of vitamin E present. Variations of fluorescence are very slight.

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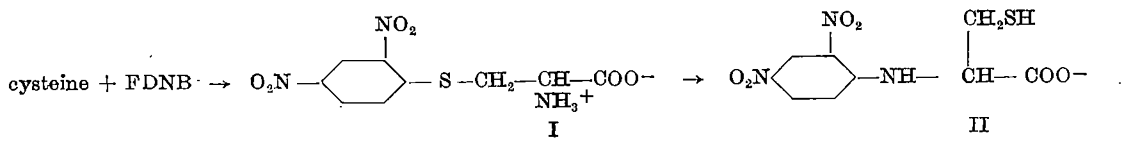
Molecular Rearrangement in the Reaction of Cysteine with 1-Fluoro-2,4-Dinitrobenzene

SINCE 1-fluoro-2,4-dinitrobenzene has fungicidal properties[1] and is useful for the end-group and sequential analysis of proteins, its reaction with cysteine was investigated as part of a study of the mechanism of action of toxicants which function as alkylating agents. In the presence of ten molecular equivalents of cysteine the reaction was first order with respect to the disappearance of 1-fluoro-2,4-dinitrobenzene in dilute aqueous buffer. At *p*H 7·0



and 29° C. the half-time for the reaction was about 38 min. at an initial concentration of $2 \cdot 7 \times 10^{-5}$ mole of 1-fluoro-2,4-dinitrobenzene per litre. When the reaction was followed by measuring the formation of the final product by absorption readings at 360 mμ, first-order kinetics were not strictly obeyed and the half-time was about 40 per cent longer. This suggested the presence of a transient intermediate.

Since it was known that 1-fluoro-2,4-dinitrobenzene reacted with cysteine and other sulphydryl compounds about 10^3 times more rapidly than with compounds containing only primary amino- and carboxyl-groups[2], it was suspected that alkylation of the mercaptan group occurred initially followed by a rearrangement to yield an N-substituted product. Thus the sequence of events was probably as indicated in the scheme above.

Measurements made with a recording spectrophotometer revealed that the absorption maximum of the products shifted from 340–345 mμ at the beginning of the reaction to 360 mμ after it was complete. These values agreed very closely with the maxima observed for the reaction products of 1-fluoro-2,4-dinitrobenzene with mercaptoacetic acid and glycine, respectively, indicating that alkylation of the amino group was preceded by alkylation of the sulphydryl group in the case of cysteine.

Further evidence for a rearrangement was obtained by acidifying a reaction mixture with hydrochloric acid at half-time and extracting with an equal volume of benzene. After separation of the phases, yellow colours appeared in both the aqueous and hydrocarbon layers. However, when the aqueous layer was re-extracted 15 min. later, all the colour appeared in the benzene layer. This can be explained if it is assumed that product I was positively charged in the acid medium because it contained a primary amino group, while product II was uncharged because the electronegative dinitrophenyl group reduced the basicity of the amino group. Thus product I should remain in the aqueous phase while product II should be extracted into the benzene since the ionization of its carboxyl and sulphydryl groups would also be repressed by the presence of hydrochloric acid. The first extraction should prevent any further formation of I since the reactants (cysteine and 1-fluoro-2,4-dinitrobenzene) would appear in different phases. Therefore, after sufficient time had elapsed for I to become rearranged to II, all the yellow-coloured material should migrate to the benzene layer on re-extraction.

The final reaction product was isolated from excess cysteine by solvent extraction from an acid medium. It gave an intensely coloured yellow precipitate with silver nitrate, a positive nitroprusside test, and reduced iodine, thus providing evidence for the presence of a free sulphydryl group.

It is not known whether this occurrence is of any importance in the alkylation of enzymes or other proteins by toxicants, but it suggests a mechanism by which otherwise unreactive receptor sites could be activated by adjacent groups. Thus the amino-group of cysteine was alkylated indirectly at a rate about 10^3 times faster than was observed for the direct alkylation of the amino-groups of methionine and other similar compounds.

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Detection of α-Ketoglutaric Acid and Other Keto-Acids on Paper Chromatograms with Ninhydrin

NUMEROUS paper chromatographic methods exist for the detection of keto-acids as their 2,4-dinitrophenylhydrazone, semicarbazone, and quinoxaline derivatives or as the free acids[1]. By the ninhydrin spray test for amino-acids on paper chromatograms, it is now possible to detect as little as 1 μgm. per sq. cm. of α-ketoglutaric acid on chromatograms of plant extracts. The procedure described here thus permits simultaneous detection of the amino-acids on the same chromatogram.

Soluble plant extracts or known keto-acids were chromatographed on Whatman No. 1 paper, water-saturated phenol being used as the first solvent and *n*-butanol–propionic acid–water[2] for the second. After drying, the chromatograms were sprayed with 0·1 per cent solution of ninhydrin in 95 per cent ethanol containing 2 drops of 2,6-lutidine per 100 ml. of reagent. The chromatograms were heated at 90° C. for 3–5 min. for development of the amino-acid colours, after which the papers were allowed to stand in the dark at room temperature for at least 24 hr. The resultant reaction with α-ketoglutaric acid (recrystallized from acetone and benzene) was observed as an intense yellow fluorescent colour under 3660-A. light or as a faint yellow colour in visible light. α-Ketoglutaric acid migrates near glutamic acid with an R_F in water-saturated phenol of about 0·2 and in *n*-butanol–propionic acid–water of 0·3.

A number of other keto-acids were also tried (Table 1). Only certain α-keto-acids reacted; none of the β-keto-acids gave positive reactions. Other organic acids such as citric, malic, fumaric, lactic, glyceric, succinic, and glycolic failed to react. Less than 1 μgm. of α-ketoglutaric acid, when spotted on a paper, could easily be detected by the procedure; however, 10–20 μgm. were chromatographed for testing. For further exploration of the variables influencing the reaction, only α-ketoglutaric acid was used since the reaction with this acid was more sensitive and faster than those with the other keto-acids tested.

The reaction with ninhydrin was apparently specific in that hydrindantin and alloxan did not react under the conditions used. Substitution of 1,3-indane-dione in the procedure gave a light yellow

Table 1. COLOUR REACTIONS OF VARIOUS KETO-ACIDS WITH NINHYDRIN ON PAPER*

Acid	Colour after 24 hr.†	
	in white light	in 3660 A.
Glyoxylic	None	None
Pyruvic	Pale Yellow	Yellow
α-Ketobutyric	Faint yellow	Blue-white
α-Ketoglutaric	Pale yellow	Intense yellow
2-Ketogluconic	None	Blue-white‡
Oxalacetic	Faint yellow	Faint yellow§
β-Ketoglutaric	Pale yellow	None

* Papers heated 30 min. at 90–95° C. after ninhydrin application.

† The visible colour in all cases was too weak to be useful as a diagnostic test. The fluorescence in 3660 A. light was of sufficient intensity for easy detection.

‡ 2-Ketogluconic acid in the absence of ninhydrin fluoresced with equal intensity.

§ This was probably caused by the formation of pyruvic acid by decarboxylation.

colour on a faint pinkish background with α-ketoglutaric acid; but the spot did not fluoresce in ultra-violet light.

A trace of pyridine derivative in the ninhydrin spray promoted more rapid development of the yellow fluorescence. Collidine, lutidine, the picolines, and pyridine were all effective in varying degrees. Neither sodium hydroxide nor sodium acetate were effective replacements for the pyridine base under the conditions used. In the absence of the pyridine base, the yellow fluorescent colour developed more slowly over a period of days. The colour reaction between amino-acids and ninhydrin on paper chromatograms is also affected by the presence of pyridine derivatives[3]. In our experience, the presence of collidine or lutidine, or both, in the ninhydrin spray promotes a variety of colours that are characteristic of the specific amino-acids.

Although heating paper chromatograms after spraying with ninhydrin markedly accelerates the colour reaction with amino-acids, the maximum production of the yellow fluorescence with α-keto-acids is best achieved with time in addition to heat. For example, small concentrations (<20 μgm.) of α-ketoglutaric acid reacted after a few minutes of heating to produce little visible colour but some blue-white fluorescence. On standing at room temperature, the intense yellow fluorescence became increasingly apparent in one to a few days. The initial blue-white fluorescence is promoted by increased time of heating to about 30 min., but not longer. When concentrations of α-ketoglutarate are large (>20 μgm.), the yellow fluorescence is producible within 30 min. of heating, but intensifies on standing.

Development of the yellow fluorescence occurred to the greatest extent in the dark. When the chromatograms were exposed to continuous illumination from a 'G. E. Daylight' fluorescent lamp over several days, little of the yellow fluorescent material developed and, instead, a less-intense dull orange colour in 3660 A. light was formed. The colour formed by reaction of ninhydrin with amino-acids is also known to be destroyed by light with time[4].

The yellow complex is easily eluted with water from the paper chromatograms, but only a broad band of light absorption was observed, possibly because of contaminants from the spray or the paper.

When 1 μgm. of α-ketoglutaric acid was added to plant extracts of *Ricinis communis* and then chromatographed, a marked increase occurred in the yellow fluorescence in the position of α-ketoglutarate as compared to the original plant extract. Large amounts of α-ketoglutaric acid have been shown to be present in the stems of *Mentha piperita*[5]. Paper chromatograms of soluble extracts from that tissue also revealed considerable amounts of α-ketoglutaric acid when they were sprayed with ninhydrin according to the procedure described. Smaller amounts of α-ketoglutaric acid were detected by the ninhydrin method in the chromatographed extracts of other plants.

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Enzymatic Dehydrogenation of Hydroxypurines and Hydroxypteridines

ONE of the steps of the biosynthesis of guanylic acid from adenylic acid involves the diphosphopyridine nucleotide-linked dehydrogenation of inosinic acid to xanthylic acid[1-3]: inosinic acid + diphosphopyridine nucleotide+ → xanthylic acid + reduced diphosphopyridine nucleotide. When this reaction was studied with chicken-liver enzyme extracts by following the appearance of the absorption peak at 340 mμ characteristic of reduced diphosphopyridine nucleotide, a strong reduction of the coenzyme was observed not only in the presence of inosinic acid but also with the corresponding purine base hypoxanthine.

In order to study this effect further, an assay was set up in which 0·5 μ*M* hypoxanthine, 1·0 μ*M* of diphosphopyridine nucleotide and 10 μ*M* of *tris* (*tris*hydroxymethylaminomethane, Sigma Chemical Co.) buffer *p*H 9·0 in a final volume of 0·5 ml. were incubated for 30 min. at 37° C. with the enzyme. The reaction was stopped by adding 0·1 ml. of 2 *M* acetate buffer *p*H 6·0, and the optical density at 340 mμ was measured in a Beckman *DU* spectrophotometer after diluting to 3·0 ml. and removing any precipitated protein by centrifugation. Controls without hypoxanthine were run at the same time and their optical density at 340 mμ subtracted from that of the experimental tubes. The difference of the two values appears in Tables 1, 2 and 3 as Δ^{340}. The *p*H of 9·0 was chosen for the assay because it is the lowest value at which full activity of the enzyme was observed. A series of experiments designed to

Table 1. ENZYME FRACTIONATION.
All operations were carried out in the cold room. The enzyme unit is arbitrarily defined as the amount of enzyme that gives a Δ^{340} of 1·000 under the conditions of our assay

Fractionation step	Specific activity	Purification (-fold)
1 Crude enzyme extract	4 U/mgm. N	—
2 Protamine precipitation, 2 mgm./ml.	6·8 U/mgm. N	1·7
3 Ammonium sulphate, *p*H 7·3, 35–47 per cent saturation	16 U/mgm. N	4
4 Ammonium sulphate, *p*H 7·6, 32–45 per cent saturation	25 U/mgm. N	6·25
5 Acetone, *p*H 7·4, 24–34 per cent	83 U/mgm. N	20·7

Table 2. Enzyme Specificity

Assay as in text, except that separate controls were run for the hydroxypteridines to correct for their absorption at 340 mμ

Substrate	Δ^{340}	Enzyme
Hypoxanthine Xanthine	0·340 0·305	Crude enzyme
Hypoxanthine 4-Hydroxypteridine 2,4-Dihydroxypteridine 2-Hydroxypteridine 6-Hydroxypteridine	0·290 0·205 0 230 0·300 0·000	Crude enzyme
Hypoxanthine 4-Hydroxypteridine 2,4-Dihydroxypteridine 2-Hydroxypteridine	0·230 0·070 0·125 0·230	Enzyme fraction 5

Table 3. Effects of SH-Group Inhibitors and of Glutathione

The concentrations are the final concentrations in the reaction mixtures. Assay as described in text

Glutathione	*p*-Chloromercuribenzoate	*o*-Iodosobenzoate	Δ^{340}
—	—	—	0·310
10^{-3} *M*	—	—	0·280
10^{-4} *M*	—	—	0·310
—	10^{-4} *M*	—	0·000
10^{-3} *M*	10^{-4} *M*	—	0·300
10^{-4} *M*	10^{-4} *M*	—	0·315
—	—	10^{-4} *M*	0·000
10^{-3} *M*	—	10^{-4} *M*	0·315
10^{-4} *M*	—	10^{-4} *M*	0·000
—	—	10^{-5} *M*	0·030
10^{-3} *M*	—	10^{-5} *M*	0·285
10^{-4} *M*	—	10^{-5} *M*	0·310

determine the optimal *p*H of the enzymatic reaction showed essentially no activity at *p*H 8·0, followed by a rapid rise in activity between *p*H 8·0 and 9·0, with the activity remaining constant thereafter until past *p*H 11·0.

To prepare the enzyme, chicken liver acetone powder was extracted with 0·1 *M tris* buffer *p*H 7·3 containing 0·2 *M* potassium chloride. After centrifugation, the supernatant liquid was dialysed overnight against 0·005 *M tris p*H 7·3–0·02 *M* potassium chloride and centrifuged again. An approximately twenty-fold purification of the enzyme with an overall yield of about 25 per cent was obtained by the fractionation steps outlined in Table 1.

When the specificity of the enzyme system was examined, it was found that hypoxanthine and xanthine are equally good substrates (Table 2), indicating that the oxidation of the hypoxanthine must proceed to uric acid through xanthine. Adenine, purine, uracil and thymine were inert in the system. 4-Hydroxypteridine and 2,4-dihydroxypteridine, however, reacted almost as effectively as their purine analogues hypoxanthine and xanthine (Table 2). This is of interest since relatively little information on the metabolism of the hydroxypteridines is available. When 2-hydroxypteridine was used as a substrate increased formation of reduced diphosphopyridine nucleotide was noted. 2-Hydroxypteridine has been shown to be covalently hydrated across the 3,4 double bond and to be more prone to permanganate oxidation than the other hydroxypteridines[4], and it is tempting to speculate that the 3,4-hydrate structure may also be responsible for the greater ease of the enzymatic dehydrogenation. It does not seem that the same enzyme acts on both hydroxypurines and hydroxypteridines since the partially purified enzyme has lost some of its activity towards the hydroxypteridines (Table 2). The enzyme system responsible for the oxidation of the hydroxypteridines is now being studied.

Both *p*-chloromercuribenzoate and *o*-iodosobenzoate completely inhibited the enzyme at concentrations of 10^{-4} *M* and 10^{-5} *M* respectively (Table 3). This, as well as the fact that the inhibition is completely reversed by glutathione, indicates that the chicken liver hypoxanthine dehydrogenase belongs to the group of sulphhydryl enzymes.

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Microchemical Method for the Determination of Sakaguchi-positive Antibiotics

ANTIBIOTICS of actinomycete origin containing a guanidine group (such as streptomycin and viomycin) are known to have an antitubercular action. Recently a new antibiotic, primycin, was described[1] as an agent active against various mycobacteria and Gram-positive pathogens (0·02 μgm./ml.), and also giving a positive Sakaguchi reaction.

The colour test (1-naphthol and sodium hypobromite) developed for arginine thirty years ago[2,3] has been modified by using 8-hydroxyquinoline[3] and naphthol-1-sulphonic-8 acid[4], respectively. However, the reproducibility of this reaction was affected to a great extent by the concentration of bromine and hypobromite, respectively. Ziegler[5] was the first to mention a selective bromine substitution with the use of N-bromosuccinimide. This well-defined crystalline compound proved to be extremely well suited for the production of nascent hypobromite in an alkaline medium: on the alkaline hydrolysis of N-bromosuccinimide, the bromine acts as a cation and combines with hydroxyl to form hypobromite.

The optimum concentrations of the reactive components were established, using arginine as a test substance. Light-absorption did not change when 1-naphthol was added to the system directly as an alkaline solution. Under identical conditions, lower values were obtained with 8-hydroxyquinoline. The shape of the arginine curves was similar whether sodium hypobromite or N-bromosuccinimide were used. On increasing the concentration of alcohol from 5 to 80 per cent in the system, the extinction values of the solutions showed a linear decrease. The method of adding the N-bromosuccinimide (dropwise addition, pouring, etc.) affected the intensity of the colour developed. A mean of thirty determinations of arginine (20 μgm./ml.) was $\varepsilon = 0·644$, with a standard deviation of ± 0·0122. Thus, the relative error of the method was ± 0·4 per cent.

The naphthol reagent (0·01 per cent) was prepared by adding to 5 ml. of a 0·2 per cent ethanolic solution of 1-naphthol (anal. grade) a 10 per cent aqueous

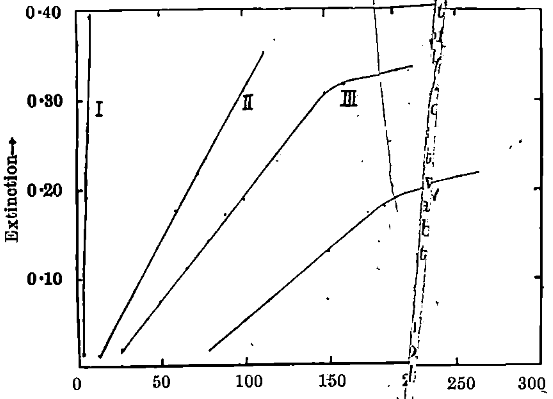

Fig. 1. Curve I, arginine; II, primycin; streptomycin; IV, viomycin

solution of sodium hydroxide (anal ade) to make up exactly 100 ml. The reagent i ble for seven days at 0° C. For the N-bromosu mide reagent, 448 mgm. of that substance (anal. e), equivalent to 200 mgm. bromine, was made in 100 ml. of 10 per cent ethanol; it is stable days at 0° C. A 40 per cent aqueous solution rea was used. The standard solution of arginin s a solution of arginine chlorohydrate (anal. e, La Roche) (10–20 µgm./ml.).

The solutions and reagents a ooled to 0° C. (30 min.), then 5 ml. of the solu to be tested is pipetted into ordinary numbered tubes (1). For a blank test, distilled water and gents were used. Then 2 ml. of naphthol reagent added, the tubes shaken and allowed to stand 3 min. In the meantime, 0·5-ml. portions of bromosuccinimide reagent are pipetted into sep e glass-stoppered test-tubes (2) placed parallel t t-tubes (1), and a medical syringe is filled with a d solution of urea. Then the liquid in test-tubes (1) ution to be tested + naphthol reagent) is rapidly p l into the N-bromosuccinimide reagent in tubes (A vivid red colour appears, the blank remaining urless. Afterwards, the tubes (2) are vigorously s n and 1 ml. of urea solution added in 15 sec. inction values were read in 5 min., against b s, using a Unicam photoelectric colorimeter wi blue filter.

The N-bromosuccinimide nod has been used for the determination of prin , streptomycin and viomycin. The content active substance in unknown solutions was ob d by extrapolation of the standard curves of s ons of known concentration (see Fig. 1). Anti cs dissolved in organic solvents immiscible with er, such as *n*-butanol, may be investigated direct rovided they are shaken with the cooled solution the reagents. In this case, the red colour ap s in the organic phase. Arginine could not be tr erred into the butanolic phase. A close correlati as found to exist between the intensity of biologi action of antibiotics and the ε-values read.

The detection by pa chromatography of Sakaguchi-positive antibiot and arginine was carried out also with the use N-bromosuccinimide. The paper strips were dipp to a 0·01 per cent solution of 1-naphthol in 5 per c methanolic sodium hydroxide, dried in air, the ts developed by a cooled 0·5 per cent solutio f N-bromosuccinimide and stabilized by a 40 per t solution of urea.

Details of the present work will be published elsewhere.

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Activity of Glucose-1-phosphate on Liver Steatosis

FOUR groups of rats were employed in studying the influence of glucose-1-phosphate on liver steatosis, induced by a high-fat, low-protein diet in rats: one, which served as control, was on a normal diet, and the remaining groups were placed on the steatogenous diet of Handler[1] for 30 days. Of the latter groups one did not receive any treatment, one was treated with 3 gm./kgm. of glucose *per os* daily and the last one was treated with 3 gm./kgm. of glucose-1-phosphate daily. Treatment with glucose or glucose-1-phosphate was started 15 days after the administration of the steatogenous diet. The effect of treatment was studied by determining the liver content of total lipids, glycogen and easily hydrolysable phosphorus.

The following procedures were adopted: method of van der Vies for glycogen[2], method of Fenn for total lipids[3], method of Le Page for hydrolysable phosphorus[4].

Table 1

Treatment	No. of animals	Content of rat livers		
		Total lipids (gm./ 100 gm.)	Glycogen (gm./ 100 gm.)	Hydrolysable phosphorus* (mgm./ 100 gm.)
Normal diet	15	4·88±0·23	3·97±0·27	15·22±0·75
Steatogenous diet	10	16·16±0·47	2·21±0·21	7·28±0·32
Steatogenous diet+glucose†	11	12·22±0·37	2·39±0·26	8·09±0·29
Steatogenous diet+glucose-1-phosphate†	12	7·77±0·29	3·77±0·24	13·65±0·58

Data represent the mean ± the standard errors of the means. The differences between groups 1 and 2, 2 and 3, 2 and 4, 3 and 4 were tested statistically. In all cases $P < 0·05$.

* Phosphorus hydrolysable in 7 min. in *N* hydrochloric acid at 100° C.

† Treatment began 15 days after the administration of the steatogenous diet. Glucose and glucose-1-phosphate were administered *per os* at the daily dosage of 3 gm./kgm. Rats were killed 30 days after the beginning of the steatogenous diet.

Glucose-1-phosphate was more effective than glucose both in preventing fatty infiltration of the liver and in bringing it back to normal when steatosis was already established. In the latter case glucose did not show any appreciable activity (see Table 1).

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Inhibiting Effect of Chlorpromazine on the Experimental Production of Liver Cancer

RECENTLY, Griffin, Rinfret and Corsigilia[1] reported that development of hepatic tumours in rats fed on a diet containing 0·06 per cent 3′-methyl-4-dimethyl-aminoazobenzene may be effectively inhibited by hypophysectomy. Chlorpromazine is a phenothiazine derivative, which is used medicinally as a potent depressant for the interbrain. Aron, Guelfi and Voisin[2] reported an atonic effect of this drug on the sensibility of the pituitary gland induced by stress.

The present communication deals with the results of the subcutaneous injection of chlorpromazine on the incidence and growth of tumours induced by 4-dimethyl-aminoazobenzene. In these experiments chlorpromazine injection was begun with a dose of 100 μgm. in 1 ml. of cold sterile distilled water and continued at intervals of two days, increasing by 100 μgm. per dose after about every four injections. A group of fifteen rats of mixed breed weighing 70–153 gm. were fed for the first month with a diet containing 0·02 per cent 4-dimethyl-aminoazobenzene, during the second month with one containing 0·04 per cent, and thereafter with a diet containing 0·06 per cent, until the dose for each rat totalled about 500–600 mgm. In addition, 1 ml. of distilled water was injected every two days over a period of six months (group 1). A second group of twenty rats was given the same diet but with injections of chlorpromazine (group 2). A third group consisted of fifteen rats fed on the basal diet without 4-dimethylaminoazobenzene but given chlorpromazine. The basal diet consisted of unpolished rice containing 2·71 mgm. riboflavin per kgm. and 73·7 gm. protein per kgm., supplemented by unlimited quantities of water and some greenstuff, daily. The amounts of basal diet consumed totalled 1,011–1,154 gm. per rat. The experiments, which began on June 16, were terminated six months later.

During the course of this investigation, it was noted that, among the animals which received chlorpromazine until they died or those killed at the end of the experiment, rats weighing 70–100 gm. showed more decrease in weight and higher mortality due to respiratory infections than those weighing 110–153 gm., suggesting toxicity of the drugs. Most of the thirteen rats which were given about 505–599 mgm. of 4-dimethyl-aminoazobenzene for a period of 162–183 days (group 1) developed hepatic cancer (Fig. 1). On the other hand, the group given chlorpromazine as well (group 2) showed carcinoma of the liver in 1 out of 6 rats which survived the same period. Further, in group 1, the induced liver cancer attained considerable size after six months when compared with the livers of group 2, and metastases sometimes appeared in the abdominal lymph nodes and lungs. These results may suggest delay due to chlorpromazine in the formation of hepatic neoplasia induced by 4-dimethyl-aminoazobenzene.

Histologically, noticeable alterations were found in the hypophysis and adrenal glands as well as the liver. Ine two goups treated with chlorpromazine, atrophy the pititary gland was noticed, and the anterior be conisted largely of the chief cells (chromopbes) vith the number of chromophils markedly creasd. In the adrenal glands, pycnosis of nucleu and vcuolation of cytoplasm were seen in the coal cels. Parenchymal cells of the liver were somhat arophic and degenerative. Precancerous cges, such as nodular hyperplasia or cholangioosis, were rarely seen except in one case where hepma developed, although cirrhotic changes of the livere observed.

Recentl Peters, Gärtner and Krais[3] have shown that a conation of radium therapy and chlorpromazine ngs about in mice an increase in the effect of ration on ascitic tumours, and that the effect of thrug is based on an increased inhibition of mitoses, reduction of the excitatory reactions produced bradiation and an increased incidence of damageds and of cells in the stages of division. It may be posed, therefore, that the inhibitory effect of tdrug for carcinogenesis induced by 4-dimethyl-aoazobenzene is due to the delay in transition from tl recancerous to the cancerous stages.

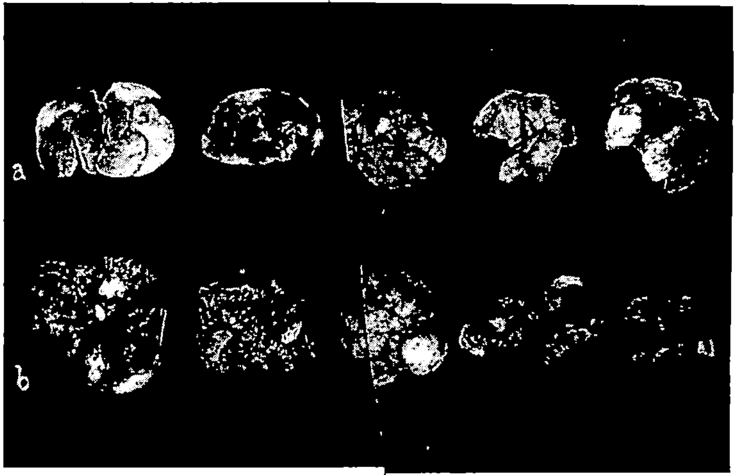

Fig. 1. Livers obtained after 180–183 days. Upw: group 2 (4-dimethyl-aminoazobenzene and chlorpromazine). Lower row: gro 4-dimethyl-aminoazobenzene)

Longer experim with more experimental animals are under with the view of obtaining definite conclusions.

We thank Shion and Co., Ltd., for the gift of chlorpromazine ('termin'), and Prof. K. Hotta and Dr. T. Oyama their encouragement and advice. This work assisted by a grant from the Niihama Psychiatric spital Foundation (Dr. Y. Fujita).

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Antibody Formation by Isolated Cells of Hen Spleen after mixing with Antigen *in vitro* and Transfer to Chicks

Recently, Šterzl[1] used newborn animals as recipients for the transfer of tissues producing antibodies as infant animals cannot produce antibodies after administration of antigens during the early post-natal period[2]. This experimental model has been used successfully by Mitchison[3], who evoked antibody production in chicks after transfer of spleen tissue from strongly immunized hens. Dixon and Weigle[4], however, were unable to demonstrate the usefulness of infant animals for the demonstration of antibody formation after transfer of tissue from animals immunized 24 hr. previously. In further work, when cells mixed with antigen *in vitro* were transferred, results were again negative[5]. In the work reported here, the possibility of using infant animals soon after birth as recipients was tested.

Normal white Leghorn hens (weight 1·5–2 kgm.) were used as donors of spleen cells. No antibodies to *Salmonella paratyphi* B and *Brucella suis* could be found in their serum by agglutination. These were used as antigen. Spleen cells were isolated according to Šterzl[6]. Isolated spleen cells were diluted quantitatively (6 × 10^7) according to counts in a Bürcker chamber either with phosphate physiological saline or directly into a suspension of heat-inactivated bacteria (*Salmonella paratyphi* B 12 × 10^7; *Brucella suis* 36 × 10^7). After 10 min of incubation at room temperature they were injected by the intraperitoneal route into Leghorn chicks 48–56 hr. after hatching. 1 ml. of suspension was administered to each bird. Blood from the chicks was obtained by cardiac puncture 3, 5, 7, 9, 12, 16, 24 and 31 days after transfer of a mixture of spleen cells and bacterial antigen. Further details of the layout of the experiment and results are apparent from Table 1. Positive results were obtained with the mixtures; but results were negative when only a suspension of bacteria or spleen cells alone was given.

Cells must be transferred to animals of the same species. Results were negative when spleen cells from rabbits mixed *in vitro* with antigen *Brucella suis* was given to chicks (Table 1).

The results of Dixon and Weigle[4,5] are not in agreement with ours. These authors conclude that infant animals are not suitable as recipients and that the environment of infant animals cannot provide conditions necessary for the realization of the first phase of antibody formation. On the other hand, the results presented here, together with those of Šterzl[1,6], are supported by the work of Simonsen[7], who injected reticulo-endothelial cells from adult hens into chick embryos and young chicks. Using the Coombs test he detected antibodies produced by adult cells against the antigens of the recipient.

It is concluded that infant animals incapable of an antibody reaction to an antigenic stimulus are suitable for studying the conditions for antibody formation by isolated mesenchymal cells.

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Table 1

Source of cells	Amount of cells injected into recipient	Amount of antigen	Age of chicks (in hr. after hatching)	No. of chicks in experiment	No. of chicks surviving at least 12 days after transfer	Maximum titre 5–9 days after transfer*	Beginning of antibody formation after transfer (in days)*
Spleen of normal adult hen	6 × 10^7	*S. paratyphi* B 2 × 10^7	48–56	19	10	16, 8, 16, 16, 8, 16, 16, 16, 8, 8	5, 5, 5, 5, 5, 5, 5, 5, 7, 7
Spleen of normal adult hen	6 × 10^7	—	48–56	5	2	0, 0	negative until 31st day
—	—	*S. paratyphi* B 12 × 10^7	48–56	8	5	0, 0, 0, 0, 0	16, >31, >31, >31, >31
Spleen of normal adult hen	6 × 10^7	*Brucella suis* 36 × 10^7	48–56	31	20	128, 64, 128, 64, 128, 32, 64, 128, 128, 32, 32, 8, 8, 32, 8, 16, 8, 8, 0, 0	3, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 5, 7, 7, 7, 9, 9, >31, >31
Spleen of normal adult hen	6 × 10^7	—	48–56	10	5	0, 0, 0, 0, 0	Negative until the 31st day
—	—	*Brucella suis* 36 × 10^7	48–56	7	4	0, 0, 0, 0	>12, >12, >12, 16
Spleen of normal adult rabbit	6 × 10^7	*Brucella suis* 36 × 10^7	48–56	10	7	0, 0, 0, 0, 0, 0, 0	12, 31, 31, >31, >31, >31, >31
Spleen of normal adult rabbit	6 × 10^7	—	48–56	6	4	0, 0, 0, 0	Negative until the 31st day

* Figures are arranged in such a way that those situated in the same place in each column always correspond to one experimental animal.

Presence of Plasma Globulins in the Hyaline Tissue in Cases of Silicosis

Previous chemical results[1] obtained by one of us show that the hyaline tissue in cases of silicosis contains appreciable amounts of non-collagenous proteins. In fact the determination of the amino-acid composition, and the ultra-violet absorption spectrum of the residue left after extraction of collagen by autoclaving, suggested the presence of proteins chemically related to β- or γ-plasma globulins. These proteins constitute up to one-half of the total protein content of the original tissue. In order to ascertain beyond all doubt the presence in silicosis hyaline tissue of plasma globulins, it was decided to investigate whether proteins having the immunological properties of plasma globulins could be identified in it. Hyaline tissue was therefore isolated carefully from the pulmonary nodules of three cases of typical silicosis immediately after autopsy. The tissue was washed and homogenized in saline with a blade blendor (15 min. at 30,000 rev./min., excessive heat being prevented by water cooling). The resulting suspension was then washed and homogenized six further times with saline to remove all traces of serum or lymph. The serum of a rabbit previously immunized with normal human serum was absorbed twice with a third of its own volume of homogenized and washed silicosis hyaline tissue and was then used as antiserum for immunoelectrophoresis (using the technique of Grabar and Williams[2]). The antigens used were a pooled normal human serum electrophoretically separated in an agar plate; as a control, the same antiserum was absorbed with an equal amount of normal human lung treated in the same way as the silicosis hyaline tissue.

The results of these experiments are shown in Fig. 1; while the unabsorbed immune rabbit serum reacts against the human pherogram with fourteen different bands of precipitation (not all visible in Fig. 1, 2,4,5) and no changes are observed after absorption with normal lung (Fig. 1, 1), the band of reaction with the protein fraction electrophoretically spread in the zones of β- and γ-globulins disappears when the immune serum has been absorbed with silicosis hyaline tissue, all other bands remaining unmodified (Fig. 1, 3). It is concluded that a single type of rabbit antibodies against human serum proteins has been removed by absorption with silicosis hyaline tissue.

As a more quantitative test, aliquots of the anti-human rabbit serum, (i) untreated, (ii) absorbed with normal lung homogenate, and (iii) absorbed with silicosis hyaline tissue have been titrated against *D*-sensitized Rh-positive red cells (indirect Coombs test). It is apparent from Table 1 that the same amounts of silicosis hyaline tissue homogenates absorb about thirty times more anti-γ-globulin antibodies than the normal lung homogenate. Three different samples of normal lungs and the hyaline tissue from three cases of silicosis have been analysed by these techniques, giving identical results.

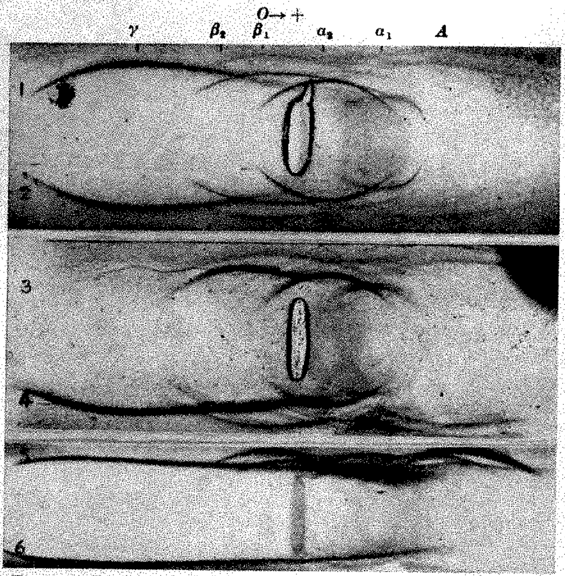

Fig. 1. Immunoelectrophoresis in agar plates (Grabar's technique). Antigen subjected to electrophoresis: whole normal human serum. Immune sera (in the longitudinal wells). (2, 4, 5) Serum of rabbit immunized with whole human serum, untreated; (1) same, absorbed with homogenate of normal human lung; (3) same, absorbed with homogenate of silicotic nodule; (6) serum of rabbit immunized with homogenate of silicotic nodule. *A*, Albumin; α_1, α_2, β_1, β_2 and γ refer to the respective globulins

Table 1. The antiglobulin serum is titrated against Rh-positive red cells, strongly sensitized with an incomplete anti-D serum. Red cells (normal and sensitized), homogenates of normal lung and of silicotic nodules, were washed ten times before being used for absorption. 5, 4, 3, 2, 1 = decreasing degrees of agglutination; 0 = no agglutination

	Anti-human globulin serum									
Absorbed (0 gm./ml.) with	Dilutions									
	2^{-3}	2^{-4}	2^{-5}	2^{-6}	2^{-7}	2^{-8}	2^{-9}	2^{-10}	2^{-11}	2^{-12}
Non-sensitized red cells	5	5	5	5	5	5	4	3	2	2
Rh-sensitized red cells	5	4	5	4	4	3	2	1	0	0
Normal lung	5	5	5	4	3	3	2	1	0	0
Normal lung	5	5	5	5	5	5	4	3	2	1
Normal lung	5	5	5	5	5	5	4	2	1	0
Hyaline silicotic tissue	3	2	1	0	0	0	0	0	0	0
Hyaline silicotic tissue	1	0	0	0	0	0	0	0	0	0
Hyaline silicotic tissue	3	3	1	0	0	0	0	0	0	0

Homogenized and washed silicosis hyaline tissue, prepared similarly to that used in absorption experiments, was then injected intraperitoneally into rabbits, and antisera were quickly obtained which reacted with normal human serum electrophoretically separated in an agar plate, giving a single line of precipitation extending through the zone of β- and γ-globulins (see Fig. 1, 6). The occurrence in these anti-silicosis hyaline tissue sera of antibodies specific for antigens peculiar to the silicotic nodule, but absent from normal human serum, is being investigated.

We can therefore assume that the acellular silicosis hyaline tissue contains a globulin fraction which may be identified with a plasma-globulin having definite antigenic properties and an electrophoretic mobility corresponding to that of β- or γ-globulins. It is well known that circulating antibodies[3] and properdin[4] belong precisely to this fraction.

Our results are therefore consistent with the hypothesis that an antigen–antibody or a properdin-substrate precipitation plays a part in the genesis of silicosis hyaline tissue. Further details will be published elsewhere[5].

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Transfer of Sheep Keds, *Melophagus ovinus* (L.), from Ewes to their Lambs

It has regularly been stated[1,2] that sheep keds (presumably of all ages) are transferred from ewes to their lambs. To this transfer has been attributed much of the decline in ked populations on ewes during the spring and summer[3]. In detailed studies of behaviour of sheep keds on ewes after parturition, it has been observed at Lethbridge that only newly emerged keds are transferred to the lambs. The older keds on the ewes gradually die off as a result of infection with *Trypanosoma melophagium*[3]. These conclusions were drawn from observations that no puparia appeared on lambs until the latter were 4–6 weeks old, and that all keds seen on lambs up to four weeks of age were small ones. Bequaert[4] has summarized the work of other authors, and claims that the ked deposits its first offspring in 14–30 days after it has emerged. On 10 lambs examined at Lethbridge, there were found an average of 11·6 ± 6·53 keds and no puparia on lambs two weeks of age, 43·3 ± 23·2 keds and 1·5 ± 1·8 puparia at four weeks of age, and 137·3 ± 59·84 keds and 25·5 ± 18·34 puparia at six weeks of age.

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Effect of Age of Young Dairy Calves on Dry-Matter Digestibility of Alfalfa Pellets

Successful attempts to rear dairy calves on high-quality forage (dry-matter digestibility more than 70 per cent) without grain feeding have been reported by McCullough *et al.*[1], McMeekan[2] and Roy *et al.*[3]. Utilizing similar forage, Preston *et al.*[4] investigated the effect of age on digestibility and intake with calves 3–9 weeks old. Their findings suggested that: "(*a*) rumen development is anatomical; (*b*) the development of microflora—in respect of their ability to ferment and digest grass dry matter—is instantaneous or practically so, and is dependent on there being a suitable substrate in the rumen".

Since all previous work with young calves had been done with highly digestible forage, it seemed desirable to determine the apparent effect of age on the digestibility of a lower-quality forage. Four Guernsey calves were fed whole milk at 10 per cent of birth weight and alfalfa meal pellets free choice from birth to 12 weeks of age. Morrison[5] lists the *TDN* of similar alfalfa as 57 per cent. Dry-matter digestibility was determined from grab samples at weekly intervals from 6 to 12 weeks of age. Previous work by Kane *et al.*[6] and Cook *et al.*[7] had shown the chromogen technique[8] to be suitable for similar hays, and the work of Preston *et al.*[4] had indicated that milk fed simultaneously with forage did not affect the digestion of grass. The pellets were unpalatable to the calves and intake was low until the calves were 10–12 weeks of age. The mean intake was 7 lb. whole milk and 2·0 lb. of pellets.

Table 1. Dry-Matter Digestibility of Forage and Average Daily Gain of Calves

Item	Calf No.	Week of age						
		6	7	8	9	10	11	12
Dry-matter digestibility (per cent)	1	53	54	55	53	53	57	55
	2	53	53	55	55	56	55	57
	3	53	57	54	55	56	56	53
	4	53	54	54	57	54	55	55
Average digestibility (per cent)		53	55	55	55	55	56	55
Average daily gain (lb.)		0·6	0·7	0·2	0·0	1·3	0·9	1·4

Average dry-matter digestibilities and daily gains for the four calves are shown in Table 1.

The results seem to indicate little or no change in apparent dry-matter digestibility from 6 to 12 weeks. The improved rate of gain after 10 weeks corresponds with the observation that the calves were unable or unwilling to consume enough alfalfa pellets for good growth before this age. The results seem to agree with the observations of Preston[4] and emphasize the ability of the calf to utilize forage at a very early age.

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Sacculina gonoplaxae Guérin–Ganivet, 1911, a Rhizocephalan Parasite New to British Waters

Sacculina gonoplaxae Guérin–Ganivet, 1911, is a Rhizocephalan parasite on *Goneplax angulata* (Pennant) [= *Gonoplax rhomboides*, L.]. Full details of the taxonomy of the genera of the family Sacculinidae and of the species of the genus *Sacculina* are given by Boschma (1955)[1].

On April 29, 1957, a single specimen was found on a *Goneplax angulata*, taken from the stomach contents of a cod trawled in 50–57 fathoms (about 100 m.) approximately eight miles north-west of Bradda Head, Isle of Man. The host had a carapace breadth of 23 mm. Apparently digestion of the crab had not yet taken place, suggesting that it had been recently swallowed. The dimensions of the parasite were: larger diameter, 13 mm., smaller diameter, 7 mm.

Dr. R. B. Pike, of the Marine Station, Millport, Isle of Cumbrae, in a personal communication, informs me that he obtained a *Sacculina* on *Goneplax angulata* on November 3, 1955, which he had provisionally identified as *Sacculina gonoplaxae*. This specimen was collected by Mr. Latham, and was taken in the Fairlie Channel, Firth of Clyde, in about 30–40 m. Dr. Pike's specimen conformed to the following measurements: width of the carapace of *Goneplax angulata* (host), 19 mm.; greatest width of parasite, 12 mm.

Both specimens were sent to Dr. Boschma, who identified them as *Sacculina gonoplaxae*.

Up to now, *Sacculina gonoplaxae* has been recorded from the Gulf of Cadiz, from off the Atlantic coast of Morocco, and from various localities in the Mediterranean. The distribution of the parasite can now be extended northwards to the Irish Sea and the Firth of Clyde.

I wish to thank Dr. H. Boschma, director, Rijksmuseum van Natuurlijke Historie, Leyden, Netherlands, for his help in identifying the specimen, and Dr. Pike for allowing his specimen to be used.

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Influence of Photoperiod on Imaginal Diapause in Acridids

It has recently been shown[1] that the rate of sexual maturation in the desert locust (*Schistocerca gregaria* Forsk.) in the laboratory in London is influenced by the length of the daily photoperiod. Adults emerging in winter or kept in artificial photoperiods corresponding with winter day-length mature more rapidly than those emerging in summer or kept in artificial summer day-length.

The red locust (*Nomadacris septemfasciata* Serv.) has its main outbreak area in the Rukwa Valley of Tanganyika, between latitudes 7 and 9° S. The adults emerge in March or April and undergo a prolonged diapause of 8 or 9 months, finally laying their eggs during the rainy season in November and December. Uvarov[2] and Hamilton[3] showed that this diapause was not obligatory and that rapid oviposition could be induced by keeping the locusts at high temperatures. Hamilton found, however, that this could only be done for one generation, after which diapause intervened in spite of high temperature. A series of breedings which has been carried out in this laboratory over a period of three years has shown that the occurrence of diapause in conditions of constant temperature and humidity is seasonal. Locusts which emerge as adults in spring and summer mature fairly rapidly in 5–10 weeks, whereas those which emerge after the end of July or the middle of August fail to mature until the following March or April. They have, therefore, a diapause of 7–8 months, comparable with that of field locusts. Whether or not a group enters diapause depends entirely on the time of the year and not on the generation. Thus the latest members of the *F*1 progeny of overwintered parents may enter diapause at the same time as the *F*2 progeny ; on the other hand, the earliest emerging *F*2 progeny may emerge before August, in which case a third generation is produced without diapause.

The windows of the breeding-room are not screened, and it has been shown that the occurrence of the diapause is entirely governed by length of day. Two artificially lit cabinets were set up, in one of which the daily photoperiod was gradually increased as in spring and in the other it was decreased as in autumn. Newly emerged adults were kept at various times in these two cabinets, and it was found that, whatever the time of the year, maturation periods appropriate to the artificial seasons were induced. Adults, for example, which emerged in the 'spring' cabinet when the photoperiod had increased to 11½ hr. (as in mid-March) matured in 69 days, while those which emerged in the 'autumn' cabinet when the photoperiod had decreased to 12½ hr. (as in mid-September) took 223 days to mature. Continuous breeding without the intervention of diapause has now been maintained for more than two years by the use of artificial lighting. Full details of the experiments will be published later.

Maturation of natural diapause adults occurs in spring ; but it has been shown that the lengthening days are not required for the termination of diapause, which occurs at the same time if the locusts are deprived of the extra hours of daylight after the shortest day.

Seasonal change in length of day at the northern end of the Rukwa Valley (about 7° S.) amounts to only 50 min. in the year ; but the most rapid decrease in length of day occurs in March, at the time when the adults are emerging. From March 1 to April 1 length of day falls by 14 min., from 12 hr. 12 min. to 11 hr. 58 min. It has not so far been practicable artificially to reduce photoperiod by such small amounts. Preliminary experiments with stationary photoperiods suggest that these are less effective in establishing prolonged diapause than decreasing ones, even although the latter may start at a much higher level. Stationary 8-hr. photoperiods allow maturation in 5 or 6 months, and in one experiment adults kept with photoperiods of 8, 11 and 13½ hr. matured in 163, 154 and 78 days respectively. This suggests that there is a critical field for effects on maturation lying between 11 and 13½ hr. Since length of day in the natural habitat varies from about 11½ to 12½ hr. the possibility that it is responsible for the establishment of diapause must be considered.

The grasshopper *Anacridium aegyptium* L., which inhabits the Mediterranean region, normally has only one generation in the year, the adults emerging in July and August but not ovipositing until the following spring. This species, like *Nomadacris*, also enters diapause in the constant laboratory environment. Adults which emerge in spring mature in 7–12 weeks, whereas those which emerge after the end of May usually do not mature until January, February or March. Here again rapid maturation of summer-emerged individuals can be induced by keeping them in artificially increasing day-length. In this species diapause appears so early in the year that it is necessary to suppose that it is only the increasing spring day-length which allows rapid maturation and that it is inhibited by the long days of summer as well as by the decreasing day-length of autumn. This has been shown by Corbet[4] to be the position in the larval diapause of the emperor dragonfly, in which immediate metamorphosis from the last larval instar to the adult occurs in increasing photoperiods, but is inhibited both by diminishing and by stationary long photoperiods.

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Ultra-Structure of the Choanocyte Collar-Cells in Freshwater Sponges

As early as 1896 Bidder[1] mentioned the presence of fibrils in the collars of the relatively large collar cells of calcareous sponges. Later, the very existence of such a structure was denied by several authors though confirmed by a few, particularly De Saedeleer[2] and Dubosq and Tuzet[3]. Kilian[4] has succeeded in demonstrating the existence of fibrillar struc-

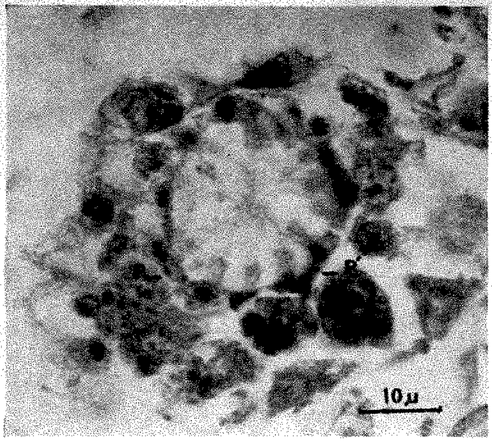

Fig. 1. General view of a 'vibratile nest' of *E. fluviatilis*, as observed with the optical microscope (immersion). *P–P'* represents the plane through which a similar 'vibratile nest' has been sectioned for observation with the electron microscope

tures in the much smaller collars of siliceous sponge collar cells. That author observed by means of the electron microscope whole Spongillidae collar cells which were previously dilacerated and fixed. Yet he stated himself that the fixatives he used caused severe contractions of the collars. De Saedeleer[2] is the only one who suggested that the collar should be considered as an 'eel-trap' made up from separate tentacles.

It was generally admitted that the fibrils were embedded in a common hyaline wall, which they would sustain and eventually make contractile.

We tried to solve the problem of the true structure of the collars by the observation of ultra-thin sections with the electron microscope.

The specimen of Spongillidae studied here was probably *Ephydatia fluviatilis*. The absence of gemmulæ in the sample collected made a more accurate determination so far impossible. The material was fixed in a solution of 2 per cent osmium tetroxide buffered at a pH of 7·4.

Fig. 1, representing a 'vibratile nest' of *E. fluviatilis* as observed with an optical microscope, will allow a better and easier interpretation of the electron micrographs. In Fig. 2 one can see that the collar consists only of about thirty fibrils, which have a diameter of 0·10–0·15μ. They are heterogeneous, visibly consisting of an osmiophil sheath, surrounding a less dense pith, itself coated by a less dense layer. Their insertion in the cytoplasm does not show any particular differentiation.

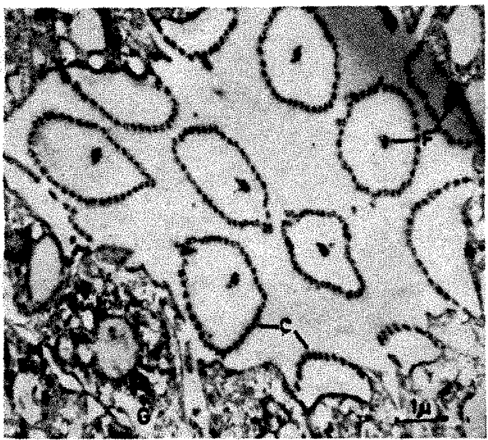

Fig. 2. Electron micrograph of a vibratile nest, cut as indicated in Fig. 1. *C*, collars; *F*, flagella; *G*, Golgi apparatus; *M*, mitochondria

In structure, as well as in diameter, they are like the microvilosities observed on the surface of the flagellated cells in various invertebrate tissues, for example, in the gut-cells of earthworms[5]. The collar seems to be composed of these fibrils only; nowhere can they be seen to be embedded in any common sheath. Nevertheless, sometimes two, or less frequently several, fibrils may be welded together by bridgelike structures. Moreover, such bridges seem also to exist between microvilosities in the gill-cells of freshwater mussels[5].

Several micrographs which have so far been examined strongly suggest that the interfibrillar bridges exist only near the bases of the fibrils, which would be completely free along their length. We have not seen, either in longitudinal or in transverse sections, any evidence which could support the idea of fibrils, consisting of alternate more and less dense parts. Such a structure, as mentioned by Kilian[4], seems to be an artefact due to contraction, as he indeed suggested himself.

As it seems to be established from our present investigations that the collars really have a web-like structure, this has impelled us to reconsider the so far generally accepted hypothesis of the functioning of these collars.

A more detailed account of this work, which is still in progress, together with further observations of the ultra-structure of the complete collar-cells, will be published elsewhere.

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Relationship between Some Clovers and *Ditylenchus destructor* Thorne, 1945

In a previous communication[1] the nematode *Ditylenchus destructor* Thorne, 1945, was recorded from the roots of a number of plants commonly found on Prince Edward Island. Two of these plants, *Trifolium pratense* L. and *T. hybridum* L., are abundant in most grass fields on the Island. Further examinations of roots of these two species from fields infested with *D. destructor* showed that there were considerable numbers of the nematode in the rhizospheres (the soil adhering to the roots after they have been dug and gently shaken) and some within mature roots of these plants but very few in or about young roots. Adults and larvæ were both present in the rhizospheres of plants taken from a frozen field in February, suggesting that there may be no special

Table 1. NUMBERS OF *Ditylenchus destructor* IN RHIZOSPHERES OF VARIOUS LEGUMES, 1954–56. TOTAL COUNT FROM SIXTEEN PLANTS, FOUR TAKEN AT RANDOM FROM EACH PLOT

	1954		1955		1956
	July 27	Sept. 7	June 21	July 15	Sept. 5
Trifolium pratense	1	1	185	5,430	9,651
T. hybridum	1	6	528	3,589	—
T. repens	1	1	174	1,233	—
Melilotus officinalis	0	3	22	305	2,666*
Medicago sativa	5	0	72	225	43

* One plot (four plants) only.

overwintering stage of the nematode such as is found in *D. dipsaci*.

In 1953 counts of *D. destructor* in an infested field showed that in samples taken from bare soil 5–8 cm. distant from *T. pratense* there was one specimen in 10 c.c. of soil, whereas in the rhizospheres of these plants there were more than 2,000.

In 1954 a small-plot experiment was commenced in a field infested with *D. destructor* to determine the species of plants that favour an increase in the nematode population. The plots were arranged in a balanced incomplete block design in four replications and planted in June 1954 with 13 species : *Trifolium repens*, *T. pratense*, *T. hybridum*, *Medicago sativa*, *Melilotus officinalis*, *Agrostis alba*, *Phalaris arundinaceae*, *Phleum pratense*, oats, barley, soy bean and potato. The annual species were replanted in 1955 in the same plots as in 1954. Random samples of four plants from each plot were examined at intervals during the summer of 1954 and of 1955. In 1956 samples of *T. pratense*, *M. officinalis*, *M. sativa*, *P. arundinaceae* and *Phleum pratense* were taken in September only. The numbers of *D. destructor* in the rhizospheres of each sample were determined by a modified Baermann funnel technique. The roots were stained with hot acid-fuchsin lacto-phenol for subsequent examination.

In 1954 fewer than one of *D. destructor* per sample were found in the rhizospheres of any plant species. None was found in the stained roots. Root necrosis was not observed.

In the same plots in 1955 *D. destructor* was abundant in the rhizospheres of the legumes, particularly of the three species of *Trifolium* (Table 1). The numbers found in the rhizospheres of the other plants were similar to those in 1954. Root necrosis was observed in the three species of *Trifolium*, but not in *M. officinalis* or *M. sativa*.

In 1956 large numbers of *D. destructor* were again found in rhizospheres of *T. pratense* and also of *M. officinalis* but not of *M. sativa*. Root necrosis was present in *M. officinalis* but was not as severe as in *T. pratense*. No necrosis was observed in *M. sativa* roots.

Examination of the stained roots of the three species of *Trifolium*, sampled in July 1955, showed that the cortical tissues of the main root had decayed and that the epidermis, although dead, still surrounded the cortex. A very large number of nematodes, including *D. destructor*, were found beneath the dead epidermis. Necrosis of the cortex of clover roots seems to be common in Prince Edward Island and is not confined to fields infested with *D. destructor*. The cause of the root necrosis is not known although the symptoms are similar to those described by Fezer[3] of a root rot caused by *Fusarium* spp.

These observations suggest that the increase in numbers of *D. destructor* may be associated with the root necrosis of the clovers. *D. destructor* is able to live on fungi[2] and hence the mature clover plant, affected by root necrosis, may provide a favourable environment for fungi upon which the nematode is able to feed, thus leading to a large increase in the nematode population.

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A Method for isolating *Pseudomonas mors-prunorum* Phages from the Soil

BACTERIOPHAGES active against plant pathogenic bacteria have been isolated from various sources, including diseased plant material[1], seed[2] and the soil[3]. We have found the soil beneath diseased cherry, plum, and apricot trees to be a prolific source of phages for *Pseudomonas mors-prunorum* Wormald, the organism causing the bacterial canker disease of stone fruits. Phages were isolated by the following method.

About 150 gm. of soil, consisting of several smaller samples taken from near the crowns of young trees in cultivated stone-fruit orchards, were placed in sterile glass jars and enriched with a 48-hr. culture of *Ps. mors-prunorum* (strain *NA*3) in nutrient broth plus 2 per cent glycerine. This appears to be essential, as attempts at recovering phages from unenriched soils were unsuccessful. The mixture was shaken periodically during the next 48 hr., after which the free liquid was decanted and partially clarified by ordinary filtration followed by centrifuging at 3–4,000 rev./min. for 30 min. Next, 5 ml. of the supernatant liquid was transferred to a stoppered 20-ml. bottle and shaken vigorously with 0·1 ml. of chloroform to kill the bacteria[4]. After the chloroform had settled out, 1 ml. of the treated soil extract was withdrawn and examined for plaque formation by the poured plate method[5], using *NA*3 as the propagating strain and a 1 per cent agar medium containing peptone (0·5 per cent), yeast extract (0·3 per cent) and glycerine (2 per cent), adjusted to *p*H 7·2 with a phosphate buffer. The surface of the agar was dried thoroughly at 37° C. and the plates incubated at 25° C. Plaques, varying in number with different soil samples from a few to several hundred per plate, were observed after 24 or 48 hr. Single plaques were picked off and the phages propagated on young cultures of *NA*3 in a broth of the same constitution as the plating medium. The phages were purified by streaking, with a glass rod, a small drop of a lysed culture across the dried surface of an agar plate sown with 1 ml. of a 48-hr. culture of *NA*3. Isolated plaques thus obtained were cut from the agar and re-propagated in broth culture. The whole process was repeated 2–3 times and the phages finally brought to high titre by serial transmissions in broth cultures.

Chloroform treatment was used as an alternative to filter-sterilization and proved very effective ; contaminant bacteria were rarely encountered on the isolation plates and never in sufficient numbers to interfere with plaque formation. By avoiding filtration the isolation procedure was considerably simpli-

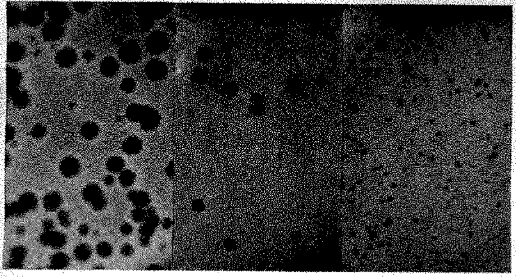

Fig. 1. Phages with different plaque forms, isolated from orchard soils using a single propagating strain, *NA3*, of *Ps. mors-prunorum* (actual size)

fied and several soil samples could be handled simultaneously. Heat treatment (58° C. for 30 min.) was also tried as an alternative to filtration, but led to inactivation of the phages.

In a test of the method on twelve soil samples taken from beneath cherry, plum and apricot trees in several different localities, phages were isolated from nine of the samples. The isolates were classified into three groups on the basis plaque morphology (Fig. 1), namely, large (2 mm.) circular plaques with a 'halo'; medium sized (1 mm.) irregularly-shaped plaques; small (0·5 mm.) pin-point plaques. These groups, which have been further differentiated by cross-resistance tests, were obtained using a single enrichment strain, *NA* 3, of *Ps. mors-prunorum.*

This work was carried out at East Malling Research Station.

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Occurrence of Soft Rot Bacteria in Scottish Soils

A method of isolating soft rot bacteria from soil using immature potato tubers as a form of enrichment medium was described by Kerr[1]. He found that of twenty Scottish soils examined all contained Gram-negative bacteria capable of rotting potato tuber slices.

When the term 'soft rot bacteria' is employed most workers generally assume that this implies 'coliform soft rot bacteria', that is, *Erwinia carotovora* and related species. With this assumption is associated the prevalent view that soft rot coliforms are commonly present in soils, and can be isolated readily from them. On this basis it is usually considered that the organisms isolated by Kerr were *Erwinia* spp., although he did not identify the genus to which his isolates belonged.

A study of the soft rot bacteria in Scottish soils was undertaken in connexion with investigations on black leg disease of potato, caused by *E. atroseptica*. During the years 1956 and 1957, seventeen soil samples, taken from different localities, and including peaty, shale, sandy and clay types, all under current cropping, were tested for the presence of soft rot bacteria. Kerr's technique was used, and soil suspensions were plated out directly on the salicin agar described by Noble and Graham[2], and on the pectate gel mentioned by Dowson[3]. A number of isolates were obtained from each soil sample by all three methods, which were capable of rotting potato tuber slices at 26° C. Most of these were Gram-negative bacteria, and further examination showed them to be members of the genus *Pseudomonas*. Many of these pseudomonads do not produce a fluorescent pigment on meat infusion agar, but will do so in a medium containing inorganic salts plus an organic acid such as gluconic acid, treated with 8-hydroxyquinoline to reduce the heavy metal content, after the method devised by Paton[4]. Such organisms are therefore easily confused with coliforms unless adequate tests are applied.

In other experiments, heavy suspensions of a mixture of two strains of *E. atroseptica* were poured on to 500 gm. of various soils (sandy, clay, shale, peat and unsterilized John Innes compost) contained in Kilner jars with loose-fitting lids. The jars were buried up to the neck in soil in the open during November 1955 and 1956, while others were kept at room temperature. Using Kerr's method and the salicin agar technique, isolations from all jars, in May 1956 and 1957, yielded only soft rot organisms of the genus *Pseudomonas*, none of which could be specifically identified. Similar pseudomonads have been obtained from naturally rotting tissues of a number of plants, including potato, carrot, leek, celery and cauliflower.

Some Gram-positive organisms were associated with rotting when Kerr's technique was used for isolation, and all were members of the genus *Bacillus*. *B. polymyxa* (Voges–Proskauer positive) was fairly common, but *B. macerans* (Voges–Proskauer-negative) was obtained on two occasions only.

It is concluded that in enrichment cultures from Scottish soils the dominant soft rot organisms are pseudomonads, and not coliform bacteria.

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Pectin-decomposing Strains of *Pseudomonas*

The ability of certain members of the genus *Pseudomonas* to cause a soft rot of plant tissue or to degrade pectin preparations has been known for some time[1]. It is surprising that this character of the pseudomonads has not been given more attention, considering the very common occurrence of members of this genus in Nature and the economic importance of soft rots in plant tissue.

While investigating cases of tomato stem necrosis or soft rot, commonly ascribed to *Erwinia carotovora*, it became evident that the coliform types of pectolytic bacteria could not be determined in the majority of specimens. The isolates most frequently obtained were members of the genus *Pseudomonas* as characterized by Dowson[2]. Two or more members of this genus were usually present in each case as could be shown by colony appearances on a nutrient agar containing sucrose. At least one strain from each specimen of tomato was found to be active in rotting sections of tomato stem and it produced the typical disease symptoms on inoculation into vigorously growing tomato plants. Cucumber, turnip and potato slices were actively rotted and inoculation into the stems of healthy potato plants resulted in a condition similar in appearance to that known as 'black leg' (*E. atroseptica*). These strains liquefied a 2 per cent pectate gel (A.S.P. Chemical Co.) superimposed on a calcium agar base as in the double layer method of Wieringa[3]. This is at variance with the statement of Dowson[2] that species of *Pseudomonas* do not liquefy pectate gel.

Following this observation, approximately 400 strains of *Pseudomonas*, isolated over a number of years from a variety of sources such as soil, water and the gut of the earthworm as well as healthy and diseased plants, were screened for active pectolysis on cucumber slices. A culture was considered active if the tissue was reduced to a pulp after 24 hr. incubation in a Petri dish containing damp filter paper at 27° C. On this basis about 5 per cent of the strains tested were actively pectolytic and a further 5 per cent produced a slower (2 days) but similar action. As these strains were not selected originally on the basis of any association with soft rots in plants it would appear that the occurrence of pectolytic pseudomonads in Nature is commoner than has been supposed. The evidence so far collected suggests that such organisms may be of greater significance than the better-known group of coliform-like organisms in causing some types of soft rot in plants. These strains of *Pseudomonas* are now the subject of a more detailed bacteriological examination, the results of which will be published elsewhere.

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Red Cell Agglutinability affected by Disease

Moskowitz and Carb[1], studying the effects of formalin on red cells, noted that formalin "was capable of completely inhibiting the agglutinability of red cells by antisera without destroying the antigens". They also directed attention to a number of papers recently published describing red cells of type A, which are only weakly agglutinated, or not agglutinated, by anti-A sera, and it appears that the agglutinability of the red cells can be modified in a number of different ways, both by disease and by genetic effects. In a case described by Weiner *et al.*[2], for example, it was considered that modifying genes were responsible for this. The most interesting case, however, was that described by van Loghem *et al.*[3], who thought it "might be possible that the blood group of the patient had changed in the course of his disease".

In a similar case, which we are investigating, the patient, S.M., has hypoplastic anæmia and has received multiple blood transfusions. His blood groups are A?, R_1R_2, $M.N.S$, $P+$, $Le(a+b-)$, $K-$, $Fy(a-)$, $Jk(a+)$.

The ABO group of this patient is of considerable interest since his red cells do not react with human anti-A of natural or immune variety, nor with immune rabbit anti-A serum, but only with human serum from certain group O individuals at 16° C. There is no agglutination with anti-B sera. No anti-A is present in the patient's serum, but his anti-B has a titre of 32. He is a non-secretor of A and H. If his red cells are mixed with anti-A serum and washed, anti-A antibody may be eluted from the treated cells. During his Army career, the patient was grouped as a normal blood group A. His wife is group O, with both anti-A and anti-B in the serum, and his daughter is a normal group A_1. Some difficulties were encountered in determining the patient's other groups owing to the large number of transfused cells present in his blood, but blood from the bone marrow was tested as well as the peripheral blood and no difference was detected. Recently, transfusions have been purposely given of selected groups, so that his own peripheral cells can be examined more readily. At this preliminary stage we have no evidence to suggest that antigens other than the A antigen are affected. In this case, we feel that this man's cells originally reacted as normal group A and that it is only recently that his cells have begun to have these peculiar reactions.

Polyagglutinability is another rare condition that arises during infections of various kinds, although on occasion the condition has been found in people who are apparently healthy at the time they were tested. It may be of a transient nature and appear and disappear in a short period of time[4]. The person's red cells so affected react with a proportion of normal sera at a lower temperature but not at 37° C. and not with their own serum. Two recent cases, both associated with infection, showed unusual features.

In the first case, the patient had a pelvic abscess of long standing. Her red cells showed the typical changes of polyagglutinability, but the unusual feature was that her own red cells reacted weakly with her own serum at lower temperatures. Her serum contained a pan-agglutinin active at lower temperatures but inactive at 37° C. This was without blood group specificity. It seems possible in this case that this pan-agglutinin arose from some effect on the patient's serum similar to that which caused the change in her red cells.

In the second case, the patient's red cells showed the typical changes of polyagglutinability, but unlike other cases these red cells were agglutinated by a number of sera at 37° C. The direct Coombs test was negative. The patient's serum contained no atypical antibody, but cultures of fæces showed a growth of *Staphylococcus aureus*. She had a severe anæmia of doubtful etiology and died before further investigations could be undertaken; it was not possible to establish that the *in vitro* reactions had any counterpart *in vivo*.

Bessis *et al.*[5] have commented on the fact that in sickle-cell anæmia the agglutinability of the red cells is much reduced or even abolished when the cells are sickled, but is normal when they are not sickled.

These observations show at least three ways in which disease can affect the agglutinability of red cells. In the first and last instances, there is a decrease of agglutinability, but in the first case we have been unable to establish any decreased agglutinability in respect of any antigen other than the *A*-antigen. This is unlike the experiments of Moskowitz and Carb, where the decrease in agglutinability appears to be of a more general nature. The change in polyagglutinability is an actual change in the antigenic constitution of the red cell; indeed, we have prepared sera in rabbits which will agglutinate certain polyagglutinable cells. It is of importance in blood grouping work to consider whether disease has affected red cell agglutinability in a particular case, and it seems possible that study of the mechanism by which disease can produce these effects could help one to understand the way in which modifying genes operate in the production of similar effects.

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Caudal Necrosis in Suckling Rats

THE communication by Njaa *et al.*[1] concerning the presence of 'ringtail' in newborn rats has prompted us to report similar observations in the colony maintained at these Laboratories. During the winter of 1954–55 signs of 'ringtail' were noticed in many suckling rats. Generally, these symptoms were seen in 8-day-old young rats, the first signs being a marked scaliness of the tail and reddening of the tail tip (Fig. 1). In many cases the condition of the tail deteriorated, resulting in necrosis followed by its severance from the body. Microscopic examination of sections of the tails revealed in the early stages a marked hyperkeratosis and parakeratosis (Fig. 2). There was œdema (spongiosis) and hyperplasia of the prickle cell layer, resulting in acanthosis. In some of the specimens, the prickle cells at all levels contained large amounts of keratohyaline granules. The hair follicles were slightly dilated and were filled with keratinized invaginations of the cornified layers of the epidermis. The corium was œdematous and often congested with blood. In the more advanced lesions, there was extensive eosinophilic necrosis of both the epidermis and the corium, accompanied by leucocytic infiltration. In general, these histological characters closely resemble those observed in the ring tails of rats born to mothers deprived of essential fatty acids[2].

The phenomenon of 'ringtail' observed in the newborn rats of our stock colony had the following interesting features: (1) The condition was not attributable to any significant fluctuations in the relative humidity as revealed by a careful study of the weather records. Actually, these cases of ringtail occurred during and after the winter 'monsoon' period, when the relative humidity ranged between 68 and 83 per cent. (2) Surprisingly enough, after the age of 17 days the condition of animals exhibiting 'ringtail' showed signs of retardation without any further aggravation. It is well recognized[3] that after the seventeenth day the young are not entirely dependent upon maternal milk supply, and, possibly, the retardation in the condition could be attributed to the nibbling of the stock ration. (3) The sudden outbreak of 'ringtail' was traceable to a minor alteration in the stock ration. The practice of incorporating crude shark liver oil in the stock ration (the fat content of which was 3 per cent, which is admittedly low) as a source of vitamin A, which also is known to be a rich source of unsaturated fatty acids, but comparatively poor in essential fatty acids, was stopped. Instead, a concentrate of vitamin A acetate ('Vanitin', manufactured by Hoffmann–LaRoche and Co., Ltd.) was introduced. (4) When the fat content of the diet was increased to more than 6 per cent by the addition of the peanut oil, there was a dramatic response resulting in the complete eradication of 'ringtail' in the suckling rats. None has been seen for the past three years.

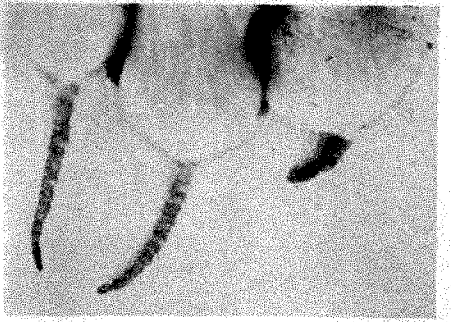
Fig. 1. Ringtails of newborn rats at various stages of development

These features would indicate that probably the nutritional status of the mother rats, particularly with regard to the essential fatty acid content of the stock diet, plays an important part in the development of 'ringtail' in newborn rats. It is not unlikely, however, that besides inadequacy of fat, environmental factors such as the one suggested by Njaa *et al.* (*loc. cit*) might also play a part. In this connexion it may be pertinent to mention that the skin

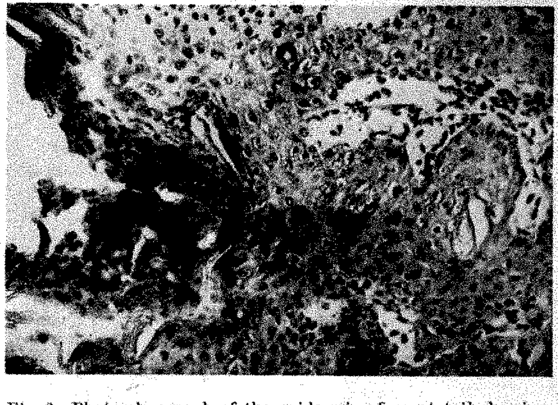
Fig. 2. Photomicrograph of the epidermis of a rat tail showing marked hyperkeratosis, parakeratosis and acanthosis. Hæmatoxylin and eosin. (×180)

lesions of essential fatty acid deficiency are known to be enhanced by a lowering of the relative humidity[4].

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An Electrical Receptor in Fishes

CERTAIN families of fishes, namely the Mormyridæ of tropical Africa and the Gymnotidæ of Central and South America, possess a small electric organ which exhibits intermittent activity. Lissmann[1] found that *Gymnarchus niloticus* Cuv., swimming freely, emitted pulses at an even rhythm of about 300 per sec.; the frequency was unaffected by the activity of the fish. Similar observations have been made on six species of the Gymnotidæ by Coates *et al.*[2] and Coates[3], who found regular rhythmic discharges the frequency of which varied with the species and ranged between 65 and 1,000 per sec. Again, the rhythm was unaffected by the activity of the fish. Coates[4] also reported a low-voltage discharge at about 50 per sec. from *Electrophorus electricus*. *Mormyrus kannume* has been reported to discharge pulses at a low rate when resting and at 80–100 pulses per min. when disturbed[5,6].

We have found that *Mormyrus kannume* discharges at about 1 per sec. when quiescent in a tank; but the discharge accelerates when the fish is disturbed and when it swims about. The frequency often increases to 30 per sec. under these conditions. The discharge continues at a declining rate during anæsthetization with urethane, but only disappears completely when the level of surgical anæsthesia is reached.

All these fishes are reported to react to conductivity changes caused by placing metal objects in their neighbourhood and also to electrical pulses delivered from electrodes[1].

It has been suggested that these impulses form part of a sensory system by which the fish detects local changes in its environment. Such a suggestion implies the possession of some form of receptor for electrical pulses. We wish to report some evidence for the existence of an electrical receptor in *Mormyrus kannume*.

Fish of about 30 cm. in length have been used in these experiments. It was necessary to keep the fish immersed throughout, and since the procedures involved exposing tissues to the fluid, frog Ringer's solution was used in the experimental bath. Although this solution is almost certainly 'unphysiological' for *Mormyrus* it was sufficiently close for minimal tissue damage. The fish were anæsthetized with urethane at a concentration of 1 : 400 in the bath and oxygen was bubbled through the solution. Spontaneous respiration remained throughout the experiments.

In *Mormyrus*, a pair of cranial nerves leaves the hind-brain and after sending a branch ventrally each nerve runs along the back, deep to the dorsal fin, sending off branches which terminate close to the base of the dorsal fin. The general arrangement is shown in Fig. 1. This nerve has been exposed on one side close to its entry into the skull but distal to the ventral branch, sectioned, and the cut peripheral end placed upon platinum electrodes. The nerve on the electrodes was isolated from the bath solution by a petroleum-jelly barrier and covered in liquid paraffin. The electrodes were connected via a cathode follower to a condenser-coupled pre-amplifier and Cossor oscilloscope.

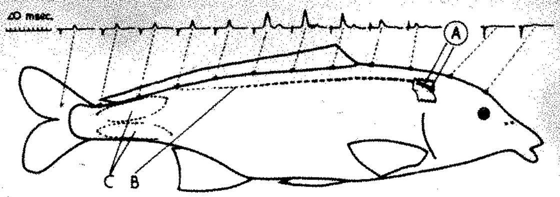

Fig. 1. Diagram showing the experimental arrangement. The recording electrodes *A* are shown in position on the dorsal nerve *B*. The recorded monophasic action potentials have been traced and are shown attached to the site occupied by the stimulating electrodes which elicited them. *C* is the electric organ

Electrical pulses of 0·1 msec. duration from an isolating transformer were delivered between silver electrodes placed in the bath but not in contact with the fish. This pulse duration approximates the natural discharge from the electric organ. The bath solution was earthed throughout. Using electrodes of 0·8 mm. diameter, 5 mm. long, and 10 mm. apart, placed horizontally 10 mm. from the fish on a level with the base of the dorsal fin in the middle region, a stimulus pulse of about 5 volts was followed by the appearance of an action potential in the dorsal nerve. Increasing the electrode size, the inter-electrode distance and/or the pulse amplitude caused an increase in amplitude and duration of the action potential. Using a fixed inter-electrode distance and stimulus intensity, but moving the electrodes forwards or backwards while retaining their position relative to the surface of the fish, caused a change in the action potential amplitude depicted in the diagram. The potential was at a maximum when the stimulating electrodes were in the vicinity of the headward part of the dorsal fin at the level of its base; it decreased tailwards and it decreased headwards near the emerging nerve and beyond it. Raising or lowering the electrodes reduced the potential amplitude. The time-interval between the stimulus artefact and the origin or peak of the action potential decreased over the region of the dorsal fin as the stimulating electrodes approached the recording ones. If it is a fair assumption that the current spread between the electrodes and the excitation processes are constant, then the plot of the time-interval against distance gives a velocity of about 100 m. per sec. at the bath temperature of about 23° C. for conduction along the nerve. Since the nerve contains many large myelinated fibres this seems reasonable. Also, towards the caudal end of the dorsal fin and beyond it, the action potential amplitude decreased, but the time interval to peak remained constant. This means that the site of excitation was no longer moving with the electrodes.

These results are necessarily incomplete. With larger stimulus amplitudes, the shape of the action potential becomes more complex, showing other fibre groups or the result of a wider stimulus spread. It has not been possible yet to obtain a discharge in part of the nerve and thus information about the localization of receptors, because the nerve deteriorates when its sheath is removed. Again, the substitution of Ringer's solution for fresh water will affect the distribution of current pulses in relation to the fish and its environment. Further experiments are in progress, and will be reported in detail elsewhere.

However, we consider that the results so far indicate that a receptor system exists in *Mormyrus kannume* which is sensitive to electrical stimuli not delivered directly to it and that the receptor system is localized to the region of the base of the dorsal fin.

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Effect of Ultra-Violet Irradiation on Electrophoretic Properties of Serum Protein

In the course of an investigation of the complement and antibody activities of animal sera (to be reported elsewhere) the effect of several agents on the serum protein has been examined by paper electrophoresis. It has recently been demonstrated that while controlled heat modified in various ways the electrophoretic pattern of serum protein it also affected differently the reactiveness of the serum with complement[1]. It has also been reported[2] that ultra-violet irradiation of immune serum would either impair or completely destroy the ability to lyse, to agglutinate, to combine with toxins, to precipitate, to fix complement, or to confer passive anaphylaxis.

Preliminary experiments with ultra-violet irradiation of sera showed that the complement activity of guinea pig serum was completely destroyed by irradiating it for 6 hr. at 3° C. On the other hand, the complement-fixing antibody to canine hepatitis virus in canine serum was active, after it had been irradiated for 8 hr. at room temperature. All irradiated sera acquired a characteristic odour resembling burnt wool; otherwise no alteration in the appearance or in *p*H of the serum was observed. However, electrophoretic analysis suggested that some modification of the protein had taken place and, since no observations could be found in the literature, it was decided to examine electrophoretically the effect of ultra-violet irradiation on the protein of sera obtained from healthy adult human subjects and three animal species (the dog, rabbit and guinea pig).

Undiluted serum was irradiated either at room temperature or at 3° C. in a 'Vycor' glass tube, sealed with a rubber stopper. The tube was placed horizontally at a distance of 15 cm. from a 15-W. mercury vapour lamp ('Hanovia') emitting predominantly at 2537 A. The irradiation was controlled by varying the times of exposure. Serum aliquots in 'Vycor' tubes protected from irradiation with tinfoil served as controls. Serum aliquots exposed to irradiation were withdrawn at intervals and stored, together with the controls, at 3° C. until irradiation had been completed. 0·01-ml. aliquots of the control and irradiated sera were streaked on filter-paper strips for electrophoretic analysis. Paper electrophoresis was carried out essentially as described previously[1], using 3 *MM* Whatman paper strips. Electrophoresis was conducted at constant current (11 m.amp. for six strips) for 28 hr. at room temperature using sodium 5,5-diethylbarbiturate buffer, *p*H 8·6. The proteins were stained with bromophenol blue, and evaluated by direct photometry of the paper strip.

The results with rabbit serum (Fig. 1) show that the protein was similarly modified in all sera irradiated either at 3° C. or at room temperature. The migration velocities and probably dye-binding ability of the protein were affected by irradiation for 2 hr. Prolonged irradiation resulted in a complete change in the electrophoretic pattern.

Detailed analysis of the relationships between the mechanism of electrical transport of the protein and the activity *in vitro* of either antibody or complement must clearly await further experimental studies. The present work shows, however, that regardless of mechanism, electrophoretic analysis of native and modified serum protein may provide a better understanding of the activities of antibodies and complement. It shows also that serum protein is considerably denatured by ultra-violet irradiation, as judged by paper electrophoresis.

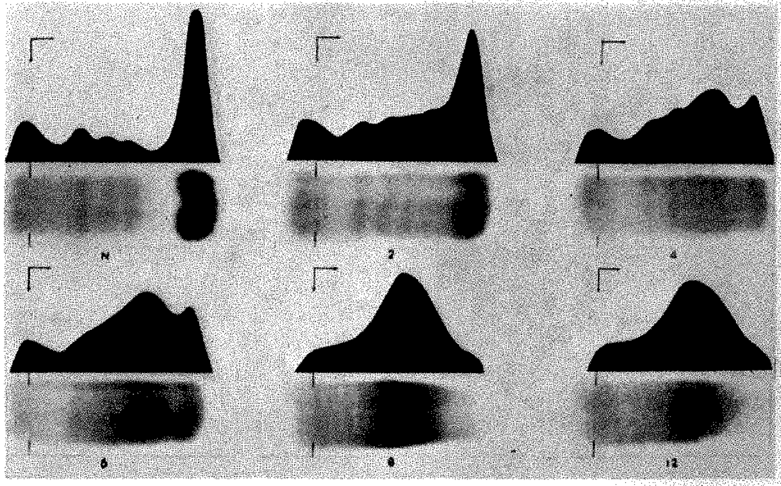

Fig. 1. Effect of ultra-violet irradiation upon proteins of normal rabbit serum. Paper electrophoretic pattern of control serum aliquot (*N*) compared with the patterns of aliquots irradiated for 2, 4, 6, 8 and 12 hr. Arrows indicate site of application and direction of run

I am grateful to Dr. C. B. V. Walker, of the Cambridge Blood Transfusion Centre, for samples of normal human serum, and to Mr. W. G. Orbell and Miss M. Baker of these laboratories for technical assistance.

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Transmembrane Potentials of Single Fibres of the Atrio-ventricular Node

Records of the electrical activity of the atrio-ventricular node obtained with extracellular electrodes[1,2] have not provided a clear picture of the mechanism of normal atrio-ventricular delay or the changes responsible for partial and complete atrio-ventricular dissociation. In the experiments to be described the trans-membrane potentials of single fibres of the atrio-ventricular node and bundle of His have been recorded by means of intracellular micro-electrodes in order to obtain an answer to these questions. The atrio-ventricular node and His bundle have been studied either in the intact perfused rabbit heart or in isolated preparations of the right atrium and interatrial septum of the same heart. A modified Tyrode solution maintained at 33° C. was employed in both types of experiments. In most instances two intracellular micro-electrodes were employed simultaneously to demonstrate conduction delay and site of origin of activity. Similar results were obtained from both intact and isolated preparations.

A micro-electrode inserted in a single atrial muscle fibre just proximal to the atrio-ventricular node records an action potential typical of this tissue[3]. Another electrode, inserted only 1 mm. away in a single fibre of the atrio-ventricular node, records, after a conduction delay of 20 msec., an action potential similar in voltage-time course to those of the sino-atrial node[4] (top trace, Fig. 1, *A*). This action potential differs from that of atrial muscle in that the rising velocity is low and diastolic depolarization is prominent. If this electrode is moved 1 mm. towards the bundle of His and re-inserted in a single fibre of the atrio-ventricular node, the action potential is virtually unchanged in configuration but appears only after an additional delay of 20 msec. (Fig. 1, *B*).

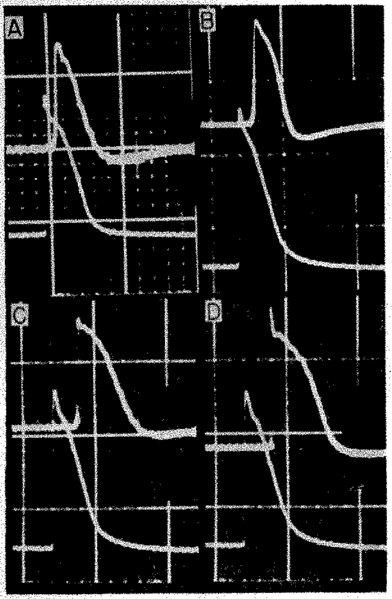

Fig. 1. On the bottom trace are trans-membrane potentials recorded from atrial muscle just proximal to the atrio-ventricular node. The same fibre is employed for records *B*, *C* and *D*. On the top trace are action potentials recorded from single fibres in the proximal (*A*), middle (*B*) and distal portions (*C*) of the atrio-ventricular node and in the His bundle just distal to the node (*D*). Calibration grid represents 10 mV. and 40 msec./division.

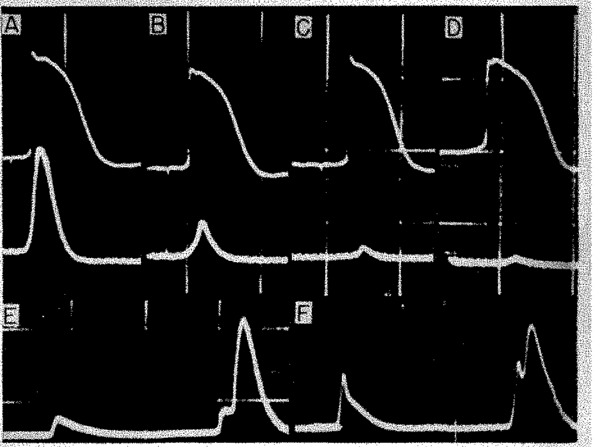

Fig. 2. *A*–*D*: On the bottom trace are trans-membrane potentials recorded from a single fibre of the atrio-ventricular node before (*A*) and after (*B*–*D*) application of acetylcholine. Records of single-fibre activity in the His bundle (top trace) show the driven response (*A*–*E*) and the onset of pacemaker activity (*D*). *E* and *F* show activity of a single fibre of the atrio-ventricular node under hypoxic conditions. Activity originates in the sino-atrial node in *E* and in the His bundle in *F*

Action potentials recorded from the atrio-ventricular node just proximal to the His bundle show an additional conduction delay of 20–30 msec. and also an increase in duration, increased velocity of rise and diminished phase of slow diastolic depolarization (Fig. 1, *C*). Finally, when the micro-electrode is inserted in a single fibre of the His bundle, the action potential resembles that of a Purkinje fibre[5]. Tracings obtained from fibres of the His bundle distal to this site show no additional conduction delay of the same order of magnitude as demonstrated within the node. Under conditions associated with pacemaker activity of the His bundle, the conduction time from the pacemaker site to the atrium is similar to that seen during normal atrio-ventricular transmission.

If the atrium is driven at a regular rate by means of electrical stimuli and acetylcholine is added to the perfusion fluid, records of the trans-membrane potential of single nodal fibres show several changes of interest. The action potential decreases progressively in amplitude and velocity of rise (bottom trace, Fig. 2, *A* and *B*) until conduction fails (Fig. 2, *C*). This failure of depolarization appears in the absence of an appreciable change in the level of the resting potential. During the period of complete conduction block, pacemaker activity originates in fibres of the His bundle and is propagated to the ventricle (Fig. 2, *D*). If the concentration of acetylcholine is low enough there is some spread of activity in a retrograde direction and small depolarizations are recorded from atrio-ventricular nodal fibres (bottom trace, Fig. 2, *D*). Graded activity of this type is a prominent aspect of nodal activity not only under the influence of acetylcholine but also during hypoxia. At times, under conditions of poor oxygenation, nodal action potentials arise out of every other one of a series of small local depolarizations both when activity originates in the sino-atrial node (Fig. 2, *E*) and it originates in the His bundle (Fig. 2, *F*).

These experiments show that normal atrio-ventricular nodal delays result from slow conduction within the node rather than from refractoriness of nodal tissue[6] or from some synaptic-like delay at the junction of nodal fibres with those of the atrium or

His bundle. The slow conduction is undoubtedly caused by the low velocity of rise of the nodal action potential. Conduction block caused by acetylcholine results from a failure of regenerative depolarization of nodal fibres; slowing of propagation due to the same agent is due to changes in the voltage-time course of the nodal action potential. During so-called escape from acetylcholine inhibition, the pacemaker site is in the His bundle rather than in the fibres of the atrio-ventricular node. The mechanism for partial block (2 : 1 response) demonstrated also constitutes an additional mechanism for conduction delay which may be of importance in the diseased heart. Finally, graded activity appears to be a frequent occurrence in fibres of the atrio-ventricular node.

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Physical Bases of the Electrohysterogram

INTERPRETATION of the electrical activity associated with the uterine contractions of labour has been beset with many difficulties. For the most part, the studies have concentrated on certain fast components[1], and did not readily lend themselves to physiological interpretation. In this laboratory a uterine electrical complex bearing a one-to-one relationship to the uterine contractions of labour has been demonstrated, and the techniques described[2].

With the aid of multichannel recording techniques now under development, additional information about the appearance of the electrohysterogram has been obtained. With two-channel recording of the electrical activity on the right and left sides of the uterus in active developing labour, the wave-forms have been observed to be repetitive on each side, yet with interesting differences as between the sides. On the left side the wave-form shows an initial large spike-like variation, followed by a sharp diphasic reversal and thereafter slow recovery. On the right side, activity seems to begin earlier, and to consist of an oscillatory repetitive discharge during most of the contractile epoch, followed by a fast monophasic shift and a slow recovery.

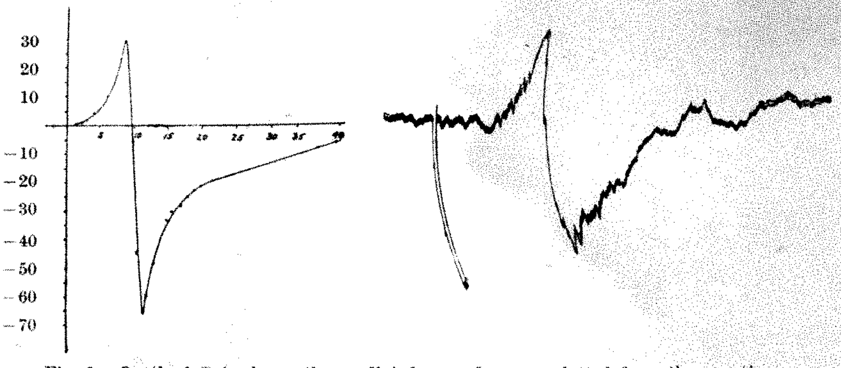

Fig. 1. On the left is shown the predicted wave-form, as plotted from the equations developed by Wilson. On the right is shown the left-sided wave-form, as recorded in a normally developing labour. The spike-like initial variation was correlated with a visible, palpable contraction. The calibration signal shown represents 5 mV., and the time of this complete complex along the horizontal axis is about 4 min.

In an investigation of the theoretical implications of these wave-forms, the cardiac investigations of F. N. Wilson have been utilized[3]. He considered theoretically the electrical effects of radial excitation. Wilson had in mind the auricle, with excitation spreading from the sinus node, but the mathematical approach is perfectly general and applies to any system in which excitation may be presumed to be spreading radially from a source, the excitation wave being considered by him to be preceded by sources and followed by sinks, that is, to be based upon dipole considerations.

The following equation for the potential of an exploring electrode was developed:

$$V_p = \frac{4c'\mu(x+a)}{\sqrt{(x+a+s)^2+b^2}}\int_0^{\frac{\pi}{2}}\frac{d\varphi}{\sqrt{1-k_1{}^2\sin^2\varphi}} - \frac{4c'\mu(x+a)}{\sqrt{(x-a+s)^2+b^2}}\int_0^{\frac{\pi}{2}}\frac{d\varphi}{\sqrt{1-k_2{}^2\sin^2\varphi}}$$

the integrals being complete elliptic integrals (of Legendre; cf. ref. 3). With evaluation, a predicted wave-form was plotted[3]. In Fig. 1, the mathematically predicted wave-form is shown on the left, and the experimentally observed wave-form of the left side of the uterus is shown on the right half of the figure. The excellent correspondence between the left-sided wave-forms observed in the human electrohysterogram and the wave-form as developed from theoretical considerations is evident. From this agreement between theory and experimental evidence the following tentative conclusions may be drawn: (1) The human uterus in developing labour behaves electrically like an auricle, namely, as a single-chambered organ in which electrical excitation spreads radially from a single source. (2) The uterus in developing labour is normally under the hegemony of a single pace-maker. (3) Dipole considerations have validity only if the measurement is being made at distances relatively far from the source: hence the observed wave-form picked up on the left side of the uterus is presumably relatively far from the source.

In the effort to elucidate the wave-forms from the right side, work on the electrical activity at the cardiac sinus node was of interest. Van Der Kooi *et al.*[4] showed that an oscillatory discharge was associated with the specific activity of the node. We made a comparison, similar to that of Fig. 1, of the activity at the sinus node and the right-sided uterine wave-forms, and found good agreement. From this interesting evidence, as well as from the measurements cited above, arises the suggestion that the particular wave-form observed on the right side is associated with pace-maker activity.

Thus an electric wave-form which is synchronous with the uterine contraction can be demonstrated at some time during developing labour. The wave-form is dominantly monophasic in certain areas, and diphasic elsewhere. In the area of monophasic wave-form, higher-frequency components may be seen which may be related to the focus of activity.

On the basis of the available electrical evidence, the following hypotheses may be suggested: (1) The human uterus in labour behaves electrically as a single-chambered, auricle-like structure. (2) The contractions of the human uterus under the given conditions are controlled by a single pace-maker. (3) Under ordinary conditions, this pace-maker seems to be on the right side. (4) Excitation of the uterus is basically radial in normally developing labour.

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California.
Sept. 29.

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Shaking of Honeybee Queens prior to Flight

Recently Hammann[1] has published a description of the way in which worker honeybees push, pull and shake their unmated queen before she leaves the hive on her mating flights. After each of these flights the 'attacks' subside somewhat, but they increase in frequency once again before the next flight, only ceasing finally when the queen commences egg-laying. Hammann lists several types of movement which the workers make around the unmated queen, and of these she found that shaking was by far the most frequent. This movement has been described previously[2,3] (although no evidence as to its function has been put forward), and consists basically of a rapid vertical vibration of the worker's body lasting 1–2 sec. while its legs grasp either the queen or another worker.

Hammann states that she has never seen an established queen shaken by the workers, and I would agree that for much of the year the queen is not normally shaken. The important exception, apart from the period between emergence and egg-laying, is during the swarming season. At this time the colony makes extensive preparations which culminate in the departure of the mated queen with the swarm[3], and during this period the queen may very frequently be shaken, as shown in Fig. 1, in which is recorded the number of times per hour the workers of a small but otherwise normal colony in an observation hive shook their queen. Observations began on April 11 and the earliest record of shaking was on May 30, but it was only after the formation of the first queen cup on June 23 that shaking reached any major proportions. From then on the frequency rose rapidly to a peak on July 13, when the queen left the hive with the swarm. A similar sequence of events was observed, though in rather less detail, in two other colonies.

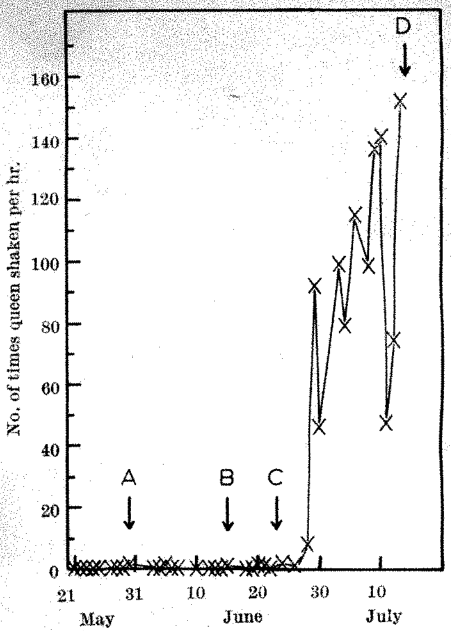

Fig. 1. Shaking of the honeybee queen by the workers. *A*, First record of shaking; *B*, first drone eggs laid; *C*, first queen cup built; *D*, departure of swarm

From the coincident occurrence of swarm preparations and the shaking of the queen it would seem evident that the two events are closely connected; furthermore, it is surely not by chance that the only times when the queen is shaken are before she flies out from the hive, either with the swarm or on a mating flight. It would therefore appear that shaking is a mechanism in some way preparing the queen for flight. It may also be assumed that the incidence of the shaking of the queen is governed at least partly by an internal (colony) factor since it occurs at definite stages in colony development. It may also possibly be influenced by external factors such as weather conditions.

As already mentioned it is known that workers may shake other workers, but little information apart from a description of the process is available on this subject. It is hoped shortly to publish elsewhere the results of a series of observations on the shaking of workers, but at present it can be stated that, in contrast to the shaking of the queen, this occurs relatively frequently throughout the year. Moreover it, too, appears to have a connexion with flight activity.

M. Delia Allen

Bee Research Department,
North of Scotland College of Agriculture,
Marischal College,
Aberdeen.
Sept. 9.

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FORTHCOMING EVENTS

Monday, January 6

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 5 p.m.—Mr. A. J. Thompson and Mr. N. Walker: "The Intro-
uction of Subscriber Trunk Dialling".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at 14 Belgrave
quare, London, S.W.1), at 6.30 p.m.—Prof. G. E. Coates: "Organo-
etallic Co-ordination Compounds".

Tuesday, January 7

BRITISH COMPUTER SOCIETY (at the Northampton College of
dvanced Technology, St. John Street, London, E.C.1), at 2.30 p.m.
—Mr. D. W. Davies: "The Logical Design of the ACE Computer at
e N.P.L.".

NSTITUTION OF ELECTRICAL ENGINEERS, MANAGEMENT AND SUPPLY
TIONS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. R.
ancox and Dr. H. Tropper: "The Breakdown of Transformer Oil under Impulse Voltages".

BRITISH INSTITUTION OF RADIO ENGINEERS (in the Lecture Theatre
the London School of Hygiene and Tropical Medicine, Gower Street,
ondon, W.C.1), at 6.30 p.m.—Discussion on "Mass Production
chniques for Television Tuners", opened by Mr. P. C. Ganderton.

Wednesday, January 8

SOCIETY FOR APPLIED BACTERIOLOGY (in the Barnes Hall, Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 10 a.m.—Winter Meeting.

At 2.15 p.m.—(in conjunction with the MICROBIOLOGY GROUP of the
OCIETY OF CHEMICAL INDUSTRY)—Meeting on "New Techniques in
icroscopy".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly
ndon, W.1), at 5 p.m.—Prof. F. W. Shotton, F.R.S., and Dr. I.
rachan: "The Investigation of a Peat Moor at Rodbaston, Penk-
dge, Staffordshire"; Dr. D. Flinn: "On the Nappe Structure of
orth-East Shetland" (to be read by Prof. R. M. Shackleton).

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, London,
S.W.1), at 6.30 p.m.—Mr. W. R. Hockaday: "Lifting Equipment"
Dugald Clerk Lecture).]

Thursday, January 9

INSTITUTION OF NAVAL ARCHITECTS (in the Weir Lecture Hall, 10 Upper Belgrave Street, London, S.W.1), at 4.45 p.m.—Dr. J. Ramsay Gebbie: Amos Ayre Lecture.

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Scientific Papers.

Friday, January 10

SOCIETY OF DYERS AND COLOURISTS, LONDON SECTION (joint meeting with the LONDON SECTION of the OIL AND COLOUR CHEMISTS' ASSOCIATION, at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Prof. W. D. Wright: "Colour for the Dyer".

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Mining Institute, Newcastle upon Tyne), at 6.15 p.m.—Prof. G. H. Chambers: "University Education in Marine Engineering".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Prof. R. M. Barrer, F.R.S.: "Molecular Sieves".

Saturday, January 11

BRITISH MYCOLOGICAL SOCIETY (in the Large Physics Lecture
heatre, Birkbeck College, Malet Street, London, W.C.1), at 11 a.m.—
cientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or
fore the dates mentioned:

ADMINISTRATIVE ASSISTANT (graduate of a British university) IN
E DEPARTMENT OF PHYSICS—The Registrar, The University,
anchester 13 (January 11).

SSISTANT LECTUR R (Grade III) or JUNIOR FELLOW IN (VETER-
) PHARMACOLOGY—The Registrar and Secretary, The University,
l (January 15).

HAIR OF PURE MATHEMATICS—The Secretary, The University,
eter (January 15).

SCIENTIF IOR SCIENTIFIC OFFICER (with a first- or second-
ass h e or equivalent, and a knowledge of one or more of
al chemistry, radiochemistry, low-level counting
e National Physical Laboratory (D.S.I.R.),
nto dating by radioactive methods including
r measurement of carbon-14 in archæo-
ry of Labour and National Service,
K), 26 King Street, London, S.W.1,

d research experience in the
RY at the University of
on of Universities of the
don, W.C.1 (Australia,

JUNIOR LECTURER IN CIVIL ENGINEERING—The Registrar, Trinity College, Dublin (January 20).

PHYSICISTS (with an honours degree or equivalent qualification and preferably experience in one or more branches of non-destructive testing) at the Research Laboratories, Central Electricity Authority, Leatherhead, for research into the non-destructive testing of all types of materials used in the Electricity Supply Industry—The Director of Establishments, Central Electricity Authority, Winsley Street, London, W.1, quoting Ref. N/514 (January 20).

LECTURER or ASSISTANT LECTURER IN GEOGRAPHY at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 30).

BRITISH COKE RESEARCH ASSOCIATION FELLOW (honours graduate in chemistry, physics, or applied science relating to fuel technology), to work on the physical chemistry of carbon, under the direction of Prof. W. F. K. Wynne-Jones—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne (January 31).

CHAIR OF CHEMISTRY in the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 31).

LECTURER IN CHEMISTRY at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 31).

LECTURER IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (January 31).

LECTURER IN THE DEPARTMENT OF ZOOLOGY, Victoria University, Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, January 31).

LECTURER/SENIOR LECTURER (with a principal interest in morphological, physiological or chemical cytology) IN HISTOLOGY AND EMBRYOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 31).

LECTURERS IN CHEMISTRY (INORGANIC AND PHYSICAL)—The Registrar, The Manchester College of Science and Technology Manchester 1 (January 31).

LECTURER or ASSISTANT LECTURER IN BOTANY at Makerere College, The University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 3).

SENIOR LECTURER or LECTURER IN RADIOLOGY in the Faculty of Medicine, University College, Ibadan, Nigeria—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (February 3).

NUFFIELD INVESTIGATOR (with a degree in metallurgy, chemistry or physics, and experience in research) IN THE METALLURGY DEPARTMENT, to conduct research on his own account and help in running the Nuffield Research Group in Extraction Metallurgy—Prof. F. D. Richardson, Imperial College, London, S.W.7 (February 15).

SENIOR RESEARCH OFFICER (graduate in mining/metallurgical engineering from a recognized university or with equivalent qualifications, and research experience in milling and treatment problems) IN THE DEPARTMENT OF MINING AND METALLURGICAL ENGINEERING, University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 15).

BABCOCK AND WILCOX RESEARCH FELLOW IN NUCLEAR ENGINEERING—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (February 28).

REGIUS PROFESSOR OF PHYSIOLOGY in the University of Aberdeen—The Private Secretary, St. Andrew's House, Edinburgh 1 (February 28).

LECTURER (graduate with an interest in electronics) IN THE DEPARTMENT OF TEXTILE INDUSTRIES—The Registrar, The Manchester College of Science and Technology, Manchester 1 (March 1).

PROFESSOR OF PURE MATHEMATICS in the Durham Division of the University—The Registrar, University Office, 46 North Bailey, Durham (March 1).

ASSISTANT CHEMIST (with a university degree in agriculture or pure science with postgraduate training or experience in agriculture or agricultural science) IN THE DEPARTMENT OF SCIENCE AND AGRICULTURE, Barbados, to undertake agronomical investigations—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/28/09.

ASSISTANT, Grade B (with a good honours degree), FOR MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham.

BIOCHEMIST, Senior or Basic grade (with a B.Sc. degree with honours in chemistry or biochemistry or equivalent qualification)—The Group Secretary, Royal Hospital, Wolverhampton.

LABORATORY TECHNICIAN FOR MEDICAL RESEARCH—mainly chemical and histological—The Secretary, Welsh National School of Medicine, 34 Newport Road, Cardiff.

MICRO-ANALYST (Senior Technician grade) IN THE ORGANIC LABORATORIES of the Department of Chemistry—Chief Technician, Department of Chemistry, The University, Oxford Road, Manchester 13.

PHYSICISTS, Scientific Officer or Senior Scientific Officer grade (with a first- or second-class honours degree in physics or equivalent), AT THE ROAD RESEARCH LABORATORY, D.S.I.R., Harmondsworth, Middlesex, for research on (*a*) rheology of solid–liquid systems and viscous and visco-elastic fluids to provide basic information for the design of bituminous road mixtures; and (*b*) the physical properties of concrete including various aspects of its rheology, effect of changes on construction procedures and properties of hardened concrete—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.362/7A.

SCIENTIFIC OFFICER (with a good honours degree or equivalent in chemistry, agricultural chemistry or biochemistry, with postgraduate research experience to Ph.D. level), for research in mineral metabolism, with special reference to Vitamin D—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

UNIVERSITY DEMONSTRATOR AND LECTURER (preferably with research experience or interest in spectrochemical analysis, X-ray crystallography or geochemistry) IN MINERALOGY—The Reader in Mineralogy, University Museum, Oxford.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

University of London. University College Calendar, 1957–58. Pp. lxiv+502. (London: University College, 1957.) [710

The Scientific Film in Poland. Pp. 27. (Extract from *Science and Film*, Vol. 6, No. 2, June 1957.) By Jan Jacoby. (London: Films of Poland, 81 Portland Place, 1957.) [710

Anti-Locust Research Centre. Anti-Locust Bulletin No. 26: The Behaviour of the Red Locust (*Nomadacris septemfasiata* Serville) in Relation to the Topography, Meteorology and Vegetation of the Rukwa Rift Valley, Tanganyika. By R. C. Rainey, Z. Waloff and G. F. Burnett. Pp. 96+24 figures. 11*s*. 6*d*. Anti-Locust Bulletin No. 27: The Population Dynamics of the Moroccan Locust (*Dociostaurus maroccanus* Thunberg) in Cyprus. By Dr. J. P. Dempster. Pp. ii+60+27 figures. 7*s*. 6*d*. (London: Anti-Locust Research Centre, 1957.) [710

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Technical Education in the U.S.S.R. By C. E. Simmonds. Pp. 36. (London: Society for Cultural Relations with the U.S.S.R., 1957.) 2*s*. 6*d*. [710

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Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 974, Vol. 250 (29 August 1957): Palaeomagnetic Investigations in Great Britain. 1: The Measurement of the Permanent Magnetization of Rocks. By D. W. Collinson, K. M. Creer, E. Irving and S. K. Runcorn. 2: Analysis of the Palæomagnetism of the Terridonian Sandstone Series of North-West Scotland, 1. By E. Irving and S. K. Runcorn. 3: The Origin of the Palæomagnetism of the Torridonian Sandstone of North-West Scotland. By E. Irving. 4: The Natural Remanent Magnetization of Certain Stable Rocks from Great Britain. By K. M. Creer. 5: The Remanent Magnetization of Unstable Keuper Marls. By K. M. Creer. 6: Geophysical Interpretation of Palæomagnetic Directions from Great Britain. By K. M. Creer, E. Irving and S. K. Runcorn. Pp. 71–156. (London: Royal Society, 1957.) 30*s*. [1110

National Central Library. 41st Annual Report of the Executive Committee for the year ending 28th February, 1957. Pp. 18. (London: National Central Library, 1957.) [1110

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Proceedings of the University of Durham Philosophical Society. Series A (Science). Vol. 13, No. 1: The Principle of Equicontinuity for Topological Vector Spaces. By J. D. Weston. Pp. 5. Vol. 13. No. 2: The Decomposition of Continuous Linear Functionals into Non-Negative Components. By F. F. Bonsall. Pp. 6–11. Title-Page and Index to Vol. 11 (1951–1954). Title-Page and Index to Vol. 12 (1954–1957). (Durham: University of Durham Philosophical Society, 1957.) [1110

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Calendar of the New South Wales University of Technology, 1957. Pp. 569. (Kensington, N.S.W.: New South Wales University of Technology, 1957.) [309

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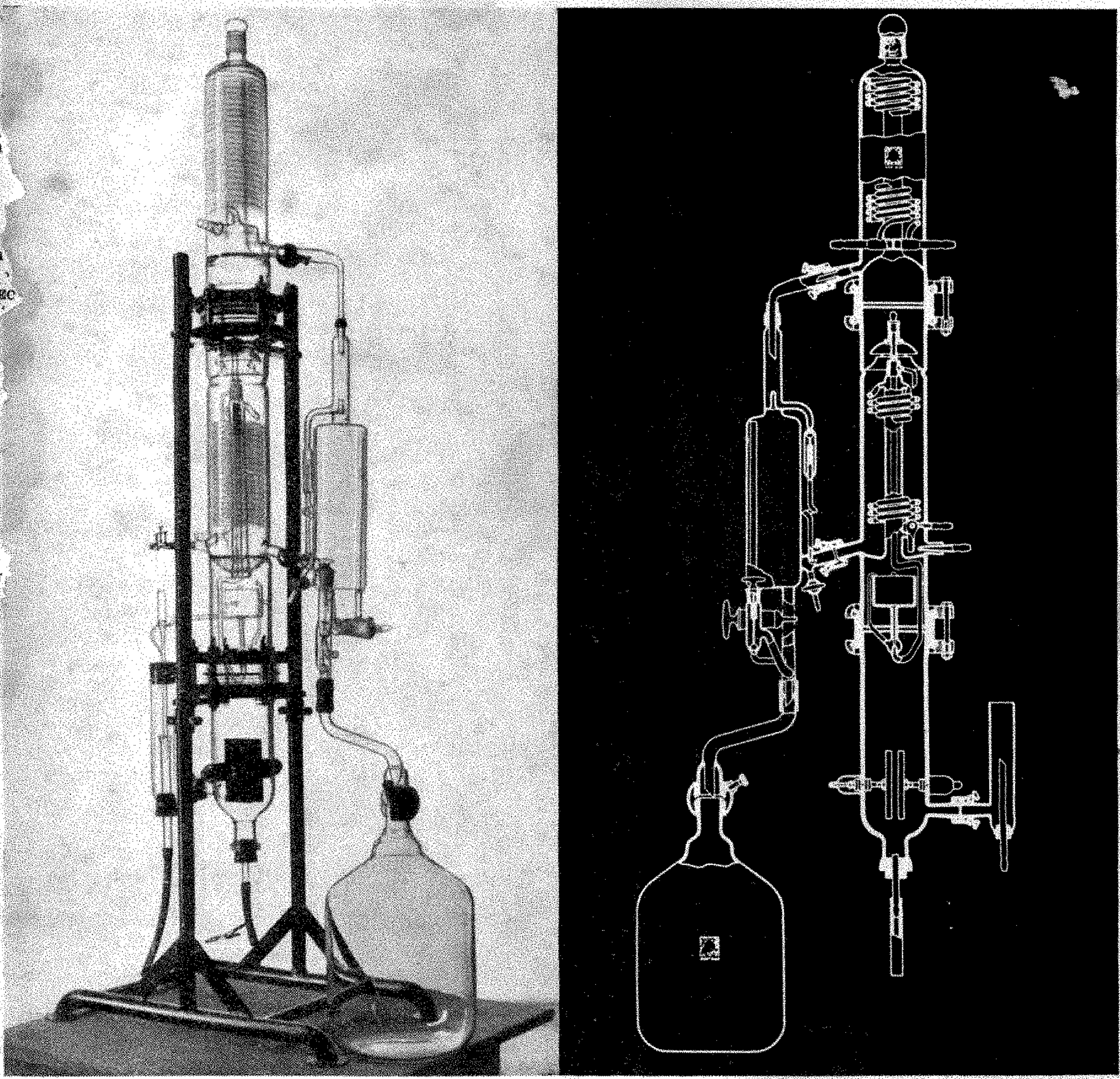

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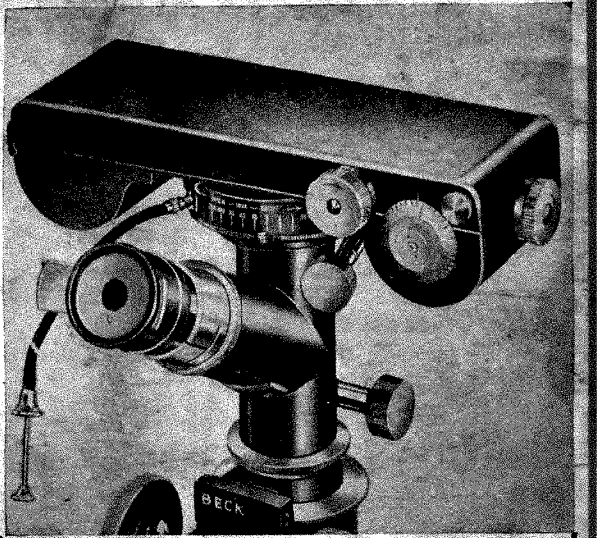

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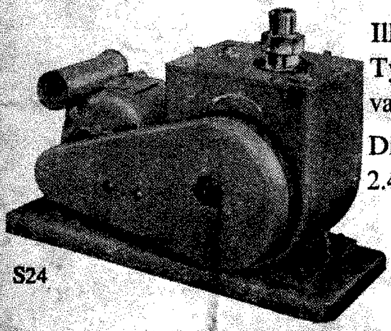

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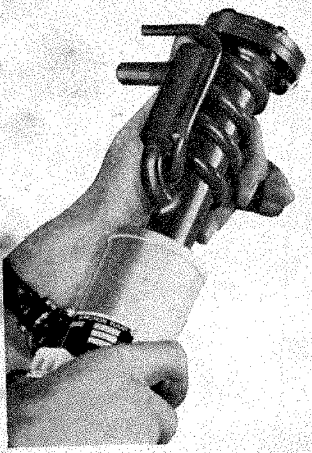

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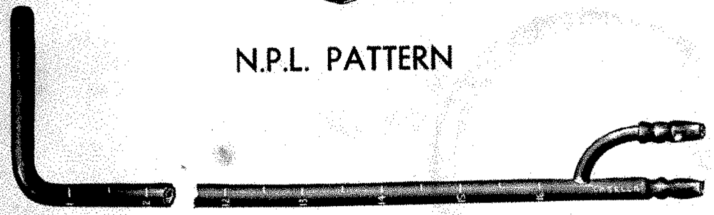

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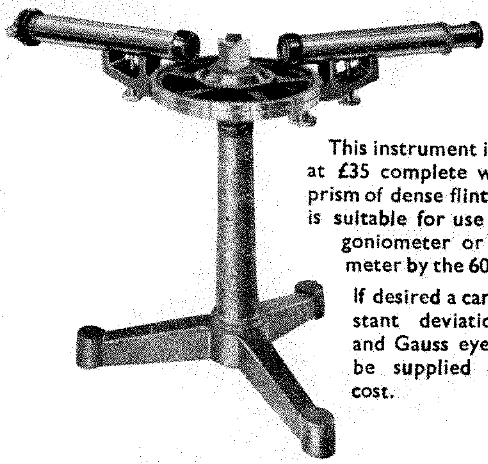

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AUTOMATION IN THE POST OFFICE: TECHNOLOGY AND HUMANISM

THE changes in the telephone service of Britain announced by the Postmaster-General in the House of Commons on November 13 and outlined more fully in a White Paper* published that afternoon have more than usual scientific and technical interest. Essentially they represent a dividend to the nation from an investment in technology. They provide also a striking example of the contribution which automation can bring to the improvement of conditions of everyday life and the way in which a service, hitherto expensive, comparatively restricted and sometimes slow, can be made cheap, almost universal and generally rapid. Perhaps even more important, they provide a noteworthy example of the way in which technical change such as automation should be handled; not merely its effect on the worker is discussed but also its dependence for full effect on his co-operation and understanding (see also p. 92 of this issue).

The White Paper explains that the Post Office is taking two big steps towards full telephone automation, and is pressing on quickly with a system in which all numbers are obtained automatically and charges for calls are recorded mechanically, thus giving better service at lower cost. The first step is to remove the system of charges designed for manual operation, which has hindered progress ever since the first automatic exchange was opened in 1912. Accordingly, from January 1, 1958, the present 6,000 exchanges, each with its own list of charges, will be reduced to about 600 charging units which will be called groups, and all exchanges in a group will have the same list of charges. In consequence, any subscriber will be able to call any other subscriber within his own group or an adjoining group (with few exceptions) for 3*d*., and existing equipment will be fully used for the first time. The 150 million calls a year now handled by operators will be dialled direct by subscribers, with very little additional equipment, and telephone costs will be cut by £2 million a year. Most trunk calls will also be cheaper under the new system; though about 3 per cent will be slightly dearer.

This step paves the way for the second step of full automation which is to follow later, commencing with the exchange at Bristol. Local, toll and trunk exchanges will be merged into one fully integrated automatic unit so that ultimately subscribers will be able to dial all calls. Charges will be recorded automatically on the subscriber's meter, eliminating all possibility of human error, and the minimum three-minute charge will be abolished. Ultimate savings in operating and accounting of £15 million a year are visualized, and by the end of 1958 it is expected that subscribers in Bristol will be able to dial about half the subscribers in Britain. Forty other towns will be similarly equipped by the end of 1960, and by 1970 three-quarters of all trunk calls in Britain will be dialled by subscribers.

The 'brain' of the new system is a robot telephone operator devised by Post Office research engineers and known as Group Routing and Charging Equipment, or 'Grace'. It will interpret the numbers dialled by subscribers, and route calls in the required direction, operate switches at intermediate telephone exchanges until the required exchange is reached, and then dial the number on that exchange. Some operators will still be required to provide such specialized services as personal calls, reverse charge calls, etc.; but the number of telephone operators will be greatly reduced during the next ten years and the automatic accounting already noted will also eliminate the work of 1,500 clerks.

The White Paper emphasizes that the biggest problems of this automation of the telephone system are not in the technical field; the human problems are much greater. Men and women are displaced, less staff is required and prospects of a career are jeopardized. The Post Office is well aware of the anxiety and hardship that could be caused in this way, and intends that this development shall be undertaken with the good-will of the staff. Full regard will be paid to the interests of those who have given long service, and to such added responsibilities as the staff may carry in future. These problems will be tackled by the Post Office and the trades unions together, and the Post Office trades unions have already declared their willingness to co-operate and to serve on working parties set up to consider the introduction of telephone automation and its problems.

These two steps together constitute the most sweeping and radical reform of the telephone service of Britain since the Post Office took over in 1912. Technically, they represent an advance of which Britain has a right to be proud, and a demonstration of how closely scientific and technical advance touches the everyday life of the community. They show that technical advance can—as it should—be shared with the community that pays for it, and perhaps the deepest interest of the White Paper even to the scientist and technologist is in the evidence it affords of the care which the Post Office has given to the social implications of automation. Lord Halsbury's arguments are seen here to be accepted and applied, and are in accord with the conclusions of the recent studies of PEP in this field.

Here, however, a remark which the Postmaster-General made should be noted. He pointed out that the development had been brought about not by new machinery but by the better use of existing machinery. Mr. Marples claimed categorically that the benefits now offered to the nation have been made possible by the removal of administrative restrictive practices from the machinery or equipment already available and not being fully or efficiently used.

---

* Full Automation of the Telephone System. Pp. 14. (Cmnd. 303.) (London: H.M. Stationery Office, 1957.) 9*d*. net.

Mr. Marples may have been using the term 'restrictive' in the sense of 'obsolete', but the point is important. If Britain is to enjoy the full benefits which automation and other major technological developments like nuclear power offer, such developments must be operated under the appropriate conditions. The proper return on the vast investment involved will not be secured unless the equipment is operated at full load; and this is equally the case for investment in roads, railways and coal mines and also nuclear power.

It is true that, as the White Paper makes clear, in these developments in telecommunications there is little danger that the replacement of the drudgery of many by the skill of a relatively few technicians will involve large or sudden dismissals of staff; but the Post Office is taking no chances that normal wastage will not suffice to meet the situation and is adopting appropriate measures to deal with the human problems. Nor is it not simply in this respect that the whole attitude revealed in the White Paper is of outstanding interest. It was a main argument in the report by Prof. C. F. Carter and Prof. B. R. Williams on "Industry and Technical Progress" that lack of vision and enterprise and obsolete or restrictive practices both on the part of management and of trades unions in important sections of industry in Britain were preventing the adoption and exploitation of inventions and new discoveries. We have here a first-class illustration of the dividends in saving of labour and reduction of costs which a forward-looking attitude can pay in both social and commercial life, and also of the way in which problems of technological development should be approached.

Tribute has rightly been paid to the research workers whose achievements have made these advances possible. It is no less fitting that tribute should be paid to the vision and enterprise of the management that has broken through the practices and methods that have hitherto prevented Britain from enjoying the advantages those achievements offered; and also to the courage and responsibility of the trades unions concerned as well as of the management in tackling the human problems of adjustment with sympathy and openmindedness. The example which the Post Office is setting of the way in which to face the human problems of technological advance could prove one of the most important benefits the nation will reap from this striking development; this must be as significant as its demonstration that full use of technological advance can reduce prices and costs for the benefit of the whole economy. It could also assist to establish that confidence in the scientist and technologist and dispel the suggestion of mystery with which they are surrounded, thus making a further contribution to the effective use both of science and technology.

THE SEROLOGICAL APPROACH TO THE STUDY OF PLANT VIRUSES

Plant Virus Serology

By R. E. F. Matthews. Pp. xii+128+6 plates. (Cambridge: At the University Press, 1957.) 27*s.* 6*d.* net.

THE fact that plants do not apparently give rise to antibodies is liable to cause some confusion on the question as to how serology can have an application in the study of plant viruses. However, in 1928, Helen Purdy Beale demonstrated that the virus of tobacco mosaic was a good antigen; in other words, that the blood of a suitable animal, usually the rabbit, contains antibodies which react specifically in an observable way to the virus antigen when injected into it. This discovery provided a new and important tool for plant virus research, and its application is continually being developed and improved. By means of the serological reactions, latent virus infections can be readily demonstrated. This is of practical importance for several economically important crops, as in the building-up of virus-free stocks of potatoes and flower bulbs, for example. Furthermore, by means of this technique, relationships can be shown to exist between viruses which would otherwise never have been suspected of a close connexion. This, in turn, may throw light upon some problems which have long puzzled plant virologists. The ability to establish serological relationships between viruses gains an added importance in view of the unreliability of cross-protection tests which is only now being realized. Up to now all this information has been scattered widely throughout the plant virus literature, or given necessarily brief treatment in text-books of general plant virology, so that Dr. Matthews is to be congratulated on his book which, for the first time, gives a descriptive survey of plant virus serological methods together with practical instructions.

After a brief introduction, there is a description of the methods of preparing the viruses for injection into the rabbit and for collection of the antisera. The types of serological tests are next explained, followed by an account of the routine testing for virus infection. In routine work, the precipitation test is of particular value when large numbers of plants have to be examined for the presence of a latent virus infection; this is especially true in certification schemes for vegetatively reproduced plants. With modern developments this technique can now be applied directly in the field by persons without much training in the subject.

Chapter 5 gives a good description of the serological tests used for determining relationships among plant viruses. In Chapter 6, in his account of the precipitation reaction, the author includes some of his own original work. Certain plant virus nucleoproteins, which can be isolated in large quantities, are relatively homogeneous from the serological point of view, as compared with other protein antigens. The virus of turnip yellow mosaic is particularly suitable in this respect, and some aspects of the precipitation reaction are illustrated by new data obtained with this virus. These experiments have implications extending beyond the field of plant virus serology and should interest the general immunologist.

Chapter 7 deals with the antibody content of sera; this has not a general application to plant virus work, but it is useful on occasions. For example, titre measurements on antisera showed that the 'top component' of turnip yellow mosaic virus, which has no nucleic acid, was much less efficient in stimulating antibody production than the 'bottom component' which is the nucleoprotein. In Chapter 8 the methods for estimating virus concentration are discussed, the precipitation reaction providing a rapid and convenient means towards this end. The specificity of the reaction allows virus to be estimated in the presence not only of plant impurities but also of unrelated viruses. In Chapter 9 the cross-absorption procedure is dealt with which can be used for estimating degrees of relationship between viruses, and in Chapters 10 and 11 experiments with mixtures of viruses and strains of viruses, and the causes of failure to obtain positive serological tests, are discussed. With regard to the last point, antisera have been prepared for about thirty plant viruses or groups of virus strains, but there are still 200 or more viruses to which serological methods have not yet been applied. In some cases repeated attempts to obtain antisera have resulted in failure; this may be in part due to lack of concentration of the virus, so that new methods of virus concentration may have to be devised. Then, of course, a large number of viruses are not mechanically transmissible and this greatly complicates the study of their serology.

This book is a valuable contribution to the study of plant viruses, and should be read by all plant virologists and by immunologists in general. The different procedures and their pitfalls are carefully and lucidly explained, and the illustrations and tables are excellent. The electron micrograph, in the frontispiece, shows dramatically how, in a mixture of viruses, the antiserum aggregates only the virus against which it was prepared. Kenneth M. Smith

THEORY OF INSTRUMENTATION

Instrument Technology

By E. B. Jones. Vol. 2: Analysis Instruments. Pp. xi+208. 40*s*. Vol. 3: Telemetering and Automatic Control. Pp. x+198. 40*s*. (London: Butterworths Scientific Publications, 1956–57.)

It is always a pleasure to read clear prose, and quite apart from the technical merits of these volumes, one is impressed by their lucidity. In these volumes, as in their predecessor, the author chooses as his audience the instrument mechanics of industry. Anyone interested in his subject can sympathize with the author in his task of selecting material and restricting explanations in a field where to-day's success may be to-morrow's museum exhibit. Mr. E. B. Jones is to be congratulated on providing a theoretical background to efficient instrument use and maintenance, even if it is possible to differ from the publisher's announcement which rather suggests the work is a maintenance guide. Obviously, nothing can replace the manufacturer's manual and still remain of general interest.

The second volume describes the principles and applications of measurements based on the composition of fluid streams or samples, and thus continues the treatment of pressure, level, and temperature measurement which was covered in Vol. 1. In this volume the very clear diagrams, and the short accounts of physical and chemical principles, are very attractive. The third volume attempts to show the application of automatic control to processes where variables are measured by the means examined in earlier volumes. In the discussion on telemetering, and especially of automatic control, all material appears to have been tested by the yardstick of usefulness, so that a well-grounded, but general, treatment results.

One can recommend this book for the training of instrument mechanics, since the level of knowledge that it will provide as adjuncts to the practical skills of installation, maintenance and 'trouble-shooting' can only result in a more intelligent use of instruments and automatic control devices. T. K. Ross

ELECTRONICS DIGEST

Handbook of Industrial Electronic Control Circuits

By John Markus and Vin Zeluff. Pp. xv+352. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 66*s*.

The Cathode Ray Oscilloscope

Circuitry and Practical Applications. By J. Czech. Pp. xii+340. (Eindhoven: N. V. Philips' Gloeilampenfabrieken; London: Cleaver-Hume Press, Ltd., 1957.) 57*s*. 6*d*.

A critical survey of some aspect of technology is no mean task when undertaken by an individual author, if his book is to be reasonably up to date at the time that it appears. There are other and complementary ways of presenting accounts of current practice, either through collected digests of articles that have appeared in the technical periodicals, or from the collective experience of a company specializing in a particular field.

The book by Markus and Zeluff might be described as 'articles of lasting interest, skilfully digested' from the well-known journal *Electronics*. Some 350 articles that appeared during 1948–55 are included in a volume weighing 3 lb., a worth-while reduction from the 6 ft. shelf and 200 lb. of the original magazines.

Czech's book for users of the cathode ray oscilloscope is translated from the German, and is one of the extensive series of Philips's technical and scientific publications. Like many titles in the series, it is closely related to the experience and products of that Company.

While both books lack the critical approach to first principles so valuable to the advanced designers of equipment, they will be helpful to the wider circle of technicians interested in particular applications. The selection from *Electronics* has been classified under such headings as amplifier circuits, capacitance control, counting circuits, measuring circuits, metal detectors, motor control, oscillators, photoelectric controls, temperature control, timing, power supply and transistor circuits. A rather full index has been added, and provides a useful cross-reference between articles containing related material; the original reference is given in each case. As the title suggests, the emphasis is upon industrial control applications, written at the consistently practical level of the journal in which they appeared.

The user of cathode ray oscillographs will find the second book helpful, particularly because of the large number of oscillograms used as illustrations. It is not recommended as a 'first reader' on the subject, but is valuable for being written from a point of view different from the several English standard works. Its origin is most evident in the bibliography, and in the illustrations of instruments and circuits of one particular manufacturer. There are excellent sections on general measuring technique in bridge circuits, for phase and frequency measurement, and for practical work on fluorescent lamps, camera shutters, flash bulbs and television receivers.

Neither book deals with the preferred functional circuit, a concept that would greatly simplify the pursuit of conventional circuits and reduce them to system-design, by building up an assembly of functional circuit 'bricks'.

Whether or not it is worth while using this approach to clear away retrospectively the profusion of detail in circuit design is in question for thermionic circuits, but it should be done for transistor circuits. The treatment of transistors in the first book extends only to the end of 1955, but is an excellent guide of what is to come, as semi-conductors are particularly suited to industrial applications. The second book looks backward rather than ahead in its field, and transistors are not mentioned, although they have made possible a significant future development, the miniature, portable, earth-free oscilloscope.

DENIS L. JOHNSTON

FLAME SPECTROSCOPY

The Spectroscopy of Flames

By Dr. A. G. Gaydon. Pp. ix+279+6 plates. (London: Chapman and Hall, Ltd., 1957.) 50*s*. net.

FROM the earliest times of recorded observations of matter, flame and fire have occupied a place of particular interest and importance, being so obviously remarkable in nature that they were frequently regarded as constituting a principle, or element. In the early nineteenth century it became clear that flames were generally to be associated with very rapid chemical reactions, usually of combustion, and attempts to understand them, on the basis of the characteristic light emitted from them, commenced. Serious attempts of this kind have had to await the development of the application of wave mechanics to spectroscopic data, which allowed of the analysis and identification of the spectra of short-lived radicals such as, for example, C_2, CH, OH, which appear in many common flames. The next step is to deduce the part played by such radicals in the physicochemical processes occurring in flames, as part of a general scheme of elucidation of the detailed reactions of combustion.

A major part has been played in these studies in recent years by Dr. A. G. Gaydon, the author of the work under review. From time to time Dr. Gaydon has published monographs relating to the physics and chemistry of flames, which have been distinguished by their scope, their presentation of conflicting theories or points of view in a fair-minded way, and their ability to stimulate further work of importance. The present volume is no exception to this, and like the previous ones, is also most valuable for the large number of useful practical hints to workers in the field.

The book opens with a number of introductory chapters on methods of studying flame spectra, on techniques for obtaining special types of flames, such as diffusion and low-pressure flames, and on the elementary theory of atomic and molecular spectra. The last of these, while by no means supplying all the spectroscopic knowledge required by an intending worker in the field, is nevertheless a useful introduction.

The next three chapters deal, broadly, with accounts of the electronic spectra of hydrogen, carbon monoxide, and hydrocarbon flames with oxygen or air. They provide very complete descriptions of the observed features, with some discussion of whether the spectra show chemiluminescence (that is, non-thermal excitation), and of whether the concentrations of emitters are in excess of those to be expected for thermodynamic equilibrium. For example, a typically balanced account of the various views of processes of reaction in carbon monoxide flames is given. A further chapter discusses the analysis of spectra so as to obtain the effective translational, rotational, vibrational, etc., temperatures, understanding of which is required if the complicated distribution and exchange of energy between various types of molecule and degrees of freedom occurring in flames is ever to be solved in detail.

In further useful chapters the book deals with infra-red emission from flames (a rather neglected topic), the correlation of spectroscopic results with processes of reaction (including an account of carbon formation in flames), and industrial flames and engines. The book ends with an interesting account of various unusual flames, in which oxides of nitrogen, halogens, compounds of sulphur, etc., take part, and with a brief discussion of spectrophotometry of trace additives, which is itself beginning to throw light on the chemistry of flame reactions.

This is a most valuable book to all those working in any field which has points of contact with the study of rapid reactions of simple molecules. It may be that spectroscopic studies tend to emphasize the role of a small number of rather special free radicals and molecules, but it must be agreed, with the author, that "emission of light is the most distinctive property of a flame and must surely be capable of giving much information about what is happening".

T. M. SUGDEN

THE BIOLOGY OF AGEING

Ciba Foundation Colloquia on Ageing

Vol. 2: Ageing in Transient Tissues. Edited by G. E. W. Wolstenholme and Elaine C. P. Millar. Pp. xi+263. 36*s*. net. Vol. 3: Methodology of the Study of Ageing. Edited by G. E. W. Wolstenholme and Cecilia M. O'Connor. Pp. x+202. 32*s*. 6*d*. net. (London: J. and A. Churchill, Ltd., 1956–57.)

The Biology of Ageing

Edited by W. B. Yapp and G. H. Bourne. (Symposia of the Institute of Biology, No. 6.) Pp. xiv+128. (London: Institute of Biology, 1957.) 25*s*.

REPORTS of the various symposia and colloquia, especially on endocrinological subjects, which have been organized by the Ciba Foundation, are by now widely known and appreciated. A series of colloquia on ageing is one of the more recent activities of the Foundation, and Volumes 2 and 3 provide the material which was presented at two meetings of gerontologists in July 1955 and July 1956.

Volume 2, which is devoted to a study of the ageing of component tissues of the body whose span of life is shorter than that of the whole animal, might at first glance be mistaken for one in the series of endocrinological symposia; for many of the papers deal with the growth and development of tissues concerned with reproductive processes in a fairly narrow endocrinological context. Thus, among various aspects of ovarian function, Sir Solly Zuckerman defends the thesis that oogenesis is a process that comes to an end at, or about the time of, birth, and deals critically with recent observations which purport to resuscitate the other view that neoformation continues into adult life, while Dr. Williams and Dr. Rowlands discuss the life, growth and fate of the large ovarian follicles and the corpus luteum respectively. Other mainly endocrinological contributions describe experiments concerned with such diverse subjects as the tissue culture of fœtal reproductive tracts and the study of the human testis with the electron microscope. The placenta is an excellent example of a transient tissue, and a further group of papers describe the morphological and biochemical changes in the organ during pregnancy. Dr. Villee thought that there was no evidence for any senile change in function which could be used to explain the onset of labour, and felt that the placenta was still quite active metabolically at the end of its life. A comparable conclusion came from Prof. Huggett, "that there is evidence that its 'efficiency', certainly for some functions, is increased in its old age; in fact, it might be said to be abruptly expelled in the prime of life".

Other papers by Dr. Mollison and Dr. Lovelock discuss what happens to the red blood cells to bring their life to such a rapid end, and what could be done to prolong their survival in storage. Age changes in the sweat glands of the human female, the factors controlling growth of the antlers in deer, and finally a botanical paper on the metabolism of senescent leaves, are titles which give some indication that, on this occasion, the limits of the definition of ageing were very widely stretched, perhaps to the extent of causing a lack of cohesion in the contents of the volume.

Contributors to the third colloquium on the "Methodology of the Study of Ageing" related their papers more closely to a single general theme. The study of ageing is of such relatively recent scientific respectability that workers in the field are acutely conscious of the need to agree on the basic definitions of their subject and on the limitations of various methods for studying the problem. At present they are more aware of the needs than confident that they have found solutions. It is clear that no one was sure about the level of organization at which ageing can be studied most profitably. Some thought that the comparative approach in studying whole populations had been badly neglected, whereas others discussed the ways in which ageing in separate organ systems or in individual cells might provide the important clues. Clinicians at the meeting were perhaps unnecessarily humble in believing that studies on human beings were less likely to be valuable than those of experimental workers on the mouse or the hamster.

The latter part of Volume 3 is taken up with a discussion of the psychological aspects of ageing and is notable for an excellent account by Welford of the problems which face those who want to understand the reasons why the work performance of human beings changes as they get older. Much of what he had to say about the design of experimental studies in psychological problems is very relevant to the design of experiments on animals for other gerontological purposes.

"The Biology of Ageing" summarizes the contributions to a symposium, organized by the Institute of Biology, which was intended for a much wider audience than is to be found at the Ciba Foundation. The papers cover all aspects of ageing from the demographic aspects in human populations to ageing in bacteria and higher plants. Several of the authors whose papers appear in the Ciba Colloquia are also represented in this volume, and some of them say little that they have not said elsewhere. The volume does, however, bring together contributions which should satisfy the many non-specialists who want to know how the subject is developing without wishing to immerse themselves in the details of experimental work which are to be found in the Ciba Colloquia.

P. L. Krohn

CHEMISTRY AND LIFE

A Symposium on the Chemical Basis of Heredity

Edited by William D. McElroy and Bentley Glass. (Sponsored by the McCollum-Pratt Institute of the Johns Hopkins University, with support from the Atomic Energy Commission.) Pp. xiv+848. (Baltimore, Md.: The Johns Hopkins Press; London: Oxford University Press, 1957.) £5 net.

This book describes in great detail the remarkable discussion of the chemical basis of heredity held in 1956 at the Johns Hopkins Institute. Almost every aspect of the problem of heredity was discussed and the very wide extent of the matters under survey is shown by the fact that Dr. Bentley Glass occupies no less than 77 pages in his summary of the whole symposium.

Original work is described in eight chapters which are subdivided into sections with the various discussions within the sections. The chapters concern "Cellular Units of Heredity", "The Role of the Nucleus", "Nucleic Acids and Associated Structures in Cell Division and Protein Synthesis", "Nucleic Acids—as Transforming Agents", "Viruses as Bearers of Heritable Characteristics", "Nucleic Acids—Chemical Composition and Structure", "Synthesis of Nucleotides and Nucleic Acids" and "Mechanism of Duplication". In this book all the papers are written with great clarity and are frequently illustrated by photographs and diagrams. For special mention one would point to the discussions on the nucleus and on the synthesis of proteins, the various aspects of nucleic acids as transforming agents, where the most astonishing discoveries are being made, and the outstanding work of Fraenkel-Conrat and his colleagues on the nature of viruses reconstituted from protein and nucleic acids. In addition there are discussions on the structure of deoxyribonucleic acid, particularly the Crick–Watson double helix, the polynucleotide biosynthesis of Ochoa and the biosynthesis of nucleic acids in some microbial systems. Delbruck's mechanism of deoxyribonucleic acid replication and the molecular basis of genetic recombination in phage are both remarkably good chapters.

The discussions of the various papers have been well recorded and form some of the most interesting reading in the book. From this conference it is apparent how much structural and physical chemistry are adding to knowledge of the biology of genes, chromosomes and studies in heredity generally.

The organizers of the symposium are to be congratulated on getting together such a wealth of talent; and the authors have done an excellent job in interpreting their ideas and latest discoveries. Every geneticist and biochemist will need to possess this book.

M. Stacey

THE FARM LIVESTOCK RESEARCH CENTRE OF THE ANIMAL HEALTH TRUST

By DR. W. R. WOOLDRIDGE
Scientific Director of the Trust

IN opening the new Farm Livestock Research Centre of the Animal Health Trust at Stock in Essex on Friday, December 6, H.R.H. Prince Philip, the Duke of Edinburgh, said: "There are three reasons why I am very pleased and delighted to be able to visit, open and look round these Animal Health Trust Laboratories. As you have just heard, I do not believe in half measures, and so I am president of the Royal Agricultural Society, president of the British Dairy Farmers Association and president of the Smithfield Show, and all of them are vitally interested in the health of farm animals. It also gives me an opportunity in the capacity of president of these three organizations and also in my personal capacity to express our admiration and appreciation of all the work that is done by the Animal Health Trust in all their laboratories in different parts of the country for the domestic animals of this country and, of course, animals all over the world.

"The third reason is because I am personally quite interested in farming and livestock generally and also because I am fascinated by all kinds of research. I like to see these ingenious techniques that are used to solve rather complicated problems. I like the atmosphere in a research establishment—the pleasure and excitement whenever some useful bit of work has been achieved after a great deal of hard work. I believe that in this world where we think that we know everything and we think that we can do everything it is sometimes good for the soul to be reminded how much we do not know, and one of the best places to find out is in a research laboratory.

"In this place there will be plenty to do—there is no doubt about that—for the prevention of disease and sickness and suffering in animals and also to help agriculture in the commercial sense. Disease in farm livestock is supposed to cost farmers something like £70 million a year, and so any investigation into disease and methods of cure and prevention is of the first importance. But there is an enormous gap between actual sickness on one hand and what one might describe as vigorous health on the other. There are all sorts of things in that gap. Infant mortality among human beings is something like 2 per cent; in farm livestock it is anything between 15 and 20 per cent. That is not an actual disease, but it is also not good health. Then there is infertility, that is not necessarily a disease, but there is something not exactly right, and in farm livestock in this country it is becoming rather a problem. A great many farm animals are becoming worn out sooner than they ought to—their productive life is not as long as it used to be. We do not know why strange things happen when we change the diet. We know some of the things that happen, but we do not know other things that happen. We do not know how the treatment of feeding stuffs with different things will affect the people who eat the animal products. I hope these and many other things will be investigated that are in the capable hands of Dr. Sellers and his helpers in these laboratories. I am quite sure they will soon be responsible for many, I hope, fruitful developments.

"I would also like to add my appreciation of the work and support that is being given to this effort by the Boreham Institute and their generosity, and I hope for their sakes also we may see some fruitful developments".

This Centre is one of four established by the Animal Health Trust—the others being organized also on a species basis and devoting their energies, respectively, to horses, dogs (and cats) and poultry. The Equine and Canine Centres are at Newmarket, and the Poultry Research Station, which is now an independent entity jointly supported by the Agri-

Fig. 1. Lilystone Hall, Farm Livestock Research Centre, Stock

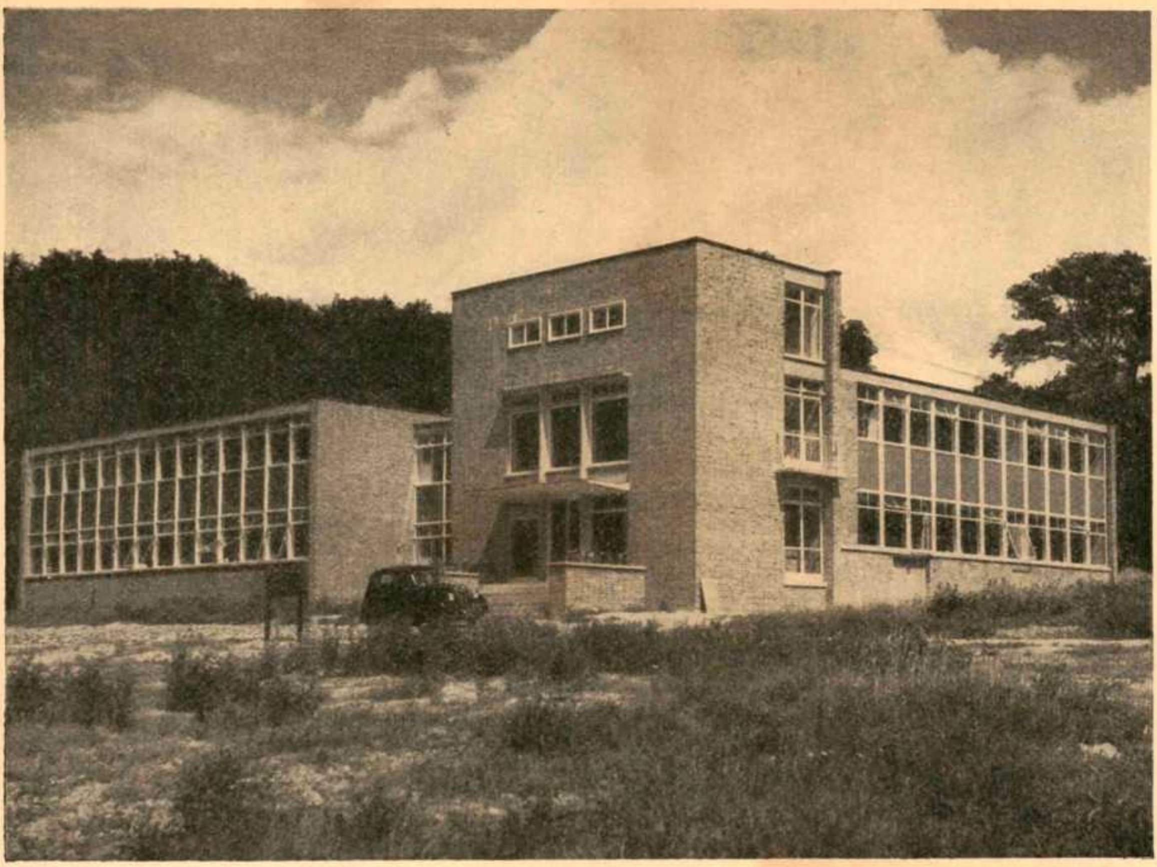

Fig. 2. New Laboratory Buildings of the Farm Livestock Research Centre

cultural Research Council and the Animal Health Trust, is at Houghton, Huntingdonshire.

The Trust is a unique organization, in that it is entirely independent ; it was founded at the end of 1942 and has maintained itself by voluntary subscriptions from owners of animals, from the general public and from organizations interested in animals. Up to date it has raised more than £1 million, which has been spent in carrying out its aims, namely to assist in the field of veterinary education and to promote researches into disease of animals and the relief of animal suffering. On the educational side it assists needy veterinary students of merit to complete their studies at the universities and makes postgraduate awards to those desiring to enter research or academic careers. It has awarded more than one hundred undergraduate studentships and more than eighty postgraduate scholarships and fellowships at a total cost of more than £100,000.

The Farm Livestock Research Centre, like the other stations, has an entity of its own, although they all come under the ultimate supervision of the scientific director of the Trust, who is advised by a Scientific Advisory Committee. Dr. K. C. Sellers is the director at Stock. The scientific staff at the moment is small, including Dr. Williams Smith as bacteriologist ; Mr. G. Skulski, pathologist ; Mr. A. L. Ogden, in charge of field surveys ; Mr. C. G. Ashton, biochemist.

The new laboratories, which will allow for some increase in the scientific staff, have been erected by the Boreham Trust, which, in addition to paying for these new buildings, has let the whole of the Lilystone Hall Estate, comprising a mansion and 37 acres, to the Animal Health Trust at a peppercorn rent (Figs. 1 and 2). The animal houses, few in number at the moment but allowing plenty of room for later development, are of a type which will permit them to be adapted fairly readily for use with different species of animals.

As with the other research centres of the Trust, the scientific staff maintains effective liaison with the farmer or other animal owner, as it is part of the policy of the Trust to employ scientists who have in addition to their own specialist experience a reasonable knowledge of the management and husbandry methods used with the species they are studying. A Livestock Advisory Committee composed of representatives of the major livestock organizations in Britain advises the director.

One of the major developments at this Centre is the carrying out of surveys in connexion with various diseases of livestock. Dr. Sellers has himself carried out a survey in east Yorkshire on the diseases of sheep, paying particular attention to losses in pregnant ewes. This survey is being continued and followed up in the laboratory.

Mr. Ogden is making a thorough survey of bovine infertility in the eastern counties in co-operation with the Milk Marketing Board. He is in close touch with the Board's progeny-testing schemes and artificial-insemination centres, and the animals, chosen at random, under his direct supervision include 3,000–4,000 cattle from some two hundred herds. Wherever possible, animals culled from these herds will be followed up in the abattoir and, where necessary, in the laboratory.

A third survey is being planned in connexion with losses in pigs. This survey is being arranged in conjunction with the staff of four large pig farms and will include several thousand animals.

It is hoped that these surveys will provide useful information and perhaps pointers to closer study of more defined problems, such as the causes of losses during early pregnancy, or during early life from birth to weaning.

The work of the Bacteriology Department is at present largely concentrated on a study of the scouring condition in calves and young pigs. The investigations have revealed that bacteria involved in the scouring condition may develop a resistance to antibiotics used in general management and as feeding additives—a fact which can have a considerable bearing upon the therapeutic use of these drugs. A technique has been devised whereby, from examination of dung samples sent in from farms, an assessment can be made within a period of only six hours, and advice given as to the best treatment for affected animals.

This work has so far been carried out mainly with *Bact. coli*, but it is being extended to other pathogenic organisms of the alimentary tract, including certain anaerobes.

Work is also continuing on Johne's disease. Following earlier work whereby a medium was devised for the more rapid culture of the Johne's disease bacillus, the presence of these microbes in various organs and tissues of the body is being examined, and useful information is being obtained which may throw light upon the route and method by which the organism gains access to the body.

Pathological work of the Centre is concerned mainly with examining material obtained from the surveys and other experimental work at the station.

In the Biochemistry Department preliminary work has been carried out upon an investigation of the blood serum proteins of cattle, sheep and pigs. The work has so far been done mainly with cattle, and the technique of examination is that of electrophoresis using specially prepared starch gels. As a result of this fairly extensive examination, it has been shown that the serum proteins of cattle fall into five patterns when examined in this way, and it has further been demonstrated that these patterns have a hereditary basis. The work is being extended to see whether, in addition, the patterns are linked in any way with such economic factors as the butter-fat or the solids-not-fat content of milk. Theoretically, it would appear that there should be a sixth pattern, and as no evidence of this has been obtained it is deduced that the mating which would give rise to this pattern is also linked with a lethal factor.

In the future it is hoped to increase the scientific staff and investigate other problems of importance to livestock farming. Certain *ad hoc* problems are already being examined, such as the treatment of bovine ringworm and the part played by iodine and vitamin A in the growth and possible disease of piglets. It is not intended, however, that this Station shall become a huge one, although there is still room for improvement which will, of course, in an organization such as the Animal Health Trust, depend upon the support it receives from livestock owners and other bodies interested in agriculture.

SCIENTIFIC OBSERVATIONS OF THE ARTIFICIAL EARTH SATELLITES AND THEIR ANALYSIS

THE advent of the Russian Earth satellites occurred so suddenly that few preparations had been made for observing them. Until July 1957, no information was available about the frequencies which were to be employed in their radio beacons. The chosen American frequency of 108 Mc./s. had been known for some time, but it was also known that the inclination of the proposed American orbits would not exceed 40°, so that it would be very difficult to make observations from stations in Britain. Considerable interest was therefore displayed when the Russians announced that their satellites would circulate in orbits at inclinations near 60°, though no detailed preparations for observation were made before the conference on rockets and satellites held under the auspices of the International Geophysical Year in Washington during September 30–October 5. It was known that a Russian delegation would attend, and it was hoped that further useful details would be forthcoming from them. In the event, the announcement of the successful launching of the first Earth satellite came during the last evening of the conference—it was announced to the conference delegates by Dr. L. V. Berkner, the American organizer of the conference, at a cocktail party, given by the Russian delegates in the Soviet Embassy in Washington.

Methods for radio, visual and radar tracking were hastily improvized. In Britain a remarkable amount of scientific work has been carried out by a great number of observers in universities and Government departments as well as by amateurs. Because of the wide range of techniques employed and the need for co-ordination of effort, a discussion was arranged by the Royal Society and was held on November 29. Papers were presented by representatives of the Cavendish and Mullard Laboratories at the University of Cambridge, the Jodrell Bank Station of the University of Manchester, the Royal Aircraft and Royal Radar Establishments, the B.B.C. and Post Office Engineering Departments, the Nautical Almanac Office, the Admiralty Signals and Radar Establishments and the Radio Research Station. Dr. J. Heywood also contributed to the discussion an account of the work done by the British Astronomical Association and the Radio Society of Great Britain. In addition to these British contributions, there was special interest in a paper presented by Dr. L. Jacchia of the Smithsonian Observatory at Cambridge, Massachusetts, on the work done in the United States on the computation of orbits for the satellites.

Much experience has been gained from the work on the first two satellites which will be of great value for future work in this field. It is now quite clear that radio tracking, while not suitable for very precise determination of satellite orbits, is quite essential as an adjunct to the use of more precise methods involving optical or radar techniques. The Russian choice of frequencies of 20 and 40 Mc./s., much lower than the American, was criticized initially because of the relatively large tracking errors introduced by the ionosphere. Experience has shown that, in fact, the accuracy is good enough to provide predictions of value for optical and radar observers, while the sensitivity to ionospheric effects can be used with great advantage for studying the structure of the ionosphere. However, it is important that the precise methods be brought to bear before failure of the radio allows the satellite to be lost.

It has been established also that optical observation of a satellite as small as the first one is a very difficult matter. This satellite seems rarely to be brighter than a sixth-magnitude star. Very good seeing conditions are required in order to observe it during the brief intervals at dawn and twilight when it is illuminated by the Sun. It was fortunate, therefore, that the rocket case which accompanied the first satellite was a very bright object when illuminated, equivalent to a star of magnitude − 1.

Because of the difficulty of optical tracking and the failure of the batteries supplying the power for the radio beacons (after three weeks for the first satellite and one week for the second), special emphasis was placed on the importance of radar tracking. The world's largest radio telescope at Jodrell Bank and also the 45-ft. diameter instrument at the Royal Radar Establishment were used with much success. In both cases the equipment was built primarily for radio-astronomical studies, and rapid improvization was necessary to fit them with reflexion radar.

The potentialities of the radar methods are considerable, and it is fortunate that two telescopes are available with such differing characteristics. The smaller, 3,000 Mc./s. telescope should be capable of detecting the small satellite at a range of 1,000 miles, and the short pulse-length (5 μsec.) gives the range to a precision of 1 km. The angular accuracy is better than ½°, and the short-wave beam is barely affected by ionospheric refraction. Further, spurious reflexions from meteor trails, which are a major annoyance in using pulses of lower frequency, are greatly reduced. However, the narrow beam width, ½°, makes searching for the satellite a long process unless its position is already fairly well known, and in fact so far the small satellite has not been observed with this instrument. Here the larger telescope, operating on frequencies of 36 and 120 Mc./s., had the advantage. Though the range on 36 Mc./s. was considerably less than that of the 45-ft. instrument, the beam width of 4° semi-angle was a great asset when searching. Radar is also of special value in the last stages of a satellite's life, and the interesting possibilities should the satellite leave a meteor type of ionization trail were emphasized.

The radar methods provide a means of determining the reflecting area of the satellite. For the rocket, a figure of 10 m.^{2} is obtained, while for the sphere it is about ½ m.^{2}. This is consistent with rocket dimensions of about 4 ft. diameter and 25 ft. long, but there appears to be some discrepancy between the drag to be expected for such a body randomly orientated and the drag actually observed. The large size of the rocket body is supported by the visual observations, and it has been suggested that the low drag is to be accounted for by the presence of sufficient aerodynamic stability to keep the rocket moving head-on to its direction of motion.

Results obtained for the orbits of the first satellite by the use of radio interferometers and Doppler recorders were described by Mr. M. Ryle (Mullard Laboratory, Cambridge) and Messrs. A. N. Beresford, E. G. C. Burt and D. G. King-Hele (Royal Aircraft Establishment). The techniques employed in the observational and analytical aspects of this work have already been described in *Nature* of November 2 and 9. The accuracy attainable is sufficient to detect and check the major effects of the Earth's equatorial bulge. Normally this produces two principal effects —a precession of the plane of the orbit about the Earth's axis in a sense opposite to that of revolution of the satellite, and a rotation of the major axis in the orbital plane. At the inclinations (nearly 65°) of the Russian Earth satellites, the second effect is very nearly zero—it vanishes for orbits with inclination 63·4°. The predicted rate of precession of the orbital plane about the Earth's axis is 3·2°, which is close to the values 3·18° and 3·17° found by the Royal Aircraft Establishment and Mullard Laboratory observers, respectively.

The effect of air resistance is to reduce the period of revolution of a satellite at a gradually increasing rate. In principle, it is possible to derive information from observations of this kind about the air density and temperature at different levels of the atmosphere through which the satellites pass. Actually, an additional complication arises from the existence of an electrical drag effect due to the effect of charging up of the satellite in its passage through the ionosphere. The fact that no less than three objects of different aspect—the satellite itself, the rocket-case and the nose-cone—were put into orbit by the first launching has been of value in studying drag. Mr. Ryle explained how it was possible, from a combination of the radio observations of the satellite with the optical and radar observations of the rocket case, to make a calibration to determine the effective drag cross-section of the latter, assuming it to be spherical. Thus in the first week or so the rate of change of period per revolution was 1·84 times greater for the rocket case than for the satellite. It seems that the satellite separated from the rocket case at a relative velocity of 186 cm./s. in a direction opposite to the orbiting motion. It thus fell to a lower altitude and commenced orbiting more rapidly, very soon overtaking the case. Soon, however, the greater drag on the case reduced its altitude and caused it once again to overtake the satellite.

Probably the most prominent feature of the discussion was the clear need for accurate orbit data. The radio methods can give apparent position with considerable precision. Thus the interferometers give apparent direction to 1 minute of arc, while the Doppler method gives the time of nearest approach (electrical) to a few milliseconds. That these results are very far from giving the true position can be judged from the fact that the time of nearest approach given by the 40 Mc./s. signal may differ by many seconds from the time given by the 20 Mc./s. signal, and signals may be received from beyond the horizon.

The discouragement of orbit-computing with data containing some material of doubtful reliability was clear from Mr. D. H. Sadler's account of the excellent work done at the Nautical Almanac Office. At Herstmonceux every observable transit had been observed. To be useful, position data should be accurate to

1/10° and 1/10 sec. time. Ten times this precision is required to derive useful information from the periodic deviation from ellipticity caused by terrestrial oblations, and for geodetic purposes another order of magnitude in precision is necessary.

Dr. Jacchia described the computational procedures used at the Smithsonian Institution, where they have the large *IBM* 704 type of electronic computer. He had ten good optical observations of the sphere and seven of the nose cone. The following expressions were given for the position of the components of the first satellite at time t; α is the right ascension of the ascending node and t_n the time of nth crossing. Time is in year days (that is, Jan. 1, 1957, $t = 0$; Oct. 7, $t = 280$).

Sputnik 1:

$$\alpha = 334{\cdot}3° - 3{\cdot}058° (t-280) - 0{\cdot}00408°(t - 280)^2$$

Rocket:

$$t_n = 282{\cdot}82058 + 0{\cdot}0686222n - 1{\cdot}47721 \exp 0{\cdot}00134n - 1{\cdot}769 \times 10^{-5} \exp 0{\cdot}0102n$$

Sphere:

$$t_n = 277{\cdot}87138(\pm 0{\cdot}00025) + 0{\cdot}0668120(\pm 0{\cdot}0000036)n - 8{\cdot}84 (\pm 0{\cdot}12) \times 10^{-7}n^2$$

Nose cone:

$$t_n = 277{\cdot}87224 (\pm 0{\cdot}00013) + 0{\cdot}0667072(\pm 0{\cdot}0000023)n - 6{\cdot}007 (\pm 0{\cdot}079) \times 10^{-7}n^2$$

The right ascension of the ascending node for *Sputnik* 2 was given as:

$$\alpha = 306{\cdot}7° - 3{\cdot}18° (t - 289)$$

The probable errors for the present position of the components emphasize the necessity of obtaining accurate data while the radio transmitter is still operative. If inadequate precision is attained during this phase, the satellite may be lost, as has occurred with the sphere, and optical and radar equipment may have much difficulty in finding it. At the time of the conference, a few kinetheodolite observations had been made in Australia, and at the Royal Aircraft Establishment it is intended soon to use kinetheodolites to give a precision of 1 msec. in time and 30 sec. of arc; but on the whole, in Great Britain especially, there has been a paucity of precise data.

The great benefit to ionospheric research of a pair of radio transmitters circulating within the F-layers was very evident. Much data have been accumulated, though of necessity interpretation lags behind. Indeed, inadequate orbit figures may reduce the value of some of the radio data. From the first, the B.B.C. carried out precise monitoring of all the telemetry and radio beacon signals. Several false starts to the Doppler frequency – time curves were noticed, which suggested 2½, 1½ and ½ hop-modes of propagation by ionospheric reflexion.

A somewhat similar phenomenon had been observed by the Post Office Engineering Department, a considerable portion of a Doppler frequency drop having occurred while the satellite was still 2,000 miles away. This was tentatively attributed to reflexion from some patch of intense ionization near to the satellite.

Using a wide-aperture high-frequency direction finder, the Admiralty Signals Establishment observed the satellite over global distances at night. Propagation, it was suggested, might be by a leaky wave-guide mode in the ionosphere, or by a multihop system. Another ionospheric effect was evidenced in the widespread observation that the Doppler frequency appeared to rise again before the signal finally disappeared. The influence of the ionosphere was also evident in the observations made of apparent bearing and elevation at 20 and 40 Mc./s. at the Radio Research Station. It was once more evident that, before these efforts can be interpreted in detail, more accurate data on time, bearing and elevation are required.

The first satellite's transmitters were keyed on both frequencies at rates varying from 108 to 180/min. The mark-to-space ratio varied considerably, and on one or two transits a curious repetitive variation in transmitter-frequency occurred during the pulse. At times also the signals from one transmitter were received at reduced strength during the transmission of the other frequency. Several measurements of field-strength gave the beacon power as a little more than 1 watt.

A variety of types of signal fading were noticed by many observers, including those using reflexion radar. A comparison of the behaviour of signals in aerials polarized at right angles and of the relative frequency of the fading on the two beacon frequencies makes it possible to distinguish between the effect of the satellite rotation, the Faraday effect and scintillation due to ionospheric irregularities. It appears that the first satellite was rotating at about 7 rev./min.

The determination of ionospheric density by Doppler measurements, by the Faraday rotation of the plane of polarization and by refraction as given by the interferometer was discussed by Dr. K. Weekes. The Faraday effect would appear to be the most promising method, though results obtained in this way so far seem to give values for electron number per unit area column in excess of those obtained by conventional radio probing.

H. S. W. MASSEY
R. L. F. BOYD

THE GRASS COVER OF AFRICA

By R. O. WHYTE and J. M. RATTRAY

Agriculture Division, Food and Agriculture Organization of the United Nations, Rome

IN those regions of Africa in which tsetse fly is not a limiting factor, domestic livestock play an important part in the economy of both European and African agriculture, and their grazing is provided almost entirely by the natural vegetation. It is therefore essential to have information on the ecological status and behaviour of that vegetation and particularly of the grass components, as a basis for what has come to be called the ecological management of grassland, in relation to its most efficient utilization and optimal productivity.

There are three main stages of the mapping of grazing lands and grass associations: (1) a physiognomic map of vegetation made by plant geographers; (2) a generalized map of the grass associations; (3) detailed studies of botanical composition and succession made on individual grass associations and on limited areas.

The latest map of the first type is that prepared by A.E.T.F.A.T. (Association pour l'Étude Taxonomique de la Flore d'Afrique), which recognizes, along with various types of forest and woodland, the geographical distribution of savannah, woodland savannah, xerophilous woodland, semi-desert scrub and grassland, all of which may represent a grazing resource of varying importance. The grassland ecologist and agronomist then knows where the grasslands are; but he must obtain further information regarding the botanical composition and ecological status and behaviour of the grass associations before he can make recommendations regarding their management.

The Food and Agriculture Organization of the United Nations has as a long-term objective the mapping of the grazing resources of the underdeveloped regions of the world on some basis which will be of value to those concerned with the improvement of grassland management and of the livestock industries which depend on them. The grazing and other resources of northern Australia are already being dealt with by Land Research and Regional Survey of the Commonwealth Scientific and Industrial Research Organization using the comprehensive survey technique involving team-work on geomorphology, geology, soils, climate, vegetation and land utilization, and leading to the recognition of land systems.

As a result of recommendations made by R. O. Whyte while acting as grassland adviser to the Government of India, a five-year reconnaissance survey of the grasslands was begun in 1954, and has already covered more than half the country. In a forest environment where climax grassland comparable with steppe, pampas and prairie (if these are true climaxes) appears to be absent, a grouping into eight main floristic grass associations has been made; the thirty or forty floristic types of grass cover which can at present be found in different parts of India are merely stages in succession produced by local variations in edaphic or other natural conditions or by the operation in varying degrees of intensity of the major biotic factors of burning, grazing and cutting.

As, apart from the broad surveys on the Australian pattern now being made by B. W. Taylor, Food and Agriculture Organization field officer in Nicaragua, the information regarding the vegetation and grass associations of Latin America is less complete than that for Africa, the Organization has concentrated first on the latter continent. J. M. Rattray has produced a map of the grass cover of the greater part of Africa on similar floristic lines to those which he had adopted earlier for his map of Southern Rhodesia.

The distribution of the main species contributing to the grass cover of Africa is a matter of considerable economic importance when it is realized that probably more than half the land surface of the continent carries a type of vegetation of which grass is an essential feature. While there already exist a number of vegetation maps of the individual territories of Africa (but only one of the continent as a whole), most if not all of these place the emphasis on the distribution of broad vegetation units which have been classified on a physiognomic or ecological basis. When a floristic classification has been used, the distribution of the woody dominants of the vegetation has generally been mapped, and the identity of the less-prominent but equally significant grass constituents has been touched on only very lightly or omitted altogether.

It is well known that the vegetation of Africa ranges from tropical forest to desert and that it includes a large number of transitional associations; it is often difficult to decide where one type starts and another ends. Rainfall and temperature are the most important factors affecting plant distribution since they are jointly responsible for the amount of moisture which the vegetation receives. When the change in climatic pattern is gradual, the change in physiognomic type is correspondingly slow, and *vice versa*. These changes in appearance are usually associated with changes in the density and nature of the tree population, the merging of forest into woodland, woodland into savannah and savannah into steppe being characteristic of the manner in which woody vegetation reacts to a gradual reduction in the amount of available soil moisture. Fire also plays a very important part in controlling the density of the tree population in Africa. Much of the more open savannah country has developed as a result of frequent burning, and when fire is excluded a tree cover tends to regenerate.

The climatic range of the grass constituents of the types of woody vegetation does not necessarily coincide with that of the associated tree species; while there may be some change in the physiognomy of the vegetation, the botanical nature of the associated grasses may remain unchanged. It has not always been possible to rely entirely on vegetation maps based on physiognomy as an accurate guide to the main grass species unless the changes in climatic pattern are sufficiently drastic to cause very considerable changes in the type of vegetation. One of the chief difficulties in compiling the Food and Agriculture Organization map has been the linking up of adjacent territories from the existing information and maps. Frequently the botanical composition of the grass cover would appear to undergo a complete change precisely on the boundary between two countries. Sometimes this may be attributed to the fact that there mountain ranges form the dividing line, for example, between certain East African territories, so that the climatic pattern on either side is sufficiently different to affect the composition of the vegetation. In other areas, however, the sudden change would appear to have resulted from differences in the technique of surveying or nomenclature, or in the interpretation of the vegetation types by those responsible for botanical surveys. In addition, the time of year when the survey was conducted is very important in relation to the dominance of the grass species in particular; surveys made early in the growing season frequently give a very different picture from those made late in the season, especially in the absence of plant counts. Where this situation arose, lists were obtained of the species which occur on both sides of the boundary; those which are characteristic of the area as a whole were ascertained, and a degree of continuity between the botanical composition of the grass cover in the neighbouring territories was thus obtained.

In the Food and Agriculture Organization map of Africa, emphasis has been placed first on the distribution of the main grass associations characterized, but not necessarily dominated, by a particular genus, and secondly, on the type of vegetation with which these are commonly found. The sixteen main types of grass associations, with a number of sub-associations which have been recognized within each main class, are as follow:

Main grass associations in Africa	No. of sub-associations	Main grass associations in Africa	No. of sub-associations
Andropogon	7	*Exotheca*	1
Aristida	8	*Heteropogon*	1
Cenchrus	2	*Hyparrhenia*	30
Chasmopodium	2	*Loudetia*	4
Chloris	1	*Panicum*	3
Chrysopogon	6	*Pennisetum*	3
Ehrharta	1	*Setaria*	2
Eragrostis	7	*Themeda*	22

The main grass associations are given in different colours (sixteen in all); these colours are entered in the map in various shadings and hatchings to indicate the occurrence of the grass type in different physiognomic formations. Thus the colour blue indicates management of lesser-known grasslands in, for of this basic blue colour represent: (1) species of *Hyparrhenia* and other grasses, forming grassland; (2) species of *Hyparrhenia* and other grasses, associated with woodland of varying density; (3) species of *Hyparrhenia* and other grasses, associated with savannah of varying density; (4) species of *Hyparrhenia* and other grasses, associated with tree steppe.

Within these types are entered a letter and number to indicate the approximate location of a particular sub-type; the thirty sub-types within the main *Hyparrhenia* type are therefore entered as *H*1 to *H*30. The accompanying text indicates in varying degrees of completeness, depending on the information available, the associated grass, tree and other species, altitude, rainfall and present management as grazing land or utilization as crop land.

These basic studies on the distribution of types of grass associations in Africa, when considered alongside the results being obtained in India and northern Australia, may be used for a number of purposes. Within the overall picture of distribution of tropical grasslands, it is expected that these studies will show a considerable degree of similarity between the types of grass cover in the great arc of lands from central, east and north-east Africa to India, and on to northern Australia. As knowledge of this type accumulates, it should be applicable to the ecological management of lesser-known grasslands in, for example, West and East Pakistan, Ceylon, Burma and the countries of south-east Asia. Since the greater part of the grass cover in the deforested areas of tropical and sub-tropical Latin America is dominated by species which may have been fortuitously or intentionally introduced from Africa, the experience obtained and the technique of mapping adopted in the preparation of the Food and Agriculture Organization map of Africa should be of great value when the Organization comes to prepare a map of the grass cover of Latin America.

From the point of view of management of natural vegetation for grazing purposes, it should be possible to transpose methods which have been worked out for one region of Africa to another with a similar type of grass cover but lacking adequate facilities for research. In the text accompanying the map it has been possible to give full details regarding management for the grass types which occur in Southern Rhodesia and Kenya, covering such aspects as the duration of the grazing season, the need for resting vegetation from time to time and the place of burning in a system of management. The ultimate objective is to be able to give this type of information for all the economically important types of grass cover in Africa. It should further be possible to use the grass map in association with soil and climatic maps to indicate the capability of various land classes for the cultivation of specific crops in fertility-maintaining rotations, bearing in mind always the optimal conservation of vegetation, soil and water.

BIOLOGICAL PRODUCTIVITY OF BRITAIN

A SYMPOSIUM on "The Biological Productivity of Britain", organized by the Institute of Biology, was held during October 4–5, in the lecture theatre of the Royal Geographical Society. It attempted to survey present and possible future production from agriculture, horticulture and forestry, from the uncultivated uplands and from rivers and inland waters of Britain. So large a subject could not be covered in detail, and some important aspects of it, notably the losses from diseases and pests, were deliberately omitted; it is hoped that these may provide subjects for future symposia.

The proceedings were opened by Lord St. Aldwyn, Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, who said that the Institute of Biology, by providing a forum for interchange of ideas between scientists of many different disciplines, and acting as a focus of views of biologists, is of great value to the Government, which regards it as its function to encourage, assist and put on a sound organizational basis the work of the scientist in the biological field. The promotion of an efficient agriculture is a vital interest of the community, and so the elucidation by biologists of productive potential takes place in a favourable climate of opinion. How far this potential can be realized depends on economic, social, psychological and political considerations, but that does not diminish the value of asking the fundamental questions.

The first session, with Prof. H. D. Kay as chairman, dealt with limitations on production set by the available land area and by climatic and physiological factors. Prof. L. Dudley Stamp (London School of Economics) said that the pattern of land-use in Britain is remarkably stable; it is determined mainly by elevation, slope and rainfall, with soil-type as a more local influence. He advocated that classification of land to indicate its agricultural potential should in future be based on the number of standard nutrition units (each equal to 10^6 calories per annum, sufficient to support one human being in health) that can be produced per acre. Recent changes in land use, described by Dr. G. P. Wibberley (Wye College), are difficult to assess quantitatively because of the inaccuracy of the records; thus loss of farm-land to other uses, mainly urban development, in England and Wales during 1900–50 was nearly twice as great as indicated by the official statistics, and amounted to 2½ million acres. Discussion of these papers revealed disagreements about the economics of glasshouse production, emphasized that urban land is not wholly sterile—it was said to account for about 5 per cent of home food production at present, and for about 10 per cent during the Second World War—and questioned the validity of a standard nutrition unit based only on calories and ignoring quality aspects of food, especially protein content.

Biological productivity depends ultimately on factors that limit total photosynthesis per unit area of land. Dr. D. J. Watson (Rothamsted Experimental Station) showed that there is little hope of improving the photosynthetic efficiency of field crops, and as the maximal leaf area of some species is already close to the optimum for dry-matter production, the main possibility for increasing yield lies in increasing leaf area during parts of the growth period when it is small. Possible ways of doing this, such as breeding for frost resistance to permit earlier leaf growth in spring, and the use of gibberellic acid, were suggested by several speakers, and others speculated on the ideal architecture of a crop plant.

The second session, with Mr. F. C. Bawden in the chair, began with an account by Dr. H. G. Sanders (Ministry of Agriculture, Fisheries and Food) of present agricultural production in Britain, which he thought "just about right", though undeniably below the biological potential of the land. The fertility of the soil is well maintained, but drainage has been neglected. Production of good-quality beef and lamb should be increased, and this depends on improvements in production, conservation and utilization of grassland herbage.

The development of more efficient systems of husbandry calls for improved varieties of crop plants adapted to changed environmental conditions. Dr. G. D. H. Bell (Plant Breeding Institute, Cambridge) described the methods of controlled hybridization and selection used by plant breeders for producing new varieties to satisfy particular needs. Of the newer techniques, chromosome doubling has already produced commercially valuable polyploid strains of sugar beet. The chief value of mutations induced artificially by ionizing radiation or chemical treatment may be to provide new parental types for hybridization.

In a paper on expansion of animal production, Prof. M. McG. Cooper (King's College, Newcastle) agreed with Dr. Sanders that only beef and lamb production should be increased; there is already some over-production of eggs and milk. The high intensity of grassland farming appropriate for milk production may not be so effective for fat lamb or beef. Much beef production would have to be a by-product of dairying, using steers bred from dairy cows by beef bulls, and reared by more economical methods based on early weaning and the use of antibiotics. Singularly little progress has been made in the past fifty years in improving the inherent quality of farm livestock, partly because most herds and flocks are too small to be effective breeding units. British livestock are performing well below their potential, and the basic problem still is adequate agricultural education.

Some very variable estimates of productivity per man in British agriculture were put forward in the subsequent discussion, ranging from nearly £700 a year to zero or a negative amount depending on how far subsidies are allowed to enter into the sum. It was claimed that capital invested in reclamation of waste land in the lowlands would give a greater return than schemes for improving hill land. It was also suggested that soils of low productivity should be improved by using earth-moving machinery to mix adjacent heavy clays and light sands, and that more wild species of animals and plants might be domesticated.

Mr. E. M. Nicholson took the chair for the third session, which dealt with productivity of rivers, lakes and forests. Dr. J. W. G. Lund (Freshwater Biological Association, Windermere) stressed the lack of information on primary production in fresh waters; most studies considered only the phytoplankton, but in fresh water benthic plants may produce far more than the plankton. The standing crop may give a fallacious idea of the primary production, if it is not measured at short intervals. There is at present little economic interest in increasing the production of aquatic plants; on the contrary, water undertakings and some industries are concerned to keep it at a low level. In a paper on the production of fish, Mr. E. D. Le Cren (Freshwater Biological Association, Windermere) said that under intensive management fresh waters can produce large crops of first-class protein that compare favourably with agriculture in yield and economic value, but except for trout there is no market for freshwater fish in Britain. A large part of the productivity of British waters goes towards the production of eggs and milt and the rearing of fry that then die; the angler catches only a tiny fraction of the fish-flesh produced, and then returns much of it in fear of depleting the spawning stock.

Present production from forestry in Britain, unlike that from agriculture, is far from being "just about right". Mr. M. V. Laurie (Forestry Research Station, Farnham) said that per head of population it is nearly the lowest in Europe, and satisfies only 10 per cent of Britain's timber requirements. Since the War, the programme of reafforestation is falling behind for lack of sites within the narrow range between what is unsuitable for agriculture and what is unsuitable for forestry, and research is in progress to extend the planting limits that are set mainly by exposure, which prevents planting above 1,500 ft., and by depth of soil. Dr. J. D. Ovington (Merlewood Research Station, Nature Conservancy) said that forestry has ceased to be exploitation of natural vegetation, and sylviculturists are attempting to domesticate trees, just as herbaceous plants were domesticated for agriculture. How far better management techniques, introduction of new species, and breeding for desirable qualities can raise the productivity of British woodlands is doubtful, because little is known about the ecological factors that control productivity. Fertilizers may be necessary for sustained production over long periods. Growth studies on an age series of Scots pine plantations showed greater annual dry-matter production than by neighbouring agricultural crops, presumably because of the continuous leaf cover, but only a small fraction of the dry matter produced in woodland is utilized by man; controlled grazing of the ground flora might be one way of increasing it.

The discussion covered a wide range of topics including the value of leguminous ground crops in young forest, the effect of coniferous trees on soil *p*H, the influence of different tree species on soil formation, the effect of forest cover on the supply of water from a catchment area, and the possibility of using some good agricultural land for hardwood forest.

In the fourth session there were papers on water control for increased crop production, the future of British uplands and unconventional production of foodstuffs. Dr. H. L. Penman (Rothamsted Experimental Station) said that though the agricultural value of field drainage is undoubted, there are no data that give a quantitative measure of it. More than half the clay lands in England and Wales are inadequately drained. In the eastern counties, irrigation would increase production of potatoes, sugar beet and grass in a majority of seasons, but to have a significant effect on national food production a very large amount of water would have to be provided by impounding winter rain that at present runs to waste, or by importation from elsewhere in Britain.

Prof. J. B. Cragg (University of Durham) advocated a multi-purpose use of the uplands, based on ecological surveys and a classification of the capability of the land. Extractive processes such as grazing should be so arranged that the ecological complex of soil, flora and fauna retains sufficient reserves and variety to resist deterioration. In some areas fertilizer application may suffice to fit the soil for grassland or crop production; in others of lower mineral status reafforestation may be essential to restore fertility, or removal of peat deposits may expose soils capable of agricultural development.

The most extreme unconventionality in food production would be total synthesis, but Mr. N. W. Pirie (Rothamsted Experimental Station) thought this could provide only a small fraction of future food supplies, because of the scale of the industry required. The primary source of food would probably continue to be higher plants grown essentially as they grow now; but biochemical engineering, by developing ways of separating edible fractions from plant material that is not directly suitable for human consumption, may enable more productive plant species to be cultivated, and circumvent wasteful conversion by animals. As a practical example, Mr. Pirie provided samples of food containing leaf protein for the audience to taste.

In summing-up the symposium, the chairman, Prof. W. H. Pearsall, directed attention to two omissions: there had been no detailed reference to the importance of either carbon dioxide or nitrogen supplies in biological production. A biological criterion of land use was required, and he suggested that the availability of soil nitrogen should determine whether a site is used mainly for protein production or for cellulose production. The meeting finished with a general discussion which referred to water meadows, human tolerance of plant protein, the yield of mass cultures of green algæ, the carbon dioxide content of the internal atmosphere of leaves, and the advantages of mixed farming. Several speakers stressed the need for better administrative machinery to decide between competing uses of marginal land.

Two distinct problems were considered in this symposium: first, the potential biological productivity from the land of Britain, and secondly, what is desirable or practicable in the current state of economics and politics. It was made clear that present production is far short of the potential, and this is a comforting thing, because with world population rapidly increasing Britain may need to produce more food in the future. It is therefore vitally important to get information now on all possible ways of increasing yield, so that the maximum can be produced when the economic situation demands it.

A full account of the proceedings of the symposium will shortly be published by the Institute of Biology.

D. J. Watson

SMOKING HABITS AND MORTALITY AMONG WORKERS IN CIGARETTE FACTORIES

A PAPER entitled "Smoking Habits and Mortality among Workers in Cigarette Factories", by H. B. Haag and H. R. Hanmer, was read before the Section on Industrial Medicine and Surgery of the Southern Medical Association at its 51st annual meeting at Miami Beach, Florida, on November 14. The paper deals with a four-year survey of the mortality among permanent employees and retired employees in nine processing plants of the American Tobacco Company and links this with observations made by Finkner and his co-workers[1] on the smoking habits of cigarette factory employees and by Haenszel and others[2] on the smoking habits of the 'general population' of the United States.

Haag and Hanmer conclude that their study of this sub-population shows "a higher-than-average percentage of smokers and a much higher-than-average rate of smoking to be associated with greater longevity, relatively lower death rates from cancer and cardiovascular diseases and respiratory cancer rates no higher than the general population". Their results are summarized in Table 1.

The authors make two further claims:

(1) That "The existence of such a population makes it evident that cigarette smoking *per se* is not necessarily or invariably associated with a higher risk of lung cancer or cardiovascular diseases or with diminished longevity". (2) "This finding assumes added significance from the fact that no sampling error is involved in the methodology." This refers to the statement of the results, not to the first claim.

The first commendably restrained and qualified claim can in fact only be made if the second claim is true.

Table 1. Observed and Expected Number of Deaths from Specified Causes among Full-time and Retired Employees of Cigarette Plants and Stemmeries of the American Tobacco Company during January 1953–December 1956

Cause	Expected No. of deaths	Observed No. of deaths	Ratio: expected to observed
All causes	350	241	1·45
Cancer—all forms (140–205)	61	47	1·30
Cancer—respiratory system (160–164)	10	10	1·00
Cancer of trachea, bronchus and lung, specified as primary (162)	4	4	1·00
Cardiovascular diseases (400–468)	137	104	1·32
Coronary disease (420)	82	56	1·46

Numbers in parenthesis refer to cause-of-death codes of the sixth revision of the international statistical classification, 1948, as used in "Vital Statistics of the United States"

It is one of the penalties of writing about such inflammatory topics as the alleged etiological role of smoking in the development of lung cancer that it is almost certain that irresponsible as well as responsible use will be made of any conclusions, with respect both to the influencing of personal habits and to the pursuit of wealth. Because of this possibility, the logical credentials of any investigation that appears to throw new light on the matter should be subjected to careful scrutiny.

In the paper under consideration the methods employed involve a comparison between the 'expected' number of deaths from different causes that would have occurred if the death-rates for the general population were in fact operating on the sub-section of the population under consideration, and the observed number of deaths that did in fact occur in the sub-section.

The arguments employed are based upon the partly explicit premise that the employees of the American Tobacco Company include a higher proportion of regular smokers, and that these smokers have a higher personal cigarette consumption, than the general population; and that this difference is sufficient to warrant the inference that, if it were true that smoking has the etiological effect claimed with respect to the diseases under consideration, the mortality from these diseases would, under the conditions of the study, necessarily be higher than the 'expected' mortality.

An implicit premise of the arguments is that the sub-section of the population differs from the general population, in respect of all those attributes that may render them liable to succumb to the diseases considered, only in their smoking habits, which form the subject of the investigation, and in age, sex, and colour distribution for which allowance can be made by using the appropriate specific death-rates.

Let us now examine the first premise. The reported association[3] between smoking and lung cancer is more marked than that between smoking and the other causes of death under consideration. It is therefore appropriate to use this alleged association to see what effect the recorded alteration of smoking habits[1,2] would have on the 'expected' number of deaths derived from the death-rates of the general population if the finding of Hammond and Horn accurately reflects the degree of association.

From these data and those provided by the authors it has been possible, by making certain assumptions, to calculate the factor by which the 'expected' number of deaths would have to be multiplied, because of the change in smoking habits, if Hammond and Horn's hypothesis is correct. The required factor is 1·7, so that the 'expected' number of lung cancer deaths would become 7 instead of 4 as a result of the change.

The assumptions which, in the absence of more precise information, have been made are that the lung cancer 'expectation' is derived largely from male employees (and retired employees) aged between fifty and seventy, and that the age distribution of these employees is the same as that in the general male population of the United States. If much of the 'expectation' is derived from male employees under fifty or from female employees, or if the number of male employees tail off with advancing age more rapidly than the number in the general population, the factor of 1·7 will have to be reduced, perhaps substantially.

Although the data for allowing for colour difference are not available, there is no reason to believe that this would affect the factor profoundly.

The sample size of the survey was such that 4 deaths from lung cancer were expected at the rates for the general population. Applying the conventional test of significance at the $P = 0{\cdot}05$ level, that is, $\pm 2 \times \sqrt{(\text{expectation})}$, the investigation could not have discriminated, at this significance level, between an observed value of 0 and 8. Since the hypothesis of Hammond and Horn only requires an observed value of 7, the conditions of the study are not such that it could have detected the difference of lung cancer mortality that would have resulted from the changed smoking pattern of the American Tobacco Company employees if Hammond and Horn's hypothesis were true.

This reasoning does not apply to cases of the diseases other than respiratory cancer under consideration, where a marked deficiency of the observed deaths compared to 'expected' deaths is found. These diseases, except for the unspecified ones in the group 'all causes', are relatively chronic ones. This circumstance should at once lead us to examine the second premise, and to ask whether the sub-section of the population, the American Tobacco Company employees, is in fact representative of the general population of the United States in respect of all the attributes, other than smoking habits, age, sex, and colour, that may render its members more liable to succumb to the diseases under consideration.

The study does not mention how the American Tobacco Company selects its employees, how rapid the labour turnover is, what the sex, age and colour distribution is, or how long the employees have been with the Company. Furthermore, the authors do not state that any cognizance has been taken of past employees who leave for reasons other than retirement.

If any kind of medical screening is employed, the sub-population at once ceases to be representative of the general population, and the difference may easily be such as to invalidate any conclusions that may be drawn from the application of rates derived from the general population.

In a survey covering a relatively short period of time (four years) and which is dealing with chronic diseases, this source of bias can be particularly important. The bias will become even more marked if the labour turnover is high, since there will always be a large proportion of the sub-population who have recently been admitted to it because they were found to be free from disease. Further bias might be introduced if there were a selective wastage due to employees with early signs of chronic disease seeking more suitable employment.

It must therefore be concluded that the evidence at present advanced in this paper does not warrant the claim that "no sampling error is involved in the methodology", and until further evidence can be produced to satisfy readers that the methodology is in fact valid, judgment on the first claim, that "The existence of such a population makes it evident that cigarette smoking *per se* is not necessarily or invariably associated with a higher risk of lung cancer or cardiovascular diseases or with diminished longevity", should be reserved. With regard to the specific topic of lung cancer and smoking, it would be necessary in addition to enlarge the survey considerably before the conclusions of Hammond and Horn could be refuted.

Since the topic is of considerable importance to the public health it is to be hoped that the authors will be able to provide the missing background information and to extend the survey. If it is at all possible, it would be highly desirable to extend the survey to discriminate between the different smoking categories within the American Tobacco Company employees, and to see if a mortality gradient corresponding to cigarette consumption is shown. Unless and until the survey is extended and doubts about methodology dispelled, the authors' conclusions should not be used as a guide to human behaviour.

R. A. M. Case

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[1] Finkner, A. L., Horvitz, D. G., Foradori, G. T., Fleischer, J., and Monroe, J., University of North Carolina Institute of Statistics. Mimeo Series No. 177 (1957).

[2] Haenszel, W., Shimkin, M. B., and Miller, H. P., Public Health Monograph No. 45 (U.S. Department of Health, Education and Welfare, 1956).

[3] Hammond, E. C., and Horn, D., *J. Amer. Med. Assoc.*, 155, 1316 1954).

NEWS and VIEWS

New Year Honours List

The following names of scientists and others associated with scientific work appear in the New Year Honours list:

Baronet: Sir Harry Platt, lately president of the Royal College of Surgeons.

G.C.V.O.: Sir Stewart Duke-Elder.

C.H.: Viscount Nuffield.

K.C.B.: Dr. Harry W. Melville, secretary, Department of Scientific and Industrial Research.

K.B.E.: Maurice E. Adams, civil engineer-in-chief, Admiralty.

Knights: William R. J. Cook, deputy director, Atomic Weapons Research Establishment, Aldermaston (United Kingdom Atomic Energy Authority); Dr. Julian S. Huxley; Prof. Christopher K. Ingold, professor of chemistry, University of London (University College); Prof. Hans A. Krebs, Whitley professor of biochemistry, University of Oxford, and honorary director of the Cell Metabolism Research Unit of the Medical Research Council; Dr. Ernest Marsden, member of the New Zealand Council for Scientific and Industrial Research; John W. Worboys, chairman, Council of Industrial Design, a director of Imperial Chemical Industries, Ltd.

C.B.: Hayne Constant, director, National Gas Turbine Establishment (Ministry of Supply); J. E. Serby, director-general, Guided Weapons (Ministry of Supply); H. Tetley, deputy government actuary.

C.M.G.: A. L. P. Kirwan, director and secretary, Royal Geographical Society.

C.B.E.: P. H. Andrews, assistant secretary, Ministry of Agriculture, Fisheries and Food; Dr. C. R. Burch, Warren Research Fellow in physics, University of Bristol; A. E. Crook, principal inspector of mechanical engineering, Mines Inspectorate (Ministry of Power); Prof. H. J. Emeléus, professor of inorganic chemistry, University of Cambridge; Prof. R. H. Evans, professor of civil engineering, University of Leeds; W. N. Foster, petroleum technologist, Trinidad; D. L. Gunn, director, International Red Locust Control Service, Northern Rhodesia; H. W. Harvey, senior principal scientific officer, Laboratory of the Marine Biological Association of the United Kingdom, Plymouth; L. Hughes, deputy chief veterinary officer, Ministry of Agriculture, Fisheries and Food; Dr. C. H. Johnson, director, Materials and Explosives Research and Development, Ministry of Supply; W. E. Lancaster, lately director of veterinary services, Federation of Malaya; H. B. McCance, chairman of council, Linen Industry Research Association; Prof. P. B. Medawar, Jodrell professor of zoology and comparative anatomy, University College, London; Dr. G. A. Reay, superintendent, Torry Research Station, Food Investigation Organization, Department of Scientific and Industrial Research; Prof. I. A. Richmond, professor of archæology of the Roman Empire, University of Oxford; H. Service, lately director, Geological Survey, Malaya; G. D. Sharman, assistant secretary, Department of Agriculture for Scotland; Dr. R. W. West, principal, Battersea College of Technology; J. Wilson, director of research, British Rayon Research Association.

Mechanical Engineering in the University of Western Australia: Prof. D. J. F. Allen-Williams

Dr. D. J. F. Allen-Williams, who has recently been appointed to the chair of mechanical engineering in the University of Western Australia, is thirty-nine. He was educated at Harrow School and Clare College, Cambridge, where he took Part I of the Mathematical Tripos and then in 1939 the Mechanical Sciences Tripos. After some official civil engineering work in 1939, he was seconded in 1940 to the Air Ministry Research Establishment, Swanage (later known as the Telecommunications Research Establishment). He worked mainly on radar countermeasures and after a visit to the United States was posted in 1945 to the headquarters of South East Asia Command. He was recalled in October 1945 to become group leader in electronic instrumentation for nuclear physics at the Telecommunications Research Establishment, Malvern. In October 1946 he returned to Cambridge as a research student in the Department of Radiotherapeutics. His main work was the development of the 30-MeV. synchrotron as a radiotherapeutic instrument. By his efforts, Dr. Allen-Williams made it practicable to carry out a useful, though limited, clinical trial with a machine which was found to present a great many difficulties. In 1950 he was elected to a British Empire Cancer Campaign Junior Fellowship to continue his work on the synchrotron and its applications to radiotherapy. In 1952 he received the degree of Ph.D. (Cantab.) for a thesis on this work, and in October 1953 was appointed physicist with special reference to the applications of electronics to radiotherapeutics in the Department of Radiotherapeutics of the University of Cambridge. In November 1954 he joined the Ruxton–Paxman Group of companies to study the development of nuclear energy in industry, and in July 1955 he was appointed senior research engineer with Davey, Paxman and Co., Ltd. He has always been interested in the contributions of engineering to social betterment and the improvement of conditions of living.

Civil Engineering at Southampton :

Prof. P. B. Morice

In view of the recent and forthcoming growth in the size of the Engineering Faculty, the University of Southampton has decided to increase the number of chairs in the faculty. In accordance with this policy, the University has instituted a chair of civil engineering ; the first professor will be Dr. P. B. Morice. After taking his degree at the University of Bristol, Dr. Morice was for a time with the Surrey County Council Highways and Bridges Department. Since 1948 he has been with the Research Division of the Cement and Concrete Association, and has been for a number of years head of the Structures Research Department. His main interests lie in the fields of pre-stressed concrete and in the theory of structural analysis. The University of Southampton can look forward to the vigorous growth of the Civil Engineering Department now that it has at its head a professor with an outstanding record of research.

Geology at Exeter : Prof. Alan Stuart

The establishment of a chair of geology in the University of Exeter is a further stage in the growth of that young institution. Mr. Alan Stuart had the task of laying the foundations of a Department of Geology twelve years ago, and a measure of the success of his efforts is now his promotion to a professorship. Prof. Stuart received his undergraduate training, after service in the First World War, in the University of Durham, specializing in mineralogy and petrology under the guidance of Dr. L. Hawkes. In 1921 he was appointed to the staff of the new University College of Swansea, where for twenty-five years he was not only responsible for much of the geological teaching and the building of the Department, but also undertook part of the College administration, notably as superintendent of examinations. He thus had experience in university affairs that stood him in good stead when he assumed his duties in Exeter in 1947. Prof. Stuart's interests have been wide : he has published work on the petrology of coal, on magnetite sands, on the mineralogy of the Old Red Sandstone and of recent dune sands, and on the ontogeny of gastropod shells. More recently he has devoted special attention to optical methods in mineralogical and crystallographic analysis, and is joint author with N. H. Hartshorne of the standard work "Crystals and the Polarizing Microscope". It is a fitting conclusion to a devoted university career that Exeter should have thought it proper to appoint him to the chair.

The Royal Society : Vice-presidents for 1958

Sir Cyril Hinshelwood, president of the Royal Society, has appointed the following vice-presidents for the year ending November 30, 1958 : Sir William Penney, treasurer of the Royal Society, director of the Atomic Weapons Research Establishment, Aldermaston ; Sir Lindor Brown, biological secretary of the Royal Society, Jodrell professor of physiology at University College, London ; Sir Charles Dodds, Courtauld professor of biochemistry in the University of London ; Sir Bryan Matthews, professor of physiology in the University of Cambridge.

European Organization for Nuclear Research : Appointments

M. François de Rose, a member of the French Atomic Energy Commission, has been elected president of the European Organization for Nuclear Research (C.E.R.N.) in succession to Sir Ben Lockspeiser, who guided the Organization during its formative period and is retiring on completion of the statutory three-year term of office. Mr. J. Willems, of Belgium, and Prof. W. Heisenberg, of Germany, have been elected vice-presidents. They succeed Mr. F. de Rose, of France, and Prof. Holtsmark, of Norway. Prof. E. Amaldi, of Italy, has assumed the chairmanship of the Scientific Policy Committee, succeeding Prof. W. Heisenberg of Germany. Mr. J. H. Bannier, of the Netherlands, has been appointed chairman of the Finance Committee, in succession to Mr. J. Willems, of Belgium. Sir Harry Melville, secretary of the Department of Scientific and Industrial Research, has been appointed to succeed Sir Ben Lockspeiser as one of the British delegates to the Council of the Organization, the other delegate being Sir John Cockcroft. During 1957 the entire staff of the Organization moved into its permanent headquarters at Meyrin, near Geneva. The total number of personnel is now 598, of which about two-thirds are scientific and technical.

American Hall of Fame

Bronze busts of George Westinghouse, inventor of the air brake, and Josiah Willard Gibbs, the thermodynamicist, are to be placed in the Hall of Fame for Great Americans at the University of New York. At an unveiling ceremony, held on December 1 in the Gould Memorial Library Auditorium of the University of New York, the bronzes were accepted by Dr. C. V. Newsom, president of the University. The principal speakers were Mr. Herbert C. Hoover, former president of the United States, and Dr. D. W. Bronk, president of the U.S. National Academy of Sciences. The bust of Westinghouse, which was given by the American Society of Mechanical Engineers, was sculptured by Edmondo Quattrocchi. The bust of Gibbs, a gift of the American Chemical Society, Yale University, and several individual donors, is by Stanley Martineau.

Site for Expansion of the University of St. Andrews

A statement by the Secretary of State for Scotland, circulated with Hansard for December 17, regarding his decision on the building site for the University of St. Andrews, which was challenged both on procedure and on merits, points out that while the University's evidence at the inquiry was given after the evidence for the objectors, the lines of the University's case had been made clear in advance and its witnesses were intensively cross-examined. The Government's broad acceptance of the Franks report did not mean reopening proceedings already concluded. On merits, Mr. J. Maclay said that the inquiry lasted for ten days, during which all aspects of the matter were fully debated, with a further day devoted to the inspection of sites. It was conducted by a senior and very experienced member of the Scottish Bar as commissioner, wholly independent of the Scottish Office, with the assistance of eminent and independent planning assessors, and his decision was in line with the recommendations in the Commissioner's report. A crucial part is the adequacy of the site for the future scientific needs of the University. The University's view that the Westburn Lane site is adequate and suitable for foreseeable needs of basic scientific teaching and research, that peripheral sites are available if any specialized research necessitated the creation of special buildings at St. Andrews, and that further expansion could still be undertaken at Queen's College, Dundee, was upheld by the Commissioner. Although criticized by the Professor of Physics as shortsighted, this view was supported by the University Grants Committee.

The Commonwealth Trans-Antarctic Expedition

The tractor train of the New Zealand Antarctic expedition led by Sir Edmund Hillary reached the South Pole on the night of January 3. This is the first time that the Pole has been reached overland since the pioneer expeditions of Amundsen and Scott. The expedition, which also includes P. Mulgrew, M. Ellis, J. Bates and D. Wright, reached the American base at the Pole having driven three tractors, two sledges and a caboose 1,200 miles from Scott Base since October 14. The New Zealand expedition, in conjunction with a R.N.Z.A.F. party under Squadron-Leader J. Claydon flying a *Beaver* aircraft, has laid down five depots of food and fuel between Scott Base and Depot 700, about seven degrees of latitude short of the Pole, in support of the United Kingdom trans-Antarctic survey party under Dr. Vivian Fuchs, which proposes to cross the continent from the Weddell Sea to the Ross Sea. At the time of writing, Dr. Fuchs' team, about three hundred miles from the Pole, is encountering hard going from *sastrugi* (ice-ridges) impeding the progress of his tracked vehicles. On January 6 Squadron-Leader J. Lewis, flying an R.A.F. *Otter* single-engine aircraft, traversed the Antarctic continent from the advance British base at South Ice to Scott Base, where Dr. Trevor Hatherington's team of scientists is continuing its programme of observations for the International Geophysical Year.

Soviet and Western Attitudes to Science

The text of a talk entitled "What is the Right Attitude to Science ?" by Dr. K. Mendelssohn, reader in physics in the University of Oxford, broadcast on December 23 on the B.B.C. Third Programme, has recently been published in *The Listener* (January 2, p. 12). Dr. Mendelssohn points out that science and technology, to which the West owes its high standard of living, have been taken so much for granted that they are now accorded second place in the educational system. Now, quite apart from military considerations, the prospect of Russian technological superiority may make it an economic necessity to re-assess the Western position. It is a dogma of Soviet economics that prosperity is based on technological progress, and the rewards to scientists and engineers both in salary and status in the Soviet Union are accordingly high. Even more important is the fact that science in the U.S.S.R. is administered at the highest levels by the Soviet Academy of Sciences and not by politicians or generals. The position is almost the exact opposite in the United States, where the direction of scientific effort is largely in the hands of non-scientists, which not only leads to defective decisions, but also relegates the scientist to a subordinate position. In Britain, on the other hand, while science is mostly directed by scientists, the false dichotomy between science and the humanities has created an almost hostile, or at least defensive, public feeling against science. This, together with early specialization in British schools, has tended to discourage entry into scientific professions. The Russian achievements are largely due to money spent on scientific education and research, even at times when the Soviet Union was passing through economic crises. Dr. Mendelssohn suggests that in Britain more money spent on education could still buy time : time essential for a good general training in both arts and science and for an extra year at a university.

Recent Earthquakes

On December 4 a very great earthquake occurred in Outer Mongolia, with epicentre near latitude 45½° N., longitude 99½° E. The initial time of this shock was 03h. 37m. 45s. G.M.T., and it attained magnitude 7·9 on the Gutenberg–Richter scale. This earthquake was registered on the seismograph at the Royal Observatory, Edinburgh, with maximum ground amplitude of almost 250μ. After-shocks from this and neighbouring epicentres were frequent, especially during the first half of December. Six great aftershocks occurred on December 4, four on December 8 and one each on December 5, 7 and 11, besides numerous smaller ones. All these shocks were registered throughout the world. The area affected macroseismically included the districts of Bayankhongor, Ara Khangai and Ubur Khangai. A wide permanent fissure more than six miles long is said to have appeared in Bayan Tsagan at the time of the earthquake.

On December 13 a smaller earthquake occurred in western Persia with epicentre near latitude 34½° N., longitude 48° E. It had magnitude 7¼, and occurred at 01h. 44m. 59s. G.M.T. It was registered on the seismograph at the Royal Observatory, Edinburgh. The macroseismic effects of this shock were very great in the triangle bounded by Kermanshah, Hamadan and Sanandaj. Murdistan, Assadabad and Kangavar were severely damaged, and Farsinaj was almost destroyed. The earthquake may have caused the deaths of 2,000 people.

The Griffin Gas Chromatography Apparatus

Messrs. Griffin and George, Ltd., have issued a very well-produced pamphlet describing the Mark 2 version of their gas chromatography apparatus. This pamphlet is profusely illustrated with diagrams and photographs, and also contains a short bibliography which will be useful to anyone intending to use gas chromatography for the first time. Typical chromatograms obtained with the Griffin and George equipment are reproduced, and these illustrate the versatility of gas chromatography, showing the analysis of a range of compounds from the C_8–C_{18} fatty acids and their esters, to a series of simple aromatic hydrocarbons. Some indication of the special virtues of a number of different stationary phases is given in a short table.

Zoological Nomenclature

The International Trust for Zoological Nomenclature has arranged for the publication in book form of the first instalment of each of the "Official Lists" of valid zoological names and of the corresponding "Official Indexes" of rejected and invalid names, together with the first instalment of the "Official Lists" of work approved as available for zoological nomenclature and of the "Official Index" of rejected and invalid works. The categories of names covered by these lists and indexes range from specific names to ordinal names, and the total number of entries now to be published is about five thousand. The first of these lists, relating to generic names, was established by the Ninth International Congress of Zoology held at Monaco in 1913, while the most recent were brought into existence by the Fourteenth Congress at Copenhagen in 1953, but owing to the large number of documents now involved it has become difficult for specialists to ascertain what names have so far been registered. This difficulty will be removed by the new publications, each of which will be supplied both with a full alphabetical index and also with alphabetical indexes arranged by major groups. The groups so selected will normally be classes, but in the case of large classes containing well-recognized orders, these supplementary indexes will be on an ordinal basis. All inquiries should be addressed to the International Trust for Zoological Nomenclature at its Publications Office, 41 Queen's Gate, London, S.W.7.

Royal Society and Nuffield Foundation Commonwealth Bursaries

THE following awards under the Royal Society and Nuffield Foundation Commonwealth Bursaries scheme have been announced : Mr. J. Attridge, assistant lecturer in zoology, Birkbeck College, University of London, to enable him to collect and study Karroo vertebrate fossils in Southern Rhodesia during June–October 1958 ; Colonel S. S. Bhatnagar, St. Xavier's College, Bombay, for the study of procedures for the characterization of chemical and pharmacological principles of plants, at Cambridge during April and May 1958 ; Dr. A. J. Buller, senior lecturer in physiology, St. Thomas's Hospital Medical School, London, to enable him to gain practical experience in studying the nervous system by the microelectrode techniques, at Canberra, for about ten months from March 1958 ; Mr. J. Dainty, reader in biophysics, University of Edinburgh, for research on the ionic relations of plant cells and the electrical properties of plant cell membranes, at Sydney, during March–September 1958 ; Dr. W. P. U. Jackson, of the Department of Medicine, University of Cape Town, for the study of specific methods and techniques in endocrine research (prediabetes, plasma insulin activity, calcium and phosphate metabolism) in London, Cambridge and Louvain, during June–August 1958 ; Mr. C. St. J. Lamb, lecturer in electrical engineering, New South Wales University of Technology, to enable him to assist in the development of instrumentation of nuclear reactors used for the production of electrical energy, at Erith, Kent, for a year from January 1958.

University News : Birmingham

THE title of reader in physiology has been conferred on Dr. I. C. Whitfield, senior lecturer in physiology. The following appointments have also recently been made : Dr. R. L. Holmes, to be senior lecturer in anatomy ; Dr. T. R. Lomer, to be lecturer in physics ; Dr. G. Gregory, to be staff tutor in the Institute for Engineering Production ; F. D. Hobbs, to be Paviors lecturer in highway engineering in the Department of Civil Engineering ; and L. Kay, to be lecturer in electrical engineering.

Two new graduate courses have been established in the Faculty of Science : one is a course in the Department of Pure Mathematics leading to a diploma in mathematical statistics, and the other is a course in operational research in the Department of Engineering Production leading to the degree of M.Sc. by examination.

London

THE title of professor of pathology in the University of London has been conferred on Mr. M. H. Ashton in respect of his post at the Institute of Ophthalmology. The title of reader in the University has also been conferred on the following : Dr. A. Armitage (history and philosophy of science) at University College, Dr. Ivy Pinchbeck (social studies) at Bedford College, Dr. C. A. B. Smith (genetical statistics) at University College, and Mr. R. J. Wilkins (civil engineering) at University College.

Malta

IN accordance with the terms of the Royal University of Malta (Constitution) Act of 1957, a Statutory Commission has been formed to "advise the Government on any matter relating to or connected with the University which the Government may refer to them for advice and report, including the expedience of amending or repealing and replacing any Statute for the time being in force or any Regulation made thereunder. No major act of the University which may involve expenditure shall be entered into by the University without the prior approval and advice of the Commissioners who, before giving such approval and advice shall make a report on the matter to the Government and shall consult with the Government on the total amount of funds available. The Commissioners shall also, if so requested by the University, advise the University in the working out of new policies".

Members of the newly appointed Statutory Commission are as follows : Sir Ivor Jennings, Master of Trinity Hall, Cambridge (*chairman*), L. J. F. Brimble, J. S. Fulton and Sir Charles Snow.

Announcements

SIR WILLIAM G. OGG, who has been director of Rothamsted Experimental Station since 1943, will retire on September 30, and the Lawes Agricultural Trust Committee has appointed Mr. F. C. Bawden to succeed him.

PROF. E. LEDERER, of the Institut de Biologie Physico-Chimique, Paris, known for his work on paper chromatography, will be visiting professor in the Department of Chemistry, King's College, University of Durham, Newcastle upon Tyne, for a period of about six weeks, starting on March 4.

THE Institution of the Rubber Industry and the Plastics Institute are holding a joint conference on February 27 at the Institution of Civil Engineers, Great George Street, Westminster, S.W.1. The subject will be "Recent Advances in Polymer Technology". Further information can be obtained from the Secretary, The Plastics Institute, 6 Mandeville Place, London, W.1.

THE Spectroscopic Panel of the Hydrocarbon Research Group of the Institute of Petroleum is organizing a conference on molecular spectroscopy, to be held at the Institution of Electrical Engineers in London during February 27–28. The programme will cover the whole field of spectroscopy. The main topics to be discussed will be nuclear magnetic resonance, technical developments, intermolecular forces and factors affecting intensities of absorption bands. Further information can be obtained from E. Thornton, c/o British Petroleum Co., Ltd., Chertsey Road, Sunbury-on-Thames, Middlesex.

DESIGN OF PHYSICS RESEARCH LABORATORIES

ON November 27, the London and Home Counties Branch of the Institute of Physics held a symposium at the Royal Institution on "The Design of Physics Research Laboratories".

In his introductory remarks, Dr. J. S. Forrest (chairman) recalled that a similar discussion had been held by the Institute of Physics ten years ago (*J. Sci. Instr.*, 25, 157 ; 1948). In the intervening decade, however, there has been intense activity in the building of new laboratories. Moreover, the character of the physics research laboratory is changing ; the conventional laboratory with standard benches equipped with standard services and apparatus is no longer suitable for dealing with many of to-day's problems, which require large machines with the attendant erection and servicing facilities. Accordingly, the time was ripe for a further discussion to put on record the lessons learned during the past ten years and to present the views of architects and research directors responsible for the planning of modern laboratories.

A basic laboratory design which seems to fulfil modern needs, and which was referred to by several speakers, takes the form of a large central area, perhaps 60 ft. wide, with relatively small enclosed laboratories along the sides. The central area must have adequate head-room (more than 20 ft.) and it is therefore possible to provide a number of smaller enclosed laboratories or offices on a gallery over the ground floor laboratories (Fig. 1).

Prof. Basil Spence said he had been concerned with the design of university physics laboratories. Teaching laboratories had to cope with large numbers of students, but the requirements could be defined clearly. Research laboratories, on the other hand, must be extremely flexible in design, as the nature of the work which might be carried out in a few years time was unknown. He had even had to provide for the possibility of increasing the roof height in one project.

Dr. T. Emerson dealt with some problems in the planning of industrial research laboratories. He emphasized the importance of good team-work between the research director, the architect and the builder. The duties and responsibilities of the various parties should be clearly defined at the outset. The requirements for accommodation and services should be co-ordinated and all instructions passed to the architect by one person only, for example, the building supervisor, who might with advantage be the person responsible for the future maintenance of the finished building. The aim should be to construct an adequate building at reasonable cost with plenty of laboratory space to provide future flexibility, sufficient office accommodation, but no unnecessary frills.

A contribution by Charles S. Haines (read by Mr. D. T. R. Dighton) discussed recent trends in the design of American industrial research facilities. In the United States it is becoming common to put the research facilities on a rural site separate from the manufacturing plant. It is important to provide adequate space for future expansion and car parks, and some companies with research organizations of approximately one hundred persons are acquiring sites of more than 200 acres. The design of the buildings must proceed from the inside outwards. To prevent early obsolescence, modular planning is essential, a module being a "three-dimensional repetitive unit of functional space". The satisfactory width of the laboratory module (usually parallel to the exterior wall) may vary from 9 to 12 ft. ; the length may be from 24 to 28 ft. Office modules of 5 ft. × 15 ft. will provide individual and group offices of 10, 15, 20 or 25 ft. × 15 ft. Factory-finished metal partitions are preferred for sub-dividing laboratories, and they should be designed so that room arrangements may be modified without moving the mechanical and electrical services. Air conditioning is desirable, and fume chambers may be required in physics as well as in chemistry laboratories. Many laboratories built in the period from 1949 to 1954 using cheap materials and poor construction are now beginning to deteriorate. Properly planned sound construction using lasting and easily maintained materials will prove to be more economical.

Mr. B. C. Fleming-Williams spoke on services and facilities from the user's point of view. The permanent services—water, gas and waste pipes, electric

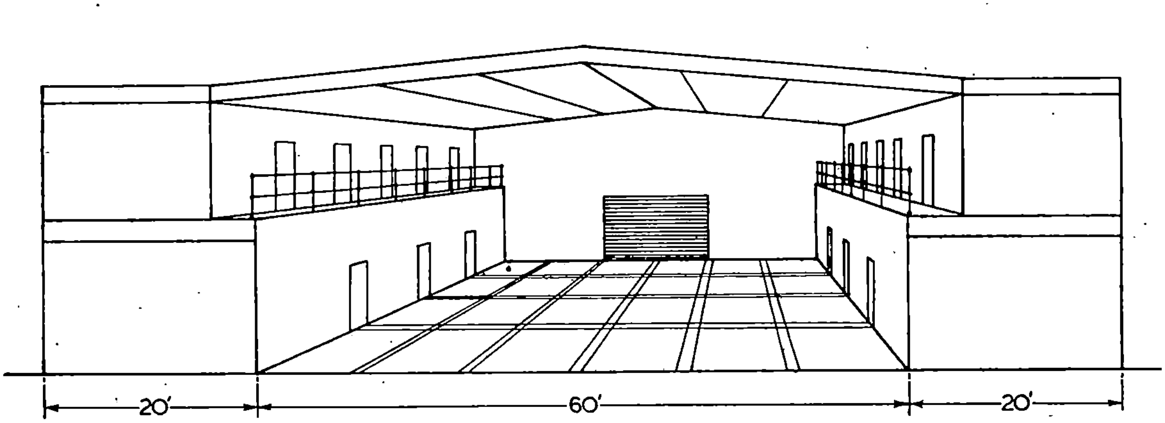

Fig. 1. A basic design for a physics research laboratory

power, lighting, heating and ventilation—should be based on a modular plan. Local supplies may sometimes be preferable to a permanent central installation. For example, direct current can conveniently be supplied from individual power packs instead of from a central battery. Similarly, vacuum requirements can usually be provided by bench pumps, and supplies of various gases from local cylinders. Facilities must be available, however, for the handling and storage of gas cylinders. An adequate and easily accessible duct system should always be installed to enable any central service to be provided at any point if it is found to be desirable in the future.

Mr. J. C. Cornwell discussed buildings and services from the point of view of the laboratory maintenance engineer. He pointed out that maintenance staffs in laboratories are more often concerned with alterations and additions to the buildings and facilities than with simply maintaining the original installation. When the laboratory is designed, provision should be made to facilitate building extensions and alterations to the services. In the choice of partitioning, sound transmission and ease of attachment of shelves are important considerations. Brick and some proprietary types of partitioning are satisfactory, but steel and glass are not. Floor surfaces and their cleaning merit particular attention. Floor ducts should be designed to minimize flooding. Fire protection should receive adequate consideration. Provision must be made for inflammable stores, radioactive sources, gas cylinders and bulky maintenance equipment.

Mr. R. G. Hopkinson spoke on the programme of research on the design of laboratories which is being carried out by the Nuffield Foundation Division for Architectural Studies in collaboration with the Building Research Station. Statistical studies have been made of the bench space and services required by laboratory workers. The work on laboratory lighting was carried out at the Building Research Station. From the determinations of minimum levels of natural and artificial lighting for the efficient performance of laboratory work, a design has been evolved which gives good day-lighting in a single-side lit laboratory. A model was used for assisting in the appraisal of the design (Musgrove, J., and Petherbridge, P., *Architect's J.*, 126, 368; 1957).

In opening the discussion, Mr. D. A. Oliver suggested that two types of laboratory accommodation are generally required—'open space', costing about £2 per sq. ft., and 'better-class' laboratory accommodation costing about £4 10*s*. per sq. ft. The better-class accommodation should be kept free from noise, vibration and dirt; workshops and heavy machines should be in a separate building.

Other matters discussed were the advantages of air conditioning and electric floor warming in research laboratories; a method of providing a wide range of electricity supplies at the benches; and a colour-light staff location system which also functioned as a fire alarm.

In summing up the symposium, Prof. F. A. Vick said that the physicist must make up his own mind as to his requirements, but it is sometimes important that the outside of laboratory buildings should be in keeping with other adjacent buildings. The use of models could be a great help in planning laboratories. Workshops and equipment causing noise and vibration should be kept separate from the research laboratories and offices. The services should be very carefully designed bearing in mind the many points raised in the discussion, and detailed plans of the services properly colour-coded should be handed over with the building. The laboratory furniture should be designed as part of the building. He agreed that it is false economy to save money on the initial cost of the laboratory—taken over a number of years the capital cost of buildings is not usually a very important item in the research laboratory budget.

J. S. Forrest

COLOUR TELEVISION IN UNIVERSITY TEACHING

GUY'S HOSPITAL AND MEDICAL SCHOOL and the British Broadcasting Corporation collaborated to present a series of sixteen demonstrations, lasting more than two hours, which was relayed from Alexandra Palace to Western House, Great Portland Street, London, on the evening of November 19. Marconi's Wireless Telegraph Co., Ltd., provided a colour television projector and a 6 ft. × 4 ft. screen. Although this presentation had been organized for the staff of Guy's Hospital and the Medical School, a large number of representatives from other faculties in the University of London and from medical centres elsewhere were also present.

The purpose was to judge the technical quality of the British system and to consider whether the apparent and potential properties of colour television are sufficiently attractive to warrant a critical trial under practical conditions.

This venture was by no means a stunt. Repeated technical experiments in the research establishment of the Marconi Company at Chelmsford preceded further trials at Alexandra Palace by members of the staff at Guy's representing fourteen different departments. The B.B.C.'s production staff had to evolve new methods and to adapt their equipment to a considerable extent. For example, teaching demonstrations were found to require big close-ups, whereas existing techniques had naturally been designed to satisfy the demands of the theatrical producer. It may be of interest to note that this was the first occasion on which the B.B.C. has transmitted a continuous colour television programme of this length. Meticulous planning was necessary to enable the two cameras to move from one demonstration to the next in less than two minutes. That the presentations followed each other with quite extraordinary precision was the more remarkable as few of the busy physicians and lecturers had been able to attend more than one or two rehearsals. This is a point of importance, as it might be assumed that television techniques in medical teaching will exact undue demands upon the lecturer's time.

The general consensus of opinion was that the quality of definition and colour balance was well above reasonable expectation and most certainly made the use of colour television a practical possibility. It is still to be decided whether this method of communication should be further tested for its effectiveness by a series of critical experiments carried out against the background of university teaching. It was not possible on this occasion to draw any valid conclusions in this respect. The audience consisted of experienced teachers and not students, most of the demonstrations were enacted by senior lecturers, who would normally have been directing such work while actually with their students; and, of course, a large technical staff was available to handle intricate and bulky equipment. Both equipment and methods will have to be simplified drastically to adapt this medium for use in everyday instruction, and there is every expectation that this could be done. However, only practical experience under realistic conditions will show to what extent and how colour television can contribute to understanding and learning.

It may be of value to consider here the essential properties of colour television and how they might possibly be applied. Events and phenomena can be observed at a distance, even when direct vision is not possible. The moving image can be viewed either on large projection screens, or on smaller television receivers in any desired number of places, by large audiences, at the exact time that events are taking place. Fine detail, such as individual hairs on the back of the hand, and large scenes, such as big machinery in a laboratory, can be portrayed with equal ease. High-power microscopic examinations can be made with considerably higher brilliance than is possible with conventional projection microscopes. Preliminary experiments with endoscopes have proved that their use may well become a commonplace, as soon as the associated optical problems have been solved. Live presentation, films, slides and charts can be shown in immediate sequence, and indeed in any desired admixture.

The images from two or more television cameras can be presented in sequence or even side by side. It will thus be possible to correlate separate aspects of the same subject or to contrast similar phenomena by using more than one camera in quite different locations, as, for example, in a laboratory and in a hospital ward.

Perhaps the most important difference from normal visual records such as diagrams, lantern slides and motion picture films is the fact that a live action is shown on the television screen at the exact moment when it happens. Apart from any other considerations, the psychological effect of this upon a student body may prove to be considerable. Whereas a film is rigid in its construction and presentation and cannot easily be arrested, the television demonstration is entirely under the lecturer's control. He can direct the demonstrator through a two-way radio link, he can ask for an alternative presentation of the same subject or for a repetition when he feels that this would be of greater benefit to the students. Mistakes and defects can be rectified immediately, a process which may in fact add to the value of a demonstration, by emphasizing its immediate and local character, and thus imparting to it a liveliness and personal nature often absent from films. Each demonstration can be varied according to the lecturer's wishes and according to the existing knowledge of his students. Participation by the audience can be used where appropriate, for students can both hear and speak to the demonstrator who is with the camera.

Many will maintain that the motion picture film can be used as effectively and more economically. A brief consideration of this contention will expose its fallacy. Even if funds could be raised to establish and maintain sufficient film production units to make films of all the many subjects which can be shown by television, few teachers would have the time required for drafting the initial treatment and for supervising the scripting, rehearsing, shooting and editing of such films. Even if all these films could be made, they would neither fit in with the ideas of other teachers, nor could they possibly be equally effective for different types of audiences. Some 'date' quickly and there are inevitable delays between preparation and exhibition.

Such handicaps do not apply to television. The lecturer discusses with his assistant what he wishes to demonstrate. The camera is placed in position, and the lecturer can direct and control the proceedings as and when he requires them while talking to his students. This demonstration can be as simple or elaborate as he himself may wish.

The use of good colour, a live presentation, the magnification of small detail for large audiences, the juxtaposition of different events or phenomena separated in space, participation by the audience, and complete control by the lecturer can be regarded as the main characteristics which might be exploited. What effect, in terms of understanding and learning, might this have on students? Which type of student will derive the greatest benefit from colour television and at what stage of his learning? Which teaching situations and which disciplines are most likely to benefit from its use? How should it be used to its best advantage? Finally, is the total effect economically worth while? The answers to these questions can only be established satisfactorily when a centre consisting of many different interests and types of student, both undergraduate and postgraduate, is prepared to undertake a full and unbiased investigation of the method. No one will be optimistic enough to imagine that colour television can solve all problems of teaching, nor will any responsible teacher wish to interpose an elaborate electronic device between himself and his class where the normal direct approach can do all he wishes. Nevertheless, experience already shows that television demonstration may permit valuable additions to the content of teaching in many medical subjects, especially by presentation to large audiences of things it is rarely possible to show even to a handful of students. Doubtless, present views and expectations will be modified, and unsuspected potentialities discovered, when it becomes possible to make a full exploration in the working conditions of a medical centre. The results of such an experiment might prove to have far-reaching effects on education, not only in university circles, but also in schools and perhaps even on television broadcasts to the general public.

A colour sound film recording of the demonstration and a booklet published by Marconi's Wireless Telegraph Co. in collaboration with the Illustration Department of Guy's Hospital Medical School are available.

C. E. Engel
Roger Warwick

AUTOMATION IN THE POST OFFICE

In moving the second reading of the Post Office and Telegraph (Money) Bill in the House of Commons on December 5, the Postmaster-General, Mr. E. Marples, said that during the next two years the Post Office would be spending about £180 million on capital equipment, of which £105 million would be by way of depreciation and ploughed back by the Post Office. Of this sum, more than £167 million would go to telecommunications, £6 million to telegraphs—mostly 'Telex'—and £7 million to postal services. Amplifying the White Paper (see p. 71 of this issue), Mr. Marples, who doubted whether there had been purposeful direction of science and shrewd timing of applied science in the past, explained how in 1958 the saving of £2 million would be achieved in wages as well as at least £10 million-worth of equipment which would have been scrapped under the old system. To secure the maximum use of the £150 million-worth of buried wires, which is increasing at the rate of £11 million a year, the Post Office is trying to bring the automatic line concentrator into operation as fast as possible, and in 1960 it is hoped to have the first all-electronic exchange in operation at Highgate Woods, as a result of the work of the Joint Electronic Research Group, a partnership between the Post Office and private enterprise. By putting in extra repeaters every three miles, it will be possible to make much better use of the existing coaxial cables, either doubling the number of conversations or providing a television channel.

Dealing with the postal services, Mr. Marples said that the procedure in sorting is essentially the same as that used one hundred years ago ; of the total cost of the postal services of £120 million, man-power accounts for 70 per cent. Of that total, sorting accounts for £40 million and delivery for £30 million. The first electronic sorting machine is already in operation at Southampton, and another, the first of a further twenty, should soon be available at Norwich. This development, which is well in advance of the rest of the world, is due to the scientists at Dollis Hill Research Station. It requires for its application a standard envelope, and Mr. Marples emphasized the importance not only of co-operation, particularly with the United States and Canada, in research, but also of public opinion. He said he is starting a scientific survey to find out what the public expect and want from the postal services and how far they are prepared to co-operate, for example, by using a code number for the address. Mentioning the International Committee of Postal Studies, Mr. Marples said that as a result of a visit by the Deputy Postmaster-General of the United States last summer, a team of five Post Office officials has studied mechanization in Canada and in the United States. He had also appointed a committee, with Sir Leonard Sinclair as chairman, "to advise the Postmaster-General on the future place of the inland public telegraph services as part of the communication facilities of the United Kingdom", and he was seeking to encourage co-operation with private industry particularly in telecommunications. Help was being given by the Council for Industrial Design in standardization of telephone exchange equipment and telephone kiosks. Referring to the human problems of automation, after a tribute to the co-operation of the trade unions, Mr. Marples said that he had appointed the general secretary of the Union of Post Office Workers and the chairman of the staff side of the Post Office non-engineering Whitley Committee to the policy committee advising him on mechanization.

In replying to a question in the debate about cable-ships, the Assistant Postmaster-General, Mr. K. Thompson, said that the new two-way Atlantic cable to be laid in a few years, as a result of an agreement with Canada, would be a new plastic-covered cable developed by Post Office engineers and the cable company. British two-way rigid repeaters would provide sixty conversation channels in the single cable, compared with thirty-six in the present double cable.

MEDICAL USES OF IONIZING RADIATIONS

FOLLOWING on the publication of the British and American documents setting out the Hazards to Man of Nuclear Energy, the United Nations Organization set up a Scientific Committee on the Effects of Atomic Radiation. This Committee invited the International Commission on Radiological Protection and the International Commission on Units and Measurements to consider how best to arrive at reliable data for estimating the doses received by different parts of the human body—by individuals, and in the aggregate by large population groups—due to medical use of ionizing radiation. A study group, under the joint chairmanship of Prof. Rolf Sievert and Dr. Lauriston Taylor (chairmen, respectively, of the two International Commissions), decided to spread the work as widely as possible. It was divided among five groups of experts drawn from fourteen countries—Austria, Canada, Columbia, Czechoslovakia, Denmark, France, Germany, Italy, Norway, Sweden, Switzerland, the United Kingdom, the United States of America, and Uruguay.

The genetic hazard is of primary importance, and the data when accumulated will be used for assessing the significant dose per annum to the gonads of any population. A study group of the World Health Organization, which reported earlier this year, considered the possibility of registering systematically doses received by all individuals, but this proposal proved to be unrealistic. There would be too great a margin of error, and too great an expenditure of man-power and of money. There would be difficult legal and psychological consequences. There are, however, certain classes of persons, and certain routine procedures, for which, by a widespread expert sampling survey, sufficiently accurate records can be obtained. The undertaking is by no means a light one. The data available from half a dozen countries, now published in *Physics in Medicine and Biology*, 2, No. 2 (1957), in some eighteen tables, prove to be difficult of collation ; they disclose wide differences of estimated gonad dose. In Denmark and the United Kingdom it is given as about 25 mrad., in Sweden 40 mrad. and in the United States something nearer 100 mrad.

The group recommends an extensive survey, preceded by a pilot preliminary survey. It sets out the desiderata for obtaining uniformly reported information from various countries. These include classifications of age groups, the anatomical type of examination, the radiological type, and the gonad dose per examination for male, female and fœtus. In estimating the dose from the internal use of radionuclides, a factor should be introduced for 'parenthood expectation' for the average patient. It is of interest that, as had been found with other surveys, even the partial investigation so far carried out in Great Britain has already led to a reduction of the gonad dose by adoption of the recommendations included in the last report of the International Commission on Radiological Protection, and the evidence from expert measurement of the actual doses delivered. The means recommended to this end include protective devices for the gonads, a minimum film-focus distance, increased tube-housing protection, permanent filters of at least 2 mm. aluminium equivalent on all diagnostic tubes, the use of higher-voltage techniques, exposure counters on all diagnostic equipment, and the use of image intensifiers.

Since the dose from diagnostic exposure outweighs that from all the other man-made sources, including that from fall-out, it is of great importance that it should be reduced by every means that does not at the same time minimize the great benefits that accrue. Radiotherapeutic dosage is of relatively far less significance.

It is recommended that basic studies should be continued; that in all countries where analysis of film records reveals a dose of more than a few per cent of natural background a detailed analysis should be made; that the sampling programme set out should be followed, after a pre-survey; that the team making the survey should be carefully trained, and make use only of approved dosimeters. Improved practice is confidently anticipated, and as indicated in the tables of Ardran and Crooks, should attain very considerable diminution of dose.

Prof. F. W. Spiers reports on the preliminary survey made in the United Kingdom, which expects to cover at least 5,000 examinations based on some 20,000 exposures, in three classes of hospital, and some clinics. Details of the instrumentation are given, together with forms for recording data so that transfer to punch cards is easy.

ERNEST ROCK CARLING

GIANT MOLECULES

IT seems only yesterday that a professor of physical chemistry told me that a manufacturer had rung him up to ask, "What is this substance 'high polymers' we hear so much about? Can I make tubes of it?" Yet to-day it would be more to the point to ask what cannot be made of it. As for the question what Nature has made of it, answers of ever-increasing wonder and beauty pour out so fast that it is hard work giving them a fraction of the attention that is their due.

Our thoughts just now are much preoccupied, and excusably so, with those problems of atomic energy which betoken such a revolution in what has made up life hitherto that our future has become impossible to assess. All the same, it can be argued that in the long run, if there is going to be a long run, this is a more superficial view of things, because what is scarcely being noticed in the excitement is the quieter but far more pregnant revolution taking place simultaneously in our understanding of the molecular basis of life. Physico-chemically speaking, life is predominantly a question of the activities of chain-molecules in one form or another, and the science of man-made fibres, plastics, rubbers, and related products is an extrapolation therefrom—the lessons of Nature exemplified in a simpler but nevertheless very gratifying piece of 'homework'. The exploration of both these worlds, the old and the new, is now opening up so rapidly and excitingly that a reminder and synthesis such as that recently provided by *Scientific American* (**197**, No. 3; September 1957) in an issue devoted to high-polymer chemistry has a timely helpfulness that makes it doubly welcome. It comprises a set of nine articles by some of the acknowledged authorities in macromolecular studies, and they summarize an enthralling story most effectively.

The first five articles are chiefly about synthetic high polymers, and the other four are about macromolecules in biological structures. Mark starts off with a historical survey entitled "Giant Molecules", followed by Debye on "How Giant Molecules are Measured", Natta on "How Giant Molecules are Made", Tobolsky on "The Mechanical Properties of Polymers", and Oster on "Polyethylene"—the simplest chain-molecule of its kind, but extraordinarily versatile and fast becoming the commonest. Preston writes next on "Cellulose", Doty on "Proteins", Crick on "Nucleic Acids", and finally Schmitt on "Giant Molecules in Cells and Tissues". The level of presentation is uneven, with the elementary concept often explained at lengths which some readers might prefer devoted to more advanced parts, which are as a result rather glossed over. Some non-uniformity is almost unavoidable in articles of this sort, semi-popular and aimed at informing and interesting as wide a range of reader as possible. Taken together, these articles must certainly succeed in doing that: there is something for everybody, from the beginner to the specialist. The illustrations are particularly fine for teaching purposes, and there is a very useful bibliography.

Among the biological contributions which I, personally, found most enjoyable, was that by Doty, in which he tells of recent progress, by measurements of light scattering and optical rotation, in detecting the states of folding of synthetic polypeptides and proteins in solution. The former can change over, reversibly, from right-handed α-helices to randomly coiled chains, depending on *p*H and other conditions, and the transition is marked also by such characteristic changes in the optical rotation and rotatory dispersion that it is natural and seems well justified to apply the criteria to the globular proteins. The results indicate (as had already been suggested from X-ray and related studies) that such globular protein molecules as have so far been tested do indeed include α-helices in their make-up, to extents varying from 15 per cent in ribonuclease to 85 per cent in tropomyosin; and what is more, these proportions can be varied reversibly, and when the protein is an enzyme, activity goes up and down correspondingly. By implication, the same sort of adaptability of the intramolecular mixture of α-helical and randomly-coiled could account for the versatility of the γ-globulins and the formation of antibodies.

The main theme of Natta's article is the astonishing advances in the controlled building of high polymers that have been made within only the past few years by means of complex ionic catalysts, following Ziegler's production, for example, of unbranched polyethylene at atmospheric pressure and temperatures not much above 30° C. Vinyl polymers now run into molecular weights of millions, with their side-groups arranged at will in a so-called 'atactic', 'isotactic' or 'syndiotactic' sequence according as they occur at random on either side, all on the same side, or regularly distributed from side to side. Truly, as Natta says, "we can hardly begin to conceive how profoundly this new chemistry will affect man's life".

All this though, impressive as it is, is still child's play compared with the kind of thing discussed by Crick in his article on the nucleic acids. Deoxyribonucleic acid and ribonucleic acid have lately come to be recognized as the 'master race' of biological high polymers, in that apparently they alone can both transmit messages of heredity and afterwards dominate the business of protein synthesis. Recent discoveries in bacterial genetics are more than fascinating; they are also perhaps rather disturbing, particularly in the light of the changes reported (J. Benoit, P. Leroy, R. Vendrely and C. Vendrely) to have been induced in White Pekin ducks simply by injecting into their peritoneal cavities soon after birth samples of deoxyribonucleic acid prepared from Khaki Campbell ducks. We can dimly see approaching a day when not merely bacteria but also higher animals and even human beings may have their transmissible characters moulded synthetically—a most alarming thought in some ways.

More dimly still, but now not nearly so as it appeared only a short while ago, a day can be envisaged when we may be able, in a process analogous with infection by a bacteriophage, or with any fertilization, to add a synthetic polynucleotide to a collection of synthetic substrates and thereby set going a little hive of 'synthetic life'.

There is something seriously wrong with dreams such as this, of course. Systems of proteins and nucleic acids and accessory molecules with nothing else can scarcely keep on thinking and asking questions about themselves and experimenting on themselves until they have at last succeeded in making themselves. Reason apart, the halt will surely be called by an ultimate indeterminacy principle which says that it is impossible to place the required components in their correct places all at the same time.

W. T. Astbury

EDUCATION FOR A TECHNOLOGICAL AGE

DELIVERING the ninth Hinchley Memorial Lecture to the Institution of Chemical Engineers on November 5, under the title "An Education for Our Times", Dr. R. P. Linstead, rector of the Imperial College of Science and Technology, London, said that the proportion of scientifically qualified men to the total employed in British industry as a whole is 0·8 per cent. The proportion varies, however, in the principal scientific industries from 10·9 per cent in nuclear power, 5·2 per cent in oil refining, to 2·7 per cent in chemical industry and 1·9 per cent in the aircraft industry. This vocational demand is likely to increase, but Dr. Linstead insisted first that science is an intellectual discipline of the first rank in its own right, and secondly that when the current very large requirement for scientists and engineers has been met by the necessary adjustments in our pattern of education, man will still have to meet his ultimate problems of virtue, civilized behaviour and the wise conduct of affairs. He argued that the study of pure and applied science provides an education peculiarly suitable to our times, and, limiting himself essentially to the higher education of boys from fifteen years upwards at school and university during the next decade, explored four questions.

The answer to the first, whether we have enough qualified engineers and scientists, is no, and Dr. Linstead said that in the next few years an increasing proportion of science specialists in the schools should be diverted from science to engineering when they reach the universities, and university departments of technology must be provided with the necessary facilities. In considering the second question, when their education should become specialized, he suggested that specialization in science and mathematics should not be pushed to the extent that a boy loses touch with the world of human studies and values, and he would like to see more flexibility in the general educational pattern, with some lightening of the requirements in factual scientific knowledge and, above all, search for intelligence. In discussing the third question, namely, whether the first-degree course should be longer, Dr. Linstead pointed out that this would involve additional capital expenditure of £15 million to £30 million, a large increase in recurrent expenditure and a hiatus in output for one year of at least 7,000 men. Rejecting this as impracticable, he urged that a real contribution could be made at the university-level by postgraduate instruction in the new types of scientific technology, where there is a real intellectual discipline to be mastered and not just a technique to be acquired.

In answer to his last question, whether scientists and engineers should be taught non-scientific subjects at the university, Dr. Linstead argued that any good system of education would provide a good product out of good material, against a good social background. In considering how far assistance can be given to students of science and technology to acquire a broader education and the attributes of leadership during their university career, Dr. Linstead suggested that, in general, compulsory and examinable non-scientific subjects should not be introduced into a three-year first-degree course. The college or university should, however, make a continuous and organized effort to provide facilities whereby a student can broaden his outlook, interests and experiences. In addition, certain types of non-scientific studies arise directly and, as it were, functionally out of a man's vocational interests and should very properly be studied in an organized way as part of them or side by side with them; for example, languages, some aspects of economics, and the history of science and technology. Finally, Dr. Linstead urged that the benefits of organized and compulsory classes in cultural subjects are limited, and in the last resort it is more important for a technological university to provide the facilities for a full life in human surroundings.

MANAGEMENT, GROUP CONFLICT AND THE SCIENCES

A PENETRATING analysis of management attitudes towards group conflicts in industry has been made by the Earl of Halsbury, managing director of the National Research Development Corporation (*Impact of Science on Society*, 8, No. 3). Management is an act which occurs in opposition to some form of resistance, and to treat it as a problem in communications is inadequate. No mere verbal exposition of what a man does not want to do will make him want to do it. The fact that someone else wants it will not make him want it either. In some way the individual has to identify his wishes and hopes with those of others, with whose wishes and hopes his own were originally in conflict.

According to text-book expositions, change occurs because 'loyalty to the firm' binds management and workers together, and what is in the interest of the whole will ultimately seem to be in each individual's own interest, and will thus produce co-operation.

Unfortunately, great numbers of the human race are psychologically immune to any such approach.

Using an approach from social anthropology, Halsbury shows that within any one culture pattern a mosaic of variant sub-patterns can be seen, each with its characteristic ideology. The tyranny of words leads to over-simplification. People talk of 'the industrialist' and 'the trade-unionist' because grammar and syntax do not permit individuals to talk of them at all unless it is done in this way. To refer to 'the industrialist' or 'the trade-unionist' implies a homogeneity that does not exist. Some North American Indian language is needed which would enable one to treat as single nouns such complexes as the following: 'Church-going-factory-manager-with-strong-sense-of-public-service'; 'Free-trade-golf-playing-managing-director-believing-keep-out-of-my-way; 'Union-chairman-christian-naming-employers-confederation-operating-ancient-agreement-never-broken'; 'Vicariously-bitter-shop-steward-with-chip-on-shoulder'.

Treatises on managerial techniques which avoid reference to basic situations merely skim the surface of the subject. If social anthropology and industrial psychology are to be the nuclei of some future intellectual discipline which will transform and adjust human relations in accordance with human needs, then present indifference to the realities of 'intractable situations' must give way to an active interest in what ought to be the heart of the subject.

Tractable situations are, after all, tractable. If one knows what to do and has the will to do it, then an undesirable state of affairs will remedy itself in due course. A few pioneers will take the lead, and the rest of the community, giving time for imitation, will follow suit. In this way, factory welfare and managerial interest in workers' recreational and social life have spread throughout the industrial community. These are the mechanical contrivances of management. What is of paramount interest is why they are frequently ineffective. Why is one local ideology apparently unable or unwilling to copy what is manifestly successful elsewhere ?

Group negotiations are, in practice, never carried on between groups. They take place between negotiators representing them. These negotiators occupy points on a spectrum stretching from the pure amateur at one end to the pure professional at the other. Their attitudes towards their status as negotiators must be a factor of some importance in determining the way negotiations proceed. They may or may not identify themselves with the group that they represent; they may or may not share its ideology. The professional will be less likely than the amateur to concern himself with group ideology and more likely to represent the group's views dispassionately on a consultant-client basis. The professional will be more anxious to calculate precisely what his client can hope to obtain, and then seek to obtain it.

An important feature of the professional's attitude is reluctance to give a point away on behalf of his client without instructions. If the client is a collective, a group, reference back for instructions is clumsy to the point of virtual impossibility, and professional reluctance to give way even on a trivial point may cause negotiations to be drawn out over a long period. The protraction of negotiations in this way may itself contribute to modifying group attitudes.

In a well-reasoned article, Halsbury shows that it is for sociologists to become the influential minority capable of switching attitudes over from one configuration to another. The social sciences are not only the youngest of the sciences; they also lack their popularizers. Of all the sciences, sociology should exercise the most powerful impact on society, just as introspection exercises the most powerful influence on minds.

DISTRIBUTION OF GLOBULIN PERMEABILITY FACTOR AND ITS INHIBITOR IN THE TISSUE FLUID AND LYMPH OF THE GUINEA PIG

By PROF. A. A. MILES, C.B.E., and D. L. WILHELM
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THE substances—like histamine, leukotaxine, plasmin and 5-hydroxytryptamine—variously held to be the initiators of the increased permeability of small blood vessels in inflammation are presumably released in the extravascular tissues. Their release in the blood itself is unlikely, because they would be removed too rapidly by the blood stream to have an effect confined to the inflamed region. The demonstration of a potent globulin permeability factor present in an inactive form (pro-permeability factor) in the serum of the guinea pig[1,2], rabbit[2–4], rat[2,3,5], man[2,6,7], and cat, dog, horse, ox and mouse (unpublished observations), while adding another candidate for the role of a natural endogenous mediator in the inflammatory response to injury, poses the problem of how, without the intervention of other permeability factors, the inactive form in the blood reaches the extravascular tissues for activation. We now have good evidence that in the guinea pig not only pro-permeability factor, but also the serum globulin inhibitor of permeability factor, are normally present in the tissue fluids.

In order to sample the tissue fluids without damaging tissue cells and thereby releasing intracellular material, we devised a method of intercellular perfusion; taking advantage of the fact that in the skin of the guinea pig's trunk, intracutaneously injected saline spreads mainly in the plane of the skin, without leaking through the epidermis or the fascia deep to the panniculus carnosus. The saline, with the materials it has gathered in its intercellular passage, can be harvested at a cut edge of skin at any required distance from the point of injection. The apparatus, designed to limit the perfusion to one direction only, is shown 'dissected' in Fig. 1. A piece of freshly excised skin, including all the layers down to the loose subcutaneous tissue immediately below the panniculus carnosus, is firmly clamped between

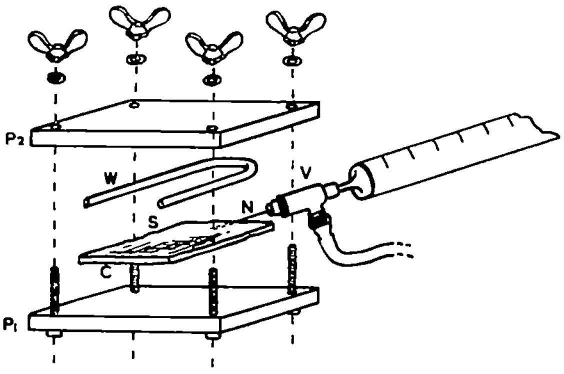

Fig. 1

two 'Perspex' plates, $P1$ and $P2$, which are kept 2–3 mm. apart by an elongated U-shaped piece of rubber-covered wire W. A strip of skin S, 10 mm. × 35 mm., is thus isolated and sealed except at one narrow cut edge C at the open end of the U-piece. At the other end of the strip a No. 26 gauge needle N, for the injection of physiological saline or Locke's solution, is inserted with its tip immediately below the dermis, and the skin clamped in position with its subcutaneous surface in contact with the U-piece. The U-piece is slightly notched at its mid-point to accommodate the thickness of the needle. The needle is mounted on a B–D double valve V No. 470V, which is used as a three-way tap, and to which is connected a tuberculin-type 1-ml. syringe and a reservoir of perfusion fluid.

Under syringe pressures of 3–4 atmospheres the saline flows along the skin strip to the open end of the U-piece, where it is sampled. Perfusion is greatly facilitated by adding 40 units of hyaluronidase to the first 0·5 ml. of perfusion fluid. In this concentration, the enzyme has no permeability factor activity and does not alter such activities in the perfusate. Its use also ensures that the tissue cells are forced apart during the injection with the minimum of trauma. Permeability factor activity is measured in terms of the diameter of the area of exudation of circulating pontamine blue (mean lesion diameter, Fig. 2) induced at the site of intracutaneous injection in the trunk of the guinea pig[8].

Locke's solution perfusates of fresh skin, 10 mm. × 35 mm., tested 30 min. after harvesting, yield a permeability factor most of which appears in the first 3 ml., which contains about 90 effective blueing doses[1] (plasma contains[2] up to 20,000 such doses per ml.). The contribution of permeability factor from any intravascular plasma in the skin strip is negligible, because the perfusates are similar whether the skin is taken from animals exsanguinated after stunning, or from an area of skin of the flank previously perfused *via* the axillary artery with gelatin–Locke's solution until free of any visible traces of blood. Like the serum permeability factor, the intercellular permeability factor is inhibited by soya bean trypsin inhibitor and by the fraction of guinea pig serum containing inhibitor of permeability factor, but not by the antihistaminic drug, mepyramine maleate.

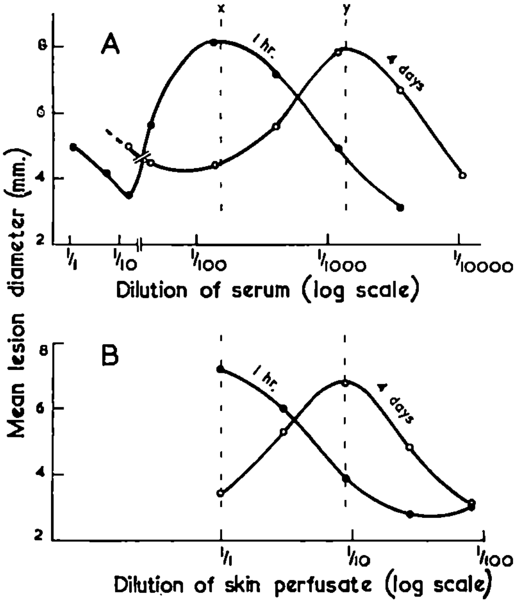

Fig. 2

That it is obtained as permeability factor, and not in its inactive form, is to be expected, since the small quantity of intercellular fluid obtainable from 0·8 gm. of skin is diluted in 3 ml. Locke's solution; and it is a characteristic of the pro-permeability factor in undiluted serum that it is activated by simple dilution[1]. After ½–1 hr. at 22° C., serum permeability factor is activated in the dilution zone 1/50–1/1,000; in the zone 1/1–1/30, any activated permeability factor has been inhibited by the native inhibitor present; but when dilutions are held for four days at 4° C., zones of activation and inactivation shift into ten-fold higher dilutions (Fig. 2*A*). A readily elicited property, therefore, of the system is that a given dilution x first contains permeability factor and later loses it, whereas a higher dilution y is at first inactive and later acquires permeability factor activity. This property is displayed by skin perfusates (Fig. 2*B*)—indicating that the intercellular fluid contains inhibitor, and suggesting that the permeability factor has been activated from its inactive precursor.

The probable existence of intercellular pro-permeability factor is established by the examination of normal lymph. Lymph was harvested in healthy animals under urethane anæsthesia from the cervical ducts lying on each side of the trachea. Both native lymph after removal of the clot, and slightly heparinized lymph, have little permeability factor activity when tested intracutaneously in the undiluted state; but on dilution activation occurs within 30 min. at 22° C. in the zone 1/5 to 1/100. Moreover, on holding the dilutions at 4° C. for 1–2 days, the zone of activation shifts into higher dilutions, as it does in dilutions of serum and of intercellular perfusates (Fig. 2). The permeability factor in lymph is inhibited by soya bean trypsin inhibitor and by guinea pig serum permeability factor inhibitor, but not by mepyramine. Since the lymph could be harvested with rigid precautions against contamination with shed blood, the results, unlike those with the skin strip, are not open to the criticism that traces of intravascular plasma permeability factor may have been present in the perfusates.

It appears, therefore, that the proteins constituting the pro-permeability factor/inhibitor system of the blood pass normally into the intercellular fluid and rejoin the circulation *via* the lymph. There are thus no topographical obstacles to an immediate, local, extravascular activation of permeability factor in the appropriate pathological circumstances; and there is no need to postulate additional mechanisms whereby serum pro-permeability factor is brought into the tissues at the time of injury. As we have noted before[2], the ready activation of serum permeability factor by simple dilution suggests that it is activated *in vivo* by relatively mild means; but the presence of the pro-factor in both lymph and tissue fluids is inconsistent with the notion that permeability factor is activated as the result of actual dilution of exuded plasma proteins in the tissue fluids.

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SPECIES-SPECIFIC DIFFERENCES IN FREE AMINO-ACIDS AND PEPTIDES IN SEA-URCHIN EGGS AND EMBRYOS (PURE SPECIES AND HYBRIDS)

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STUDIES of amino-acid metabolism in sea-urchin development have been carried out on *Strongylocentrotus purpuratus*[1,2] and *Paracentrotus lividus*[3,4]. In both species it was found that free glycine is present in large quantities in the developing eggs, and that distinct quantitative changes of the free amino-acids occur in the course of morphogenesis. Recently, in connexion with experiments devoted to studies of protein metabolism in sea-urchin hybrids, we used the technique of paper partition chromatography to study the amino-acids at various developmental stages of *Paracentrotus lividus*, *Arbacia lixula* and *Sphaerechinus granularis*. These species belong to three different families and, according to our chromatographic results, differ from each other in their patterns of free ninhydrin-positive substances. This is a preliminary report on such species-specific differences detected on our two-dimensional chromatograms and on the corresponding chromatographic patterns in the hybrids *Paracentrotus* ♀ × *Arbacia* ♂ and *Sphaerechinus* ♀ × *Paracentrotus* ♂.

Materials of all three sea-urchin species were collected from the Bay of Naples in March and April, 1957. Only fresh specimens were used for fertilization. The fertilized eggs were kept at 18° C. until the desired stages of development were reached. The latest stage examined in the present study was the pluteus shortly before feeding. In addition, the amino-acid content of the unfertilized eggs was also determined. These eggs were usually obtained from that female which had been used for the fertilization.

The procedures of preparing the amino-acid extracts are as follow: a measured volume of culture suspension containing on the average 10,000 eggs was first concentrated by centrifugation. The sedimented eggs, after removing the sea-water very carefully, were homogenized in a microhomogenizer and extracted in 80 per cent methanol. After centrifuging the sample again, the supernatant was applied with a fine pipette to a Whatman No. 1 filter paper (28 cm. × 46 cm.). A second extraction was carried out, and the supernatant again transferred to the sheet. The paper was first run in 70 per cent *n*-propanol (ascending) and then in water-saturated phenol (descending). After the phenol run the spots were made visible by spraying the sheet with 0·5 per cent ninhydrin in 96 per cent ethanol, followed by heating at 90° C. for 15–20 min.

Three typical two-dimensional chromatograms of the sea-urchin species investigated are reproduced in Fig. 1. In *P. lividus* the following free amino-acids, amides and peptides have been found in eggs and embryos of different stages: aspartic acid, glutamic acid, serine, glycine, threonine, tyrosine, α-alanine, β-alanine, glutamine, cystine, ornithine, lysine, asparagine, arginine, histidine, proline, valine (and/or methionine), leucine (and/or *iso*leucine) and five peptides (Fig. 1, *A* and Table 1). In accordance with the results reported by earlier authors[1,2,4], glycine was found to occur in abundant quantities with α-alanine next to it. The concentration of other free amino-acids is very low. Among the peptides, spot No. 20 has been identified as glutathione by adding pure substance to the extract. Spot No. 21 gives a brown, and spot No. 22 a green-blue, colour with ninhydrin. Since both spots disappear from the extract after acid hydrolysis, they are probably peptides, too. Because of their low concentrations we have not been able to carry out further analyses on these two substances.

The free amino-acid picture of *A. lixula* (Fig. 1, *B*) looks quite different from that of *P. lividus*. First, the concentration of glycine is by no means higher than that of the other amino-acids detectable in the free form. Second, spots No. 21 and No. 22, which showed a constant occurrence in the *Paracentrotus*-extract, have never been traced in this species. Third, the *Arbacia* chromatogram is characterized by the appearance of a new spot of particularly high concentration (spot No. 17 in Fig. 1, *B*). Considering that this substance reacts readily with ninhydrin and is resistant to acid hydrolysis, it is assumed to be an amino-acid. With the solvents used in the present study its R_F values (0·48 in 70 per cent *n*-propanol, 0·74 in water-saturated phenol) are very close to those of methionine sulphoxide, and β- and γ-aminobutyric acid. It is obviously not methionine sulphoxide, because no methionine sulphone was formed by oxidation with hydrogen peroxide. It behaves very similarly to the substance 'fast-aminobutyric acid' described by Dent in plant extracts and in blood and urine[5]. Our investigations to ascertain the chemical nature of this spot are still in progress.

Table 1. FREE NINHYDRIN-POSITIVE SUBSTANCES IN METHANOL EXTRACTS OF SEA-URCHIN EGGS AND EMBRYOS*

	Paracentrotus lividus and *Paracentrotus* ♀ × *Arbacia* ♂	*Arbacia lixula*	*Sphaerechinus granularis* and *Sphaerechinus* ♀ × *Paracentrotus* ♂
α-Alanine	+	+	+
β-Alanine	+	–	–
Arginine	+	+	+
Asparagine	+	–	+
Aspartic acid	+	+	+
Cysteine	–	–	+
Cystine	+	+	+
Glutamic acid	+	+	+
Glutamine	+	+	+
Glycine	+	+	+
Histidine	+	–	–
Leucine (*iso*Leucine)	+	+	+
Lysine	+	+	+
Ornithine	+	–	–
Proline	+	–	–
Serine	+	+	+
Threonine	+	+	+
Tyrosine	+	+	+
Valine (Methionine)	+	+	+
'Fast-aminobutyric acid'	–	+	–
Peptide 1	+	+	+
Peptide 2	+	+	+
Peptide 3 (Glutathione)	+	+	+
Peptide 4	+	–	–
Peptide 5	+	–	–
Peptide 6 (Tripeptide)	–	–	+
Unknown	–	–	+

* Those substances, which are listed in the present table and not shown on chromatograms in Fig. 1, give very faint spots, and have been observed only occasionally.

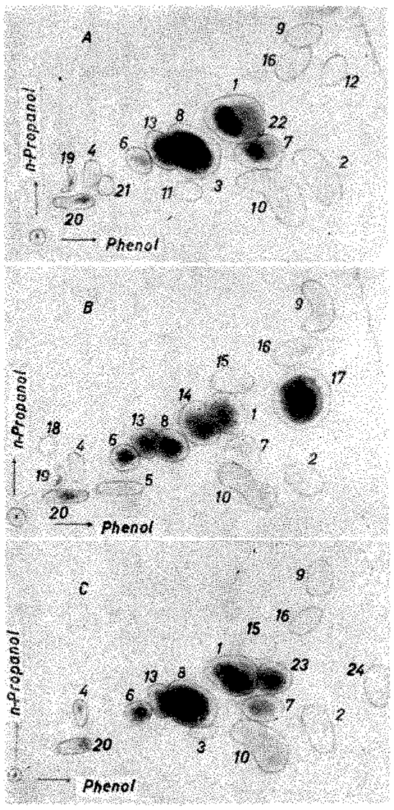

Fig. 1. Free ninhydrin-positive substances in methanol extracts of sea-urchin eggs and embryos. The chromatograms are not from corresponding stages, but the amino-acid pattern of each species remains largely unchanged during development. *A*, *Paracentrotus lividus* (10, 178 unfertilized eggs); *B*, *Arbacia lixula* (20, 772 early plutei); *C*, *Sphaerechinus granularis* (6,266 unfertilized eggs). 1, α-Alanine; 2, Arginine; 3, Asparagine; 4, Aspartic acid; 5, Cystine; 6, Glutamic acid; 7, Glutamine; 8, Glycine; 9, Leucine (and/or *iso*leucine); 10, Lysine; 11, Ornithine; 12, Proline; 13, Serine; 14, Threonine; 15, Tyrosine; 16, Valine (and/or methionine); 17, 'Fast-aminobutyric acid'; 18–23, Peptides; 24, Unknown spot

The chromatogram of *S. granularis* is similar to that of *P. lividus* in so far as glycine occurs in enormous quantities, and spot No. 17, which is characteristic for *A. lixula*, was also not recorded in this species. However, a closer examination of the chromatogram revealed another new spot which is apparently specific for *Sphaerechinus*, and has been found in extracts in both unfertilized eggs and developmental stages ranging from blastula to pluteus (spot No. 23 in Fig. 1, *C*). The R_F values (0·41 in 70 per cent *n*-propanol and 0·64 in water-satured phenol) suggest this substance to be β-alanine. Its ninhydrin colour is, however, not blue, but purple. It cannot be citrulline, because no yellow spot was formed by spraying the paper with a 1 per cent solution of *p*-dimethylaminobenzaldehyde. The fact that the unknown compound disappeared from the extract upon hydrolysis indicates that it is a peptide. This point was confirmed by eluting the material from the area and subjecting the eluate alone to hydrolysis. The hydrolysate was shown to contain chiefly α-alanine with a moderate amount of glutamic acid and a trace of aspartic acid. Another substance (spot No. 24 in Fig. 1, *C*, and unknown in Table 1) has been traced also only in *S. granularis*. It gives a very faint spot, and was not investigated further by us.

In all three types of eggs the patterns of free amino-acids, in spite of their quantitative changes, remain largely constant during development. (Results concerning the quantitative changes of free amino-acids and peptides during the development of both parental species and the hybrids will be published elsewhere.) Thus, the specific differences described above can be noted in every stage of development. Table 1 is a summary of all free ninhydrin-positive substances, the existence of which has been so far established in the three sea-urchin species examined by us.

Further efforts were made to analyse the amino-acid composition of the proteins denatured during the methanol extraction. After pipetting out the supernatant for chromatographic separation, the protein precipitates were suspended in 6*N*-hydrochloric acid for hydrolysis at 110° C. for about 12 hr. In contrast to the findings quoted above, the protein hydrolysates of all three sea-urchin species are strikingly similar in their amino-acid constituents. These consist of aspartic acid, glutamic acid, serine, glycine, threonine, α-alanine, tyrosine, lysine, arginine, histidine, proline, valine (and/or methionine) and leucine (and/or *iso*leucine). It is of particular interest that glycine, which was found to be present in unusually large quantities in the methanol extracts of both *Paracentrotus* and *Sphaerechinus*, shows a relatively low concentration in their protein hydrolysates. In *Arbacia* the substance corresponding to spot No. 17 has never been located on the hydrolysate chromatogram. In other words, the species-specific differences described for the free amino-acids are not reflected in the amino-acid composition of the proteins. This may indicate that differences of specific proteins in the sea-urchin egg, as demonstrated by serological studies[6], probably lie on the structural level.

The chromatographic patterns of the corresponding substances in the two hybrids studied show an entirely maternal character (compare Table 1). It may be added that these hybrids are very different in their developmental behaviour. The development of *Paracentrotus* ♀ × *Arbacia* ♂ is normal and maternal until the beginning of gastrulation (like many inter-specific hybrids). Then the development stops and the inhibited gastrulæ die. On the contrary, *Sphaerechinus* ♀ × *Paracentrotus* ♂ develops normally to the pluteus stage, which shows, as it is well known, maternal and paternal character in the skeleton[8]. In spite of this intermediate behaviour the chromatographic pattern is completely maternal.

The relationship between protein metabolism and morphogenetic development has been demonstrated to be a complicated one[7]. The fact that the amino-acids, in spite of their high concentration in the free, non-protein fraction, are either not detectable or occur only in unproportionally minute quantities in the proteins, suggests that they serve some special purposes rather than being merely building stones of proteins. In the *S. purpuratus* egg there is evidence that certain amino-acids play a part in the energy metabolism, while others play a part in the osmoregulation[2]. It is uncertain if this conclusion also holds true for the other sea-urchin species and for the hybrids. The function of the new spots found in *Arbacia* and *Sphaerechinus* reported here for the first time is entirely unknown. We shall now try to ascertain their metabolic roles. Given a more complete knowledge about these substances it would be possible to find out to what extent such specific differences in the amino-acid patterns are responsible for the developmental potencies of the hybrid embryos[8].

Our work was made possible by a grant from the Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung. We wish to thank the authorities at the Zoological Station of Naples for their most generous help. Thanks are also due to Prof. E. Hadorn for encouragement and valuable discussion.

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PHOTOPERIOD, AUXIN AND SEX BALANCE IN A LONG-DAY PLANT

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REPORTS on the effects of photoperiod on sex expression in diclinous flowering plants have mostly suggested that photoperiodic régimes which promote early or abundant flowering tend, initially at least, to enhance femaleness, the response being apparent in the production of a greater proportion of pistillate flowers, or in intersexuality in staminate ones[1]. Comparable effects can be induced by treatment with synthetic auxins in various monoecious Cucurbitaceae[2-5] and in the dioecious *Cannabis sativa*[6]. The present article reports corresponding results in a long-day plant with monoclinous flowers, *Silene pendula* L.

Seeds of two cultivars, *ruberrima* and *compacta* (obtained from Messrs. Thompson and Morgan, of Ipswich), were germinated in a mixture of sand and peat, and the seedlings transplanted at a height of 4–5 cm. to individual pots, where they received on alternate days a 15-ml. ration of a balanced nutrient solution containing about 200 p.p.m. nitrogen. The plants were grown throughout in a greenhouse with night temperature regulated between 20° and 22° C. Short-day treatment was given by enclosing the plants in ventilated dark cabinets from 5 p.m. until 9 a.m. daily. Plants receiving long days were exposed to natural daylight with supplementary illumination at 300–400 ft.-candles from a mercury vapour source to give a total light period of 21–22 hr.

Matched groups of eighteen plants of var. *ruberrima* and ten of var. *compacta* were grown to an age of 40 days in long days, and half of each group then transferred to short days. Short-day treatment was continued for 50 days with the plants of var. *compacta*. Those of var. *ruberrima* had a break of 4 long days after 24 short days, during a period when the dark cabinet was required for another experiment; they were then returned to short days for a further 22 days. This long-day break appeared to have no effect on the development of the plants of var. *ruberrima*, and at the end of the 50-day period, all plants of both varieties which had received short days were rosettes with a condensed main axis and no extended lateral branches. At this time, the series of both varieties which had received long days throughout had developed 6–9 first-order laterals and were differentiating flower buds. Following restoration to long days after the 50-day period, the short-day series of both varieties rapidly produced lateral branches, and flowering began in all within three weeks. The final records of flowering behaviour were taken in all series 130 days from the beginning of germination.

Estimates of male fertility were based upon samples of 100 randomly collected flowers from each plant. In male-sterile flowers, development of the androecium may be arrested at any stage from the emergence of the primordia to the end of micro-sporogenesis. However, since the formation of fertile pollen is marked by a change of the anther colour from yellow to purple, male sterility may be recognized without resort to microscopy even when its onset is delayed until the completion of meiosis. Every stamen in

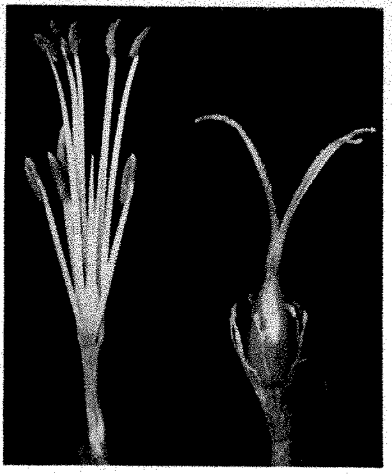

Fig. 1. (*a*) Normal flower (calyx and corolla removed) from a plant of *Silene pendula* var. *compacta* flowering in long days (21–22 hr. light) after an interlude of 50 short days (8 hr. light). Anthers of the first flush are shedding pollen; those of the second group have not yet dehisced, and the styles have not yet emerged from the corolla tube. (× *c.* 3). (*b*) Male-sterile flower at a corresponding stage from a plant of *S pendula* var. *compacta* grown throughout life in long days,. showing the contabescent anthers and greatly enlarged gynœcium. (× *c.* 3)

each flower of the sample was examined, so that the proportion of sterile stamens in a total of 1,000 was recorded. The results are given in Table 1. Whereas in the plants which received a period of exposure to short days male fertility was consistently high, all the plants grown throughout in long days were male sterile to a greater or lesser extent. In none of the totally male-sterile flowers were the anthers exserted beyond the limb of the corolla, and the ovary was usually considerably more swollen than in the perfect flowers of plants of the short-day series at the time of anthesis, an effect reflected in the enlarged calyx of the young flowers (Figs. 1 *a* and *b*). Male sterility was associated also with a marked diminution of corolla size; thus the mean maximum diameter of the limb of the corolla in a sample of forty flowers from a short-day plant of var. *compacta* was 20·06 ± 0·26 mm., and in the same number of totally male-sterile flowers from a long-day plant of the same variety 12·99 ± 0·22 mm. The fully male-fertile flowers produced on the long-day plants were mostly the distal ones in each partial or complete dichasium. Like those of the short-day plants (Fig. 1*a*) they were protandrous, the anthers emerging in two flushes, the five of the outer antepetalous whorl followed by those of the inner whorl, 50–60 hr. before the exsertion of the styles.

In preliminary experiments with auxin, general applications of α-naphthaleneacetic acid in aqueous solution were given to plants under various photoperiodic régimes. Though clear indications were obtained of the induction of male sterility under conditions in which control plants showed normal fertility, the concentration of α-naphthaleneacetic acid producing this effect was sufficient to cause high mortality among treated plants and severely to depress the general vigour of survivors. With plants showing general debility, it did not seem justified to conclude that loss of male fertility was a specific auxin effect. In further experiments a specific effect was demonstrated by limiting treatment to particular branches of vigorously growing plants during the period of flower differentiation.

Table 1. Mean Numbers of Sterile Anthers per Sample of 100 Flowers per Plant in Two Varieties of *Silene pendula* under Two Photoperiodic Régimes

Long-day and short-day treatments as in text

	Long-day	Short-day
Var. *ruberrima* (9 plants per series)	522·3 ± 56·0	6·67 ± 2·14
Var. *compacta* (5 plants per series)	427·8 ± 95·8	13·00 ± 1·85

In an experiment with var. *compacta*, two vigorous 90-day old plants were transferred to long days after exposure to fifty short days. Lateral shoots began to extend after ten long days, and at this stage, at the onset of flower differentiation, three pairs of basal leaves of five shoots in one sector of each plant were treated with lanolin paste containing α-naphthalene-acetic acid at 0·5 per cent, each leaf receiving about 0·1 gm. of the paste. The flowering behaviour of these shoots was followed during the subsequent four weeks, and the over-all male fertility compared with that of other floriferous untreated branches of the same plants. The striking effect of α-naphthalene-acetic acid in depressing male fertility is apparent from Table 2.

Table 2. Effect of α-Naphthaleneacetic Acid on Male Fertility in *Silene pendula* var. *compacta*

Sterility of anthers in all flowers formed on five treated laterals of each plant compared with that in a sample of 100 flowers from untreated branches of the same plant. Treatment details as in text

Plant No.	Untreated laterals per cent sterile anthers (100 flowers)	Treated laterals	
		No. of flowers	per cent sterile anthers
*SC*7	1·2	27	84·8
*SC*15	1·1	21	75·7

In a similar experiment with var. *ruberrima*, treatment was restricted to one outgrowing lateral, the auxin paste being applied to the lower surfaces of successive pairs of leaves as they opened. Flowering was retarded and somewhat reduced by this treatment, but again an unequivocal effect upon male fertility was apparent, as may be seen from the records of the individual plants in Table 3.

A feature of auxin-induced male sterile flowers of both varieties was the remarkable precocity of development shown by the gynœcium. Frequently the styles were exserted and the stigmas became receptive before the corolla opened (Fig. 2), and it was not unusual for the corolla to fail to expand altogether. Flowers of this type were mostly female-fertile, producing a normal crop of seed when pollinated artificially. In a few instances auxin

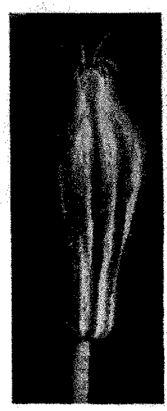

Fig. 2. Intact male-sterile flower of *S. pendula* var. *ruberrima* from an auxin-treated branch of a plant flowering in long days after an interlude of 50 short days, showing the precocious emergence of the styles, the arrested corolla, and the inflated calyx surrounding the abnormally enlarged ovary. (× *c.* 2·5)

Table 3. Effect of α-Naphthaleneacetic Acid on Male Fertility in *Silene pendula* var. *ruberrima*

Sterility of anthers in all flowers formed on the single treated lateral in each plant compared with that in a sample of 100 flowers from untreated branches of the same plant. Treatment details as in text

Plant No.	Untreated laterals per cent sterile anthers (100 flowers)	Treated laterals No. of flowers	Treated laterals per cent sterile anthers
*SR*5	0·9	5	98·0
*SR*7	0·0	4	100·0
*SR*13	0·3	5	100·0
*SR*15	0·9	2	100·0
*SR*17	1·3	2	100·0

treatment through the leaves resulted in parthenocarpy, capsules being formed directly without opening of the flower and without pollination.

Of the small numbers of fully or partly male-fertile flowers formed on the auxin-treated lateral branches in the experiment with var. *compacta*, most showed strong protogyny, the styles being exserted two to four days before the dehiscence of the anthers. Flowers of the untreated branches of these plants were regularly protandrous.

Cytological aspects of the male sterility induced in *Silene pendula* by photoperiodic and auxin treatments will be described elsewhere ; here it is sufficient to state that morphologically and histologically the effects produced through the two agencies are very much alike. The similarity of the reaction suggests that the influence of photoperiod on sex balance may be exerted through the native auxin metabolism of the plant during the period of flower differentiation, a possibility already indicated by work with short-day species[1,3,7] but still without direct proof based upon auxin assay.

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'PURITY' OF GELATIN AS A PROTEIN

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BAILEY has recently written[1] that, because of the use of newer techniques, the "most respectable" proteins are turning out to be mixtures. I wish to describe experiments which bring gelatin within this category.

It is generally believed that, neglecting inorganic impurities, gelatin represents a fairly 'pure' protein. This assumption is implicit in much research work on gelatin[2]. Eastoe, for example, regards gelatin as a purified form of collagen[3], the main criterion of purity in this case being constancy of amino-acid composition.

It has long been known that gelatin contains small quantities of proteins similar to albumin. Thus, by heat coagulation, Sheppard[4] was able to isolate small quantities (about 0·5 per cent) of a protein which he identified as being similar to albumin. In later work[5], Sheppard described a process for removing albumin ($\leqslant$ 1 per cent) from gelatin by solvent precipitation, for example, with acetone. Similar results are described by Stainsby[6] for ethanol fractionation. Maron has described[7] the isolation of an albumin-like protein (0·3 per cent) by treatment of gelatin with active charcoal.

Following the application of Sheppard's technique of heat coagulation[4] to samples of gelatin, we wished to use some less-destructive procedure for assessing the effects of any purification methods which might be suitable for gelatin. The first procedure attempted was chromatography of the whole (unhydrolysed) protein on ion exchange resin columns as described by Boardman and Partridge[8]. The following work applies to high-grade lime-processed gelatins with iso-electric points[9] in the region of pH 5. The resin used was 'Amberlite *XE*-97', 200–400 mesh in a column 16 cm. high and 1 cm. diameter. Runs were carried out either on 1 ml. of 0·5 per cent w/v gelatin solution (= 5 mgm.) for analytical purposes or 2 ml. of 2·5 per cent w/v gelatin solution (= 50 mgm.) for preparative purposes. Buffer was passed through the column at 4 ml./hr. and 1 ml. fractions were collected on a Locarte fraction collector. Analysis was usually carried out by acid hydrolysis of the fractions, followed by a colorimetric ninhydrin procedure[10] for total amino-nitrogen. Occasionally, a modified biuret procedure[11] was also used.

When the resin was buffered at pH 7 or pH 6 (McIlvaine buffer), and the column was eluted at this pH, the major part of the protein was fairly rapidly removed from the column, as shown in Fig. 1 (left). When the pH of the resin and of the eluting buffer was reduced to 5·5, a much lower peak was observed (Fig. 1, right). The remainder of the protein was not eluted at pH 5·5 up to 250 fractions either at 25° C. or 35° C., nor did shortening the resin column to 5 cm. allow it to be eluted. It must

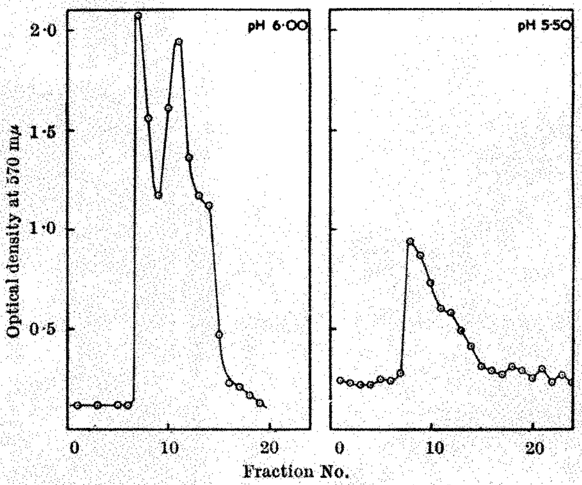

Fig. 1. Behaviour of gelatin on a 16 cm. × 1 cm. column of 'Amberlite *XE*-97' at different pH's

be concluded that it is very firmly bound by the resin at this *p*H.

Changing the *p*H of the buffer to 6 or 7 after elution of the first peak did not produce a great effect because of the considerable buffering capacity of the resin. However, if, after elution of the peak mentioned, the run was continued with 0·1 *N* sodium hydroxide at 35° C., the *p*H of the effluent rose rapidly to 8 and simultaneously the remainder of the protein began to come off the column (Fig. 2).

This procedure, therefore, has divided the gelatin into two fractions. It is estimated that the total ninhydrin colour produced by the first peak corresponds to about 15 per cent by weight of the gelatin. The protein in this peak may be isolated by pooling the fractions, dialysis and precipitation with ethanol. In two experiments, the yield of protein obtained in this way was 15 and 19 per cent, respectively. The isolated protein was examined qualitatively by paper chromatography. This showed that the protein resembled serum albumin and differed from gelatin in the following respects. It contained no hydroxyproline and only a low concentration of glycine. Tyrosine was easily detectable. Hydroxylysine was absent. Cystine was only present in traces as it is largely destroyed by the liming treatment in gelatin manufacture[12] (Fig. 3).

The question of tyrosine content is an interesting one. According to Eastoe[3], the tyrosine content of gelatin is very variable and may represent the extent of contamination by another protein. This view is shared by Harkness *et al.*[13]. I have carried out tyrosine determinations by direct measurement in 0·1 *N* sodium hydroxide in the ultra-violet[14]. The tyrosine content of the group of gelatins studied varied from 0·31 to 0·54 per cent on an air-dry basis. The tyrosine content of the protein eluted at *p*H 5·5 was not accurately determined, but was about 3 per cent; the protein eluted at *p*H 8 contained very little detectable tyrosine (lower limit of detection 0·01 per cent). This would imply that the concentration of the other protein in the gelatins studied varied from 10 to 18 per cent.

The implications of such a finding are many. It may be that either an inter-protein complex or a definite impurity of possibly variable concentration is present. In the latter case, such studies as N-terminal amino-acid groups, gelatin structure and amino-acid sequence may be regarded as of doubtful validity. The present conceptions of other properties such as surface activity, adsorption and viscosity of gelatin solutions may also be influenced by the new evidence. A discussion of such implications as well as a more detailed account of the present work will be given elsewhere.

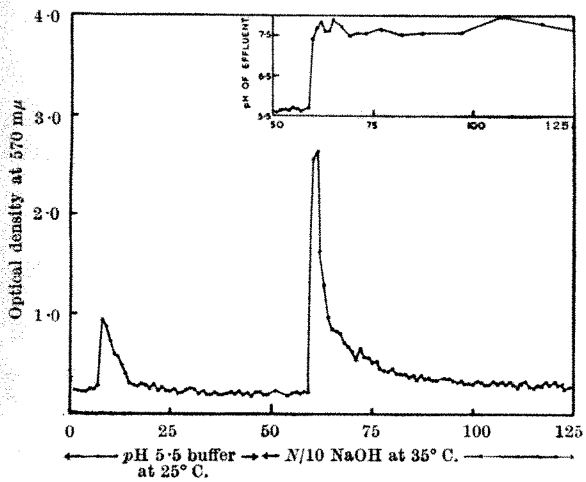

Fig. 2. Elution of two peaks from 5 mgm. gelatin. The upper portion (inset) shows the *p*H changes in the effluent when the sodium hydroxide run begins

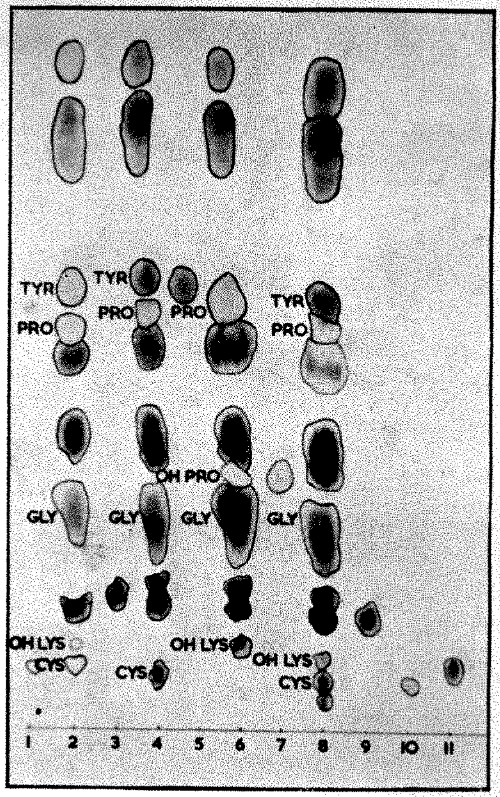

Fig. 3. Paper chromatogram of various protein hydrolysates (descending, Whatman No. 1, butanol-acetic acid). Detection by ninhydrin

1, Cystine; 2, protein eluted at *p*H 5·5; 3, lysine; 4, blood albumen (B.D.H.); 5, tyrosine; 6, gelatin; 7, hydroxyproline; 8, heat-coagulated protein, according to Sheppard (ref. 4); 9, lysine; 10, cystine; 11, hydroxylysine. Zones shown dotted are very faint

Technical assistance in the present work was given by Mrs. B. Ormerod and Miss M. E. Bell. I should also like to thank Mr. A. G. Ward, director of research at the British Gelatine and Glue Research Association, and members of his staff for valuable discussions.

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LETTERS TO THE EDITORS

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Observations in Australia of Radio Transmissions from the First Artificial Earth Satellite

THE choice by the U.S.S.R. of frequencies of 20 and 40 Mc./s. for radio transmissions from their Earth satellites provided a new approach to the study of the ionosphere, the main interest of the Radio Research Board in Australia. So arrangements were made to record the intensity variations of the signals.

The Overseas Telecommunication Commission generously made available a low-noise site and good receiving facilities at Bringelly, near Sydney.

The 20 Mc./s. signal was recorded using a quarter-wave vertical dipole antenna, a sensitive stable highly selective receiver, and a Brown high-speed potentiometric pen recorder. Observation was confined mainly to times when the signal was received by a direct path and was no longer modulated by the $\frac{1}{3}$ sec. modulation.

A 60-sec. sample of one record is shown in Fig. 1. It will be noted that there is a slow signal variation with sensibly constant period of the order of 5 sec. and a faster deep fading of variable periodicity.

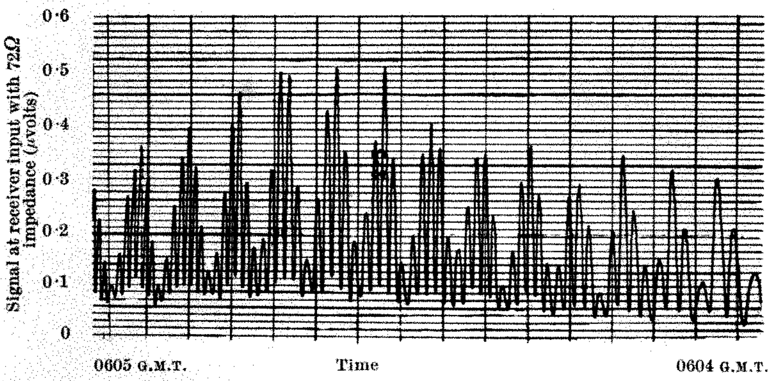

Fig. 1. Strength of 20 Mc./s. signals from satellite α1957 recorded at Bringelly, N.S.W., Australia, on October 19, 1957, at 0604–0605 G.M.T.

The faster fading-rate varies according to a regular pattern which is shown plotted in Fig. 2 for three close transits. It can be seen that the rate passes through a minimum which occurred always to the south of the observing station. There are also points of inflexion in the curves which occur at times when the satellite is near to the position of closest approach to the station as deduced from Doppler shift measurements.

The south to north transits were at a height of approximately 500 km. and from north to south they were at approximately 900 km. For the north to south transits only one record has been found which shows both sides of the minimum.

The minimum appears to occur when the satellite position is such that the propagation of the wave is nearly perpendicular to the direction of the Earth's magnetic field; but more accurate orbital information than is at present available is needed to establish this precisely.

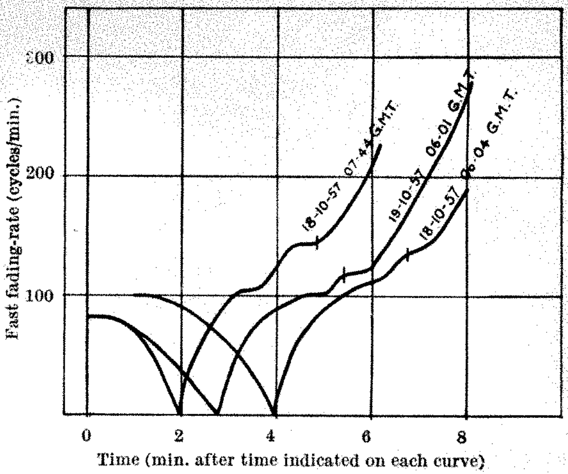

Fig. 2. The fast fading-rate of the 20 Mc./s. signal of satellite α1957 as a function of time during south to north transits. Vertical stroke, time of nearest approach to station

Similar effects appear to be present on 40 Mc./s. records which were made simultaneously with the 20 Mc./s. measurements; but the recordings were made with less satisfactory equipment. The slow fading pattern, because of its regularity, is considered to be a feature of the transmission, possibly due to rotation of the satellite. There seems little doubt that the fast deep fading is due to interference between the ordinary and extraordinary components as the respective received phases vary due to a combination of variation in path difference and Doppler frequency shift difference for the two components. The relative magnitude of the two effects has not yet been computed.

In addition, the depth of the beats has enabled calculation of the relative strengths of the two components as a function of time and hence of the relative absorption in the ray paths. Due to attenuation of the extraordinary component the fading at the time when the fading rate is a minimum is small so that if the attenuation was high or the transmitted signal weak, this portion of the curves was not recorded.

Theoretical examination and detailed computation are continuing in anticipation of accurate information on the satellite orbit being obtained.

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Dec. 12.

Propagation of Radio Waves from Cosmical Sources

WHEN a radio wave passes through an un-ionized medium its ray path is rectilinear. On passing through such ionized layers, which usually surround the Earth, its trajectory is satisfactorily determined by Snell's law:

$$\mu\rho \sin i = \rho_{\parallel} = \sin i_0 = \text{constant} \qquad (1)$$

which is valid for any point of the ray path. For the sake of simplicity the radius of curvature ρ_m of the maximum of electron density is taken as the unit of length. The significance of the parameters used follows from Fig. 1.

According to (1) and Fig. 1, the rectilinear part of the ray path must be tangential to the sphere defined by $\rho_{\parallel}$, everywhere in the un-ionized medium. Thus a ray which passes through spherical ionized layers of the same centre of curvature O is turned about this centre of curvature by the angle R (Fig. 1).

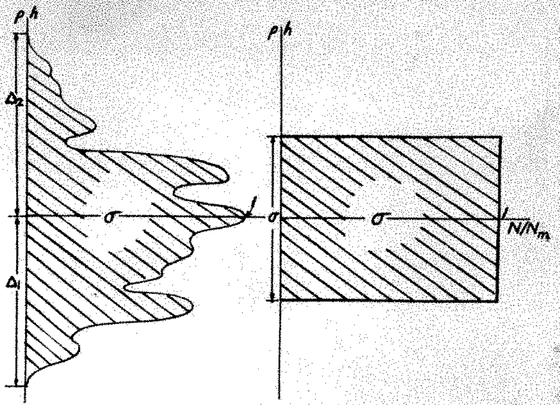

Fig. 2. The true and the equivalent layer, introduced in order to avoid discrepancies that could appear as the electron density is usually expressed in cm.[3] while the introduced unit of length is ρ_m. In this equivalent layer having the same contents of electrons and the same N_m, the electrons are squeezed together in order to form a layer of uniform electron density (N_m). The thickness of this equivalent layer $\sigma > 1$ is to be introduced into formula 2

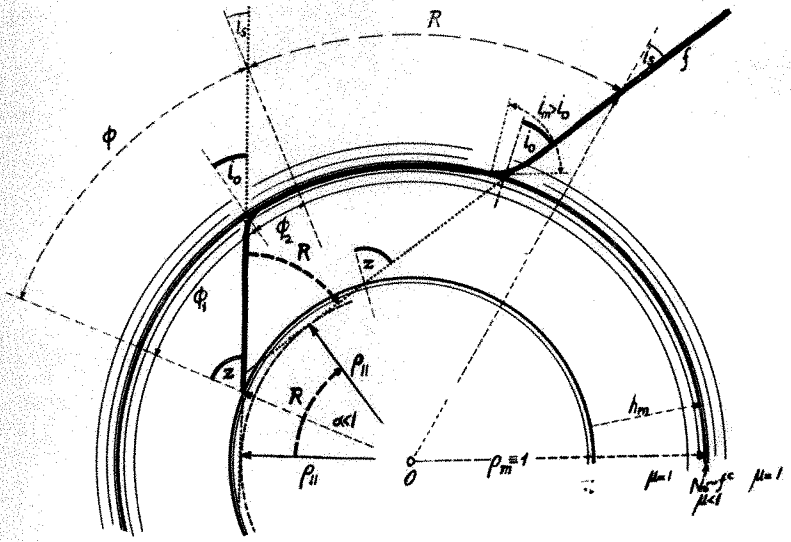

Fig. 1. Parameters used in formulæ 1 and 2. f is the wave frequency, f^c the critical frequency of the layer,

$$\mu = \sqrt{1-\left(\frac{f^c}{f}\right)^2} \text{ and } \rho = \frac{6{,}400 \text{ km.} + h}{6{,}400 \text{ km.} + h_m}$$, h and h_m being in km.

For this angle of refraction R the following simple formula has been derived[1]:

$$R = \frac{90^\circ}{\pi}\left(\frac{f^c}{f}\right)^2 \frac{\sin i_0}{\cos^3 i_0} \cdot \sigma \qquad (2)$$

where again $\rho_m = 1$, i_0 is the angle of incidence of the rectilinear parts of the ray path, related, however, to this level $\rho_m = 1$, and the equivalent thickness σ of the layer is to be determined according to Fig. 2.

Formula 2 is valid for $\dfrac{f^c}{f \cos i_0} < 0{\cdot}4$ and $\Delta < \rho_m/5$.

For $f^c/f \cos i_0 > 0{\cdot}4$ the true refraction is greater than the calculated one, and it increases to infinity; this case, dealing with a perpetual propagation of radio waves around the Earth along one of the two different levels of the ionosphere, has been treated previously[2].

The refraction formula 2 has the advantage that it depends only upon the total content of all free electrons present in the layer, but not upon the irregularity in electron distribution with height, which up to the present time has made the calculation of refraction uncertain. Formula 2 is valid even for sharp gradients of electron density, and for parabolic types of layer, $\sigma = \frac{4}{3}\Delta$, it goes over into Bailey's formula[3].

The theoretical result, mentioned above, is in good agreement with experimental results obtained from the signal records of the first artificial satellite. The angular distance of the satellite $\varphi + R$ was determined from formulæ 1 and 2 and Fig. 1 as follows:

$$a \sin z = (a + h_m) \sin i_0$$

$$\sin i_{\text{sat.}} = \frac{a}{a + h_{\text{sat.}}} \sin z$$

$$\varphi_1 = z - i_0, \quad \varphi_2 = i_0 - i_{\text{sat.}}$$

$$\varphi = \varphi_1 + \varphi_2 = z - i_{\text{sat.}}$$

and $\sin i_0 \leqslant \mu_m\rho_m$ corresponds to the minimum of the $\mu\rho$-curve. In accordance with the calculated values the received signal disappeared usually sooner on 20 Mc./s. than on 40 Mc./s., and only in cases when the signal was coming from countries where for 20 Mc./s. $f \doteq f^c$ was long-distance propagation of the signal around the Earth from the magnetic equator observed.

Summarizing, the rectilinear part of a ray path becomes rotated about the centre of curvature of the ionized layer through which it has penetrated by the angle of refraction R. This deviation R depends only upon i_0, f^c/f and the content of free electrons present in the whole layer, but it is independent of their distribution.

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Free Acid in British Soils

Under the humid climate of northern and western Britain organic materials often accumulate as *mor*[1] humus layers on well-drained woodland soils or as bog peats in wetter locations. Both types of humus are characteristically very acid, and this communication examines the possibility that sulphuric acid is mainly responsible for their low *p*H values.

To study this question in the wetter habitats, water samples were collected from pools on seven areas of bog, listed in order of increasing hydrogen ion concentration in their waters: Cooran Lane, Galloway; Druimbasbie and Strathy, Sutherland; Rannoch Moor; Tregaron, Cardiganshire; Dergoals and Kilkahockadale, Galloway; Moor House, Cumberland; Coom Rigg, Northumberland. All exhibit a good cover of *Sphagnum* moss, a sign that the peats are very wet and in a more or less natural condition. Moreover, they are so deep and extensive that the bog surfaces probably depend for their ion supply almost wholly upon the atmosphere.

Hydrogen ion concentration in the seven areas ranges from 0·03 to 0·13 m.equiv./l., averaging 0·066 m.equiv./l.; while sulphate ranges from 0·06 to 0·24 m.equiv./l., and averages 0·133 m.equiv./l. The coefficient of correlation (r) between free hydrogen ions and sulphate is 0·964, a highly significant value which may be increased by taking into account the appreciable amount of sulphate reaching the bogs in blown sea spray. This fraction may be estimated by assuming all chlorides in these waters to be derived from sea spray[2,3], and dividing the chloride values by 9·7—the ratio of chloride to sulphate in sea water. On subtracting the sea spray contribution from total sulphate, the correlation coefficient between hydrogen ions and the remaining sulphate becomes 0·985. Such a high coefficient strongly suggests that the low *p*H values of these bog waters are indeed due to sulphuric acid. A similar correlation has been observed for individual pools within the Moor House bog[4]. The regression of hydrogen ions upon corrected sulphate in the seven bog areas follows the formula $y = 0{\cdot}556x + 0{\cdot}006$.

The highest acidities are recorded from bogs near industrial areas, while the lowest come from sites remote from industry. Since fuel combustion produces large amounts of sulphur dioxide, which oxidizes to sulphuric acid, bog acidities are directly increased by industrial development nearby. Ringinglow Bog outside Sheffield provides an extreme example, with water analyses from this bog—now in a far from natural state—yielding hydrogen ion and sulphate concentrations of 0·57 and 0·96 m.equiv./l. respectively. In this connexion also, the influence of air pollution on rain acidity is clearly evident in the English Lake District, where the *p*H of precipitation averages less than 4·5 and may occasionally[2,3] go below 4·0.

It may be noted that in these bog waters hydrogen ions are only equivalent to 61 per cent of sulphate (exclusive of that from sea spray). In the Lake District rain the proportion is rather similar.

The free acid in *mor* humus layers was investigated by expressing the soil solution, with the aid of a hydraulic press, from sixteen samples collected in Lake District oakwoods on Silurian substrata. These *mors* overlie heavily leached mineral soils transitional between brown earths and podzols, and exhibiting strong profile development[1].

Hydrogen ion concentration in the *mor* waters ranges from 0·02 to 0·36 m.equiv./l., averaging 0·109 m.equiv./l.; while sulphate ranges from 0·26 to 1·01 m.equiv./l. and averages 0·508 m.equiv./l. The correlation between free hydrogen ions and sulphate (after subtraction of sulphate from sea spray) is again highly significant, with $r = 0{\cdot}872$. Once more, sulphuric acid seems likely to be the main factor responsible for low soil *p*H values, and must greatly enhance leaching. The regression of hydrogen ions upon corrected sulphate follows the formula $y = 0{\cdot}307x - 0{\cdot}033$.

The association between hydrogen ions and sulphate is stronger for the bog waters than for the *mor* soil solutions ($r = 0{\cdot}985$ as against 0·872). Moreover, the proportion of sulphate balanced by hydrogen ions is much greater in the bog waters than in the *mor* solutions (61 as against 24 per cent). It seems likely that an appreciable part of the *mor* acid is neutralized by bases from mineral soil particles embedded in the humus, in which case a lower correlation between hydrogen ions and sulphate is not surprising. It may also be remarked that the average corrected sulphate level in the *mors* (0·46 m.equiv./l.) is considerably above the highest bog value (0·24 m.equiv./l.), owing probably to concentration of the interstitial water in these well-drained soils by evaporation.

As in the case of the bog waters, air pollution can account for much of the free acid in Lake District *mors*[3]. However, even in areas without much industry, sulphuric acid will probably be produced from decomposing organic sulphur compounds[5]. Support for this view may be found in the inter-correlations between free hydrogen ions, sulphate and dissolved organic carbon in waters of Nova Scotian lakes, draining acid peaty soils on substrata low in lime[6].

In conclusion, it must be pointed out that the *p*H values of both bog waters and *mor* soil solutions are a good deal higher than those obtained by direct insertion of a durable glass electrode into fresh soil. For example, at Moor House the *p*H range of 3·7–4·1 for six surface pools may be compared with a range of 3·3–3·9 for eight fresh peats from the same area; while the *p*H range of ten Lake District *mor* solutions, 3·8–4·6, may be compared with a range of 3·2–3·5 for the fresh soil. The much lower *p*H values of the fresh soils are presumably due to a 'suspension effect' on the glass electrode by hydrogen ions adsorbed on soil colloids. Exchangeable hydrogen ions are abundant in both woodland *mors* and bog peats[1,7], and must be, like the sulphuric acid free in solution, of great importance for soil development.

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Influence of Water-Content of Sand on Rate of Uptake of Rubidium-86

The relationship between nutrient absorption and the moisture content of the soil has been the object of numerous investigations. Complications arise, however, if an attempt is made to disentangle the separate processes involved. The growth of the plant itself is strongly influenced by the moisture content of the soil and the ionic equilibria between

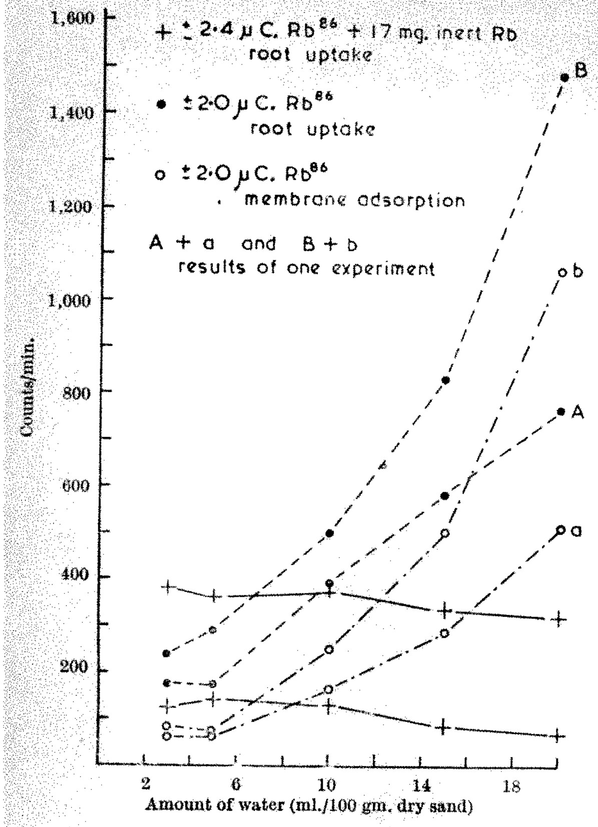

Fig. 1. Uptake of rubidium-86 by excised roots of *Vicia faba* (+ and ●); and by a cation resin membrane, 'Permaplex *C*-10' (○) from 100 gm. dry sand containing a varying amount of water (3–20 ml.)

the adsorbed ions and those in solution undergo a change. Another difficulty encountered is the fluctuation in moisture content of the soil as brought about by transpiration and watering, so that the conditions are not constant during the experiment.

The problem has recently been investigated by Dean and Gledhill[1] and by Danielson and Russell[2], who used techniques to eliminate a number of complications. Their results, however, are contradictory in some respects.

Dean and Gledhill[1] used excised rootmats of young rye seedlings that were pressed upon sand containing a fixed amount of labelled phosphate. One of their findings is that uptake can decrease with an increase of moisture content of the sand, although the reverse may also occur.

Danielson and Russell[2] made use of very young corn seedlings completely buried in the soil. They find that the ion uptake decreased rapidly with initial increases in soil moisture tension, and levelled out at higher tensions to give a curve nearly logarithmic in nature.

An attempt was made to extend our knowledge on the influence of the amount of moisture on the rate of uptake by means of a technique which eliminates complications to a great extent.

The experiments were performed with excised young root pieces of the broad bean (*Vicia faba*), which were taken from the primary laterals of plants cultivated in tap-water. A batch of twenty-five root pieces was buried in 100 gm. of washed sand to which ±2 μc. rubidium-86 was added and a varying amount of water. In part of the experiments a varying amount of inert rubidium chloride was added besides the tracer amount. Experiments lasted about twenty-four hours and were mostly conducted at room temperature.

The results demonstrate that if only a minute amount of rubidium is present in the sand, the uptake greatly increases as the amount of water rises from 2–20 ml. If, however, a larger amount of inert rubidium is added the reverse trend is found and uptake decreases somewhat with increasing moisture content (Fig. 1).

The following explanation seems justified, and is in agreement with experience gained in work with other ions.

As long as the sand contains only a very small amount of rubidium (not exceeding ±4 mgm./100 gm. of sand) the layer in direct contact with the root cannot furnish enough substance to meet the demands of the root. So the rate of uptake will be dependent on the number of ions able to diffuse towards the root from more distant layers. As the moisture content of the sand rises, this diffusion is enhanced, as has been shown by Klute and Letey[3], and uptake increases. The purely physical nature of this response can be demonstrated by the fact that a cation exchange membrane reacts in exactly the same way (Fig. 1).

If, however, the amount of rubidium in the sand is higher, the moist layer surrounding the root will contain more substance than the root can absorb during the experiment. As the sand can be considered as a practically inert medium, the concentration of the rubidium in solution will vary inversely with the amount of water added. Uptake is now governed by the concentration of rubidium in solution in the pore space. So the rate of uptake diminishes somewhat with an increase in the amount of water added.

Thus the relation between moisture content of the medium and rate of uptake depends on the amount of soluble substance. At low concentrations of rubidium the rate of uptake is enhanced by increased moisture content and at higher concentrations the rate of uptake is somewhat lowered.

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Age Determinations of Southern Ocean Waters

A model of Southern Ocean circulation has been provided by Deacon[1] based on that for the South Atlantic and supported by detailed observations made during the cruises of R.R.S. *Discovery II*. On this model, cold dense water forming in the Weddell Sea sinks to the ocean floor to form Antarctic bottom water which exhibits northward and eastward components of motion.

In December 1956 and January 1957 we obtained twenty-gallon samples of bottom water at each of the two stations in the Southern Ocean south of New Zealand. Sampling was carried out from

H.M.N.Z.S. *Pukaki* in the course of an investigation by the New Zealand Oceanographic Institute of the Antarctic convergence and the hydrology of the Ross Sea sector of the Southern Ocean.

The stations were located as follows: (1) Lat. 64° 54′ S., long. 178° 10′ E., 150 miles north of Scott Island (N.Z. O.I. Station B27, 28.12.56). Depth to bottom 3,000 m., depth of sample 2,643 m. (2) Lat. 53° 38′ S., long. 169° 52′ E., 100 miles south-east of Campbell Island. (N.Z. O.I. Station B32, 1.1.57.) Depth to bottom 800 m., depth of sample 765 m.

The apparent carbon-14 ages of these samples were determined by Mr. T. A. Rafter and Mr. G. J. Fergusson in the Nuclear Sciences Division, N.Z. Department of Scientific and Industrial Research: the ages were 2,540 ± 100 years and 1,900 ± 100 years respectively for samples 1 and 2.

The southern station (B27) is located on the north-facing slope leading from the Pacific Antarctic Ridge into the Pacific Antarctic Basin. The station is 500 miles from the nearest Antarctic coast and a somewhat lesser distance north of the average northern limit of Antarctic land. The northern station (B32) is over the Campbell Plateau, south of New Zealand. Here the general depth is 400 fathoms and the Plateau rises steeply from depths greater than 2,000 fathoms to the south and west.

At Station 2 and adjacent to Station 1, temperature–salinity–oxygen profiles were sampled, to bottom at Station 2 and to 2,000 m. near Station 1, the deepest water sampled in the latter case being in the 'warm deep' layer[1]. The carbon-14 sample from Station 1 has come from the boundary zone between Antarctic bottom water and the southward moving 'warm deep' current. Consideration of the hydrological observations obtained at the same time as these samples is being prepared for publication.

Apparent ages of deep Atlantic water have been reported by Kulp[2], the maximum age being 1,950 ± 200 years for a sample from 4,663 m. in the north-west Atlantic. Cooper[3] has pointed out a number of factors, the re-cycling of 'old' water, the time required to achieve equilibrium with the atmosphere and physio-chemical 'ageing' with increase in temperature, which affect direct application of apparent carbon-14 ages to determinations of rates and nature of oceanic circulation systems.

If the generalized model of Southern Ocean circulation be accepted, then, whatever the true age of the water mass from time of formation, the total time which a significant proportion of the water mass sampled has been shielded from the atmosphere could be very great: in high southern latitudes northward-moving deep water will have an apparent age principally determined by the apparent age at formation and the time since sinking.

The Campbell Plateau sample has been obtained from an area in which upwelling induced by the submarine topography could operate to give the high apparent age.

These initial observations are now being continued by the N.Z. Oceanographic Institute over these and more northerly latitudes. The present isolated observations at least suggest that: (1) the value of the latitudinal component of movement of bottom water is low; (2) the total turnover time of ocean circulation systems is of the order of thousands of years; (3) the present oceanic circulation may be found to be complicated by factors inherited from a late Pleistocene hydrological environment.

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Manganese Deposition and Deep Water Movements in the Caribbean

In the course of a study of the chemical composition of certain deep-sea cores, particular attention has been paid to one such core (*A* 179–4) collected south-west of Hispaniola in 2,965 m. at lat. 16° 36′ N., long. 74° 48′ W. in the Caribbean and subjected by Emiliani[1] to oxygen-18 : oxygen-16 palæothermometry.

The material of this core is predominantly calcium carbonate with varying quantities of lithogenous sediment. There is no correlation between variations in either calcium or the major lithogenous constituents (silica, iron, aluminium, titanium) and temperature. The major lithogenous constituents exhibit variations highly correlated *inter se*, though there seems to be a slight systematic rise in titanium relative to the other constituents throughout the period of deposition of the sediment, which embraces, on Emiliani's interpretation, most of the Pleistocene.

The manganese content, however, is entirely unrelated to the lithogenous group of constituents or to calcium. Inspection of the graph (Fig. 1) indicates that manganese is inversely, if somewhat irregularly, related to surface temperature. The correlation coefficient of manganese on temperature, namely, −0·511, is, in fact, highly significant (with 35 pairs of observations, $P \simeq 0{\cdot}001$).

Since manganese is the only abundant constituent likely to be sedimented by purely chemical process in the Atlantic Ocean or adjacent seas, its independent behaviour is not surprising; but the nature of its distribution raises the question as to why it should tend to precipitate at this station more rapidly during glacial than during interglacial periods.

We believe that the best explanation is to be found in Goldberg's[2] hypothesis that colloidal manganese dioxide is deposited electrophoretically in

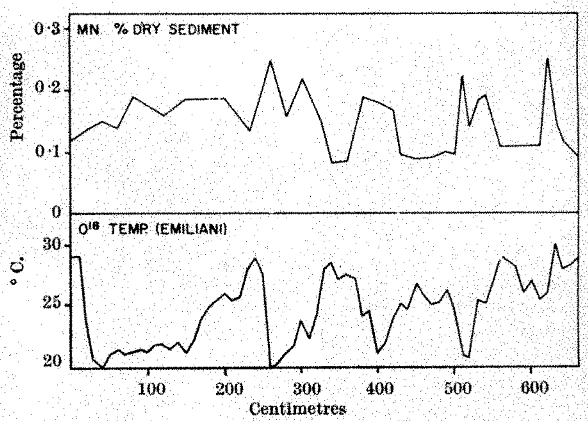

Fig. 1

regions of potential gradient set up as water containing charged particles moves through the Earth's magnetic field. The rate of deposition will clearly depend on the velocity and direction of the current. We consider, therefore, that the enhanced deposition of manganese in this part of the Caribbean during glacial periods is probably due to enhanced water movements related somewhat irregularly to glaciation. The most reasonable type of movement would presumably be the spilling of cold water over the rim of the Caribbean basin. Non-steady state movements of this type are becoming recognized[3] as features of deep water circulation in various parts of the Atlantic. If our hypothesis proves reasonable, variation in manganese content in deep water sediments should throw considerable light on the incidence of such movements throughout the Pleistocene and possibly during more remote periods of the history of the ocean.

We are indebted to Prof. Maurice Ewing and to Dr. David B. Ericson of the Lamont Laboratory, Columbia University, and to Dr. Cesare Emiliani of the Marine Laboratory, University of Miami, for the opportunity to study this material. The work was supported by contract from the Office of Naval Research. A detailed report on the analyses will be published by one of us (P. J. W.) later.

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Sept. 30.

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Grain Boundaries and Electroluminescence in Gallium Phosphide

Some interesting properties of gallium phosphide have been studied in polycrystalline specimens kindly provided by H. Welker, of Seimens Schuckertwerke, Erlangen. Etching of the surface has revealed grain boundaries, and annealing twins. Etch pits have also been observed along slip lines.

Electroluminescence has been reported previously[1], but that observed here shows unusual features, in that the light sources form a pattern of narrow lines and are identifiable with grain boundaries. Most sources are found in the surface, though sheets of light have been observed, joining more intense sources in opposite faces. Not all boundaries luminesce, and on reversal of the current the light pattern changes markedly. Voltage probing shows that a large and constant proportion of the total applied voltage is developed across the luminescent boundary. Electroluminescence is also observed at a cathode point contact to the *p*-type gallium phosphide, indicating that minority carrier injection and radiative recombination occurs. It is proposed that this is the mechanism responsible for the grain boundary luminescence, and that impurity segregation at the boundary creates an *n*-layer between the *p*-type grains. This forms a *p–n–p* junction, or two *p–n* junctions 'back-to-back', and minority carrier injection and consequent radiative recombination occurs at whichever is the forward-biased junction. A junction of this sort in the grain boundary would account for the observed voltage distribution, and the results of current-voltage studies are in agreement with the theories of Shockley and Prim[2] and Dacey[3] for *p–n–p* structures.

The observation of etch pits along slip lines indicates the possibility that these pits are formed at the points of emergence of dislocations, which would be of considerable interest. Further, if impurities at grain boundaries are responsible for electroluminescence, this phenomenon may prove a useful tool by which to study impurity atmospheres during boundary migration.

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Reaction of Carbon Monoxide with Graphitic Carbon at 450° C.

Published investigations of researches on the reaction of carbon monoxide with carbonaceous solids have been concerned with the Boudouard reaction, $2CO \rightleftharpoons C + CO_2$. Many measurements have been reported above 500° C. in which range the rate of reaction is appreciable and the resultant partial pressure of carbon dioxide is measurable. Below 500° C. the observed partial pressure of carbon dioxide is so low that it cannot be differentiated experimentally from that normally expected on outgassing such materials, although the equilibrium values for the carbon dioxide are higher than those above 500° C.

Experimental conditions have now been discovered whereby an appreciable reaction occurs between carbon monoxide and some graphites at 450° C. However, carbon dioxide is not formed. The sample was contained in a 'Vycor' tube through which purified carbon monoxide was circulated. Traces of water vapour were continuously removed by liquid nitrogen traps on both sides of the sample tube. When necessary each sample was previously treated with hydrochloric and hydrofluoric acids to assure the absence of metallic impurities as evidenced by spectrochemical analyses. It was then heated for 20–40 hr. with evacuation at either 450° or 700° C. and then cooled in the latter case to 450° C. before the introduction of carbon monoxide. A definite chemisorption of the carbon monoxide was observed. A more significant result was the formation of a carbon deposit downstream at locations well beyond the bed of graphite. Mass-spectroscopic analyses proved the almost complete absence of gases other than carbon monoxide even after the liquid nitrogen was removed. A chemical analysis of the deposit demonstrated it to consist of carbon.

The following mechanism could account for these observations. The first step is the chemisorption of a carbon monoxide molecule. A second carbon monoxide molecule is then chemisorbed to the chemisorption complex, which then reacts to form gaseous carbon suboxide, C_3O_2. This serves to transport the carbon atoms of the graphite through and out of the bed of sample. Carbon suboxide is unstable at the temperature of the reaction and decomposes in one or more steps to deposit carbon and liberate carbon monoxide.

The first implication of these results is that at a temperature as low as 450° C., small amounts of carbon monoxide can cause migration of carbon atoms and, thus, in a sufficiently long time, could re-form an appreciable fraction of the graphite into a possible new crystalline or amorphous form. Thus far, appreciable reaction has been observed only with graphites which have been irradiated in nuclear reactors, while unirradiated graphite, charcoal, etc., showed only very small traces of carbon transport or none at all. Thus, it is possible that the added energy in the irradiated graphite, and the accompanying structural changes, is responsible in some way for this effect. Further work is needed to prove that only irradiated graphite can produce this transport.

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An Electronic Mechanism of Addition Reactions

IT has now become abundantly clear that in ethylene ($CH_2{=}CH_2$) one of the two bonds is of the normal covalent type (σ-bond), while the other belongs to a distinct and separate class (π-bond). Thermochemical studies have further revealed that the bond-strength of a C=C double bond is appreciably less than twice the value for a C—C single bond, showing that the π-bond is not as strong as the σ-bond. Thus it was quite natural to assume that addition reactions occur by the direct rupture of the weaker π-bond. However, it has been found that addition proceeds generally in the *trans* sense, which is exactly contrary to expectation. The reactivity towards addition reactions also decreases unexpectedly with increase in the number of π-bonds (except in conjugation). Acetylene ($CH{\equiv}CH$) with two π-bonds is less reactive than ethylene[1]. The first stage addition to one of the cumulated double bonds in allene ($CH_2{=}C{=}CH_2$), which is expected to be very much strained, is also much slower than the second stage addition to its remaining simple double bond[2]. It is remarkable that higher cumulenes ($>C{=}C{=}C{=}C{=}C{=}C<$) are quite stable[3].

It is thus generally realized that the π-bond itself is not the seat of any weakness in the molecule[4]. It may be that the σ-electrons are in some way connected with this subtle and devious attack on the multiple bonds. It has been found that electrophilic groups retard addition reactions (as in $HOOC{-}CH{=}CH{-}COOH$), while electron repelling groups accelerate them (as in $CH_3{-}CH{=}CH_2$)[4]. These groups are attached to the carbon atoms of the double bond through σ-bonds. As such, they can affect the reactivity only by depleting or by supplementing the σ-electrons of these carbon atoms. This argument is further supported by the fact that the retarding effect of the electrophilic groups on the reactivity of acetylene derivatives is very small (as in $HOOC{-}C{\equiv}C{-}COOH$)[5], because it is difficult to withdraw σ-electrons from a triple bond which itself is strongly electrophilic. On the basis of all these considerations it can be postulated that the initial attack in addition reactions occurs on the σ-electrons and the reactivity of the unsaturated molecule depends upon the σ-electron density of the carbon atoms. This concept of addition mechanism through σ-electrons is also in agreement with the fact that frequently substitution and addition occur side by side. At high temperatures substitution increases at the cost of addition. Furthermore, the electrophilic groups also retard substitution in benzene. They de-activate mainly the *ortho* and *para* positions and thus become meta-directing.

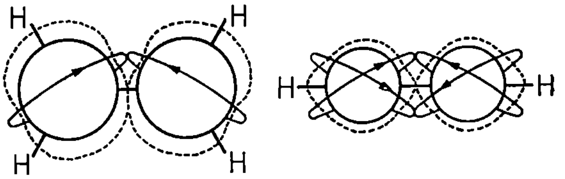

Fig. 1. Electronic structures of ethylene and acetylene. The broken line shows the distorted σ-electron density

It now remains to find the cause of enhanced reactivity of the σ-electrons in unsaturated molecules. It appears that the π-electrons somehow cause this activation of σ-electrons. As the quantum-mechanical approach has not yet succeeded in solving this problem, it may be worth while to develop a tentative speculative explanation based on simple physical concepts. It is generally agreed that the π-electrons can be regarded, from many points of view, as forming a separate shell 'outside' the other electrons[6]. I have gone a step farther in postulating that the planes of the π-electron orbits remain fixed[7]. They couple at an angle which causes the restriction on the free rotation of their orbital planes. Probably the high electron density between the two carbon atoms due to the σ-bond does not permit the exchange of two more (π) electrons through the same region (Fig. 1).

The spherical symmetry of the σ-electron density of the carbon atom becomes distorted as a result of the fixation of π-electron density around it. On the particle concept of the electron, these distortions of σ-electron orbits would be unsteady and non-uniform. Some of the σ-electrons may become deviated (due to repulsion from the fixed π-electron orbit) much more than others. These abnormally deviated σ-electrons may bond an extra atom temporarily. This sudden electronic disturbance would break the π-bond, and one of the π-electrons set free is utilized in forming a stable covalent bond with the addendum. The π-electron on the other carbon atom remains free for a while and becomes saturated through a distinct second phase of addition. This interval provides scope for steric rearrangements giving *trans* products. In the fast reactions the *cis* products predominate. In some of the molecules one of the atoms already present may be knocked out in favour of the new entrant, thus causing substitution. In benzene, substitution is relatively easier than addition as the π-bond in it is stronger than in simple multiple bonds[8].

The distortions of the σ-electron orbits would be proportional to the σ-electron density on the carbon atom. This explains the lower reactivity of acetylene (two σ-electrons per carbon atom), and the retarding effect of electrophilic groups. The central atoms in cumulenes, containing only two σ-electrons each, act as electrophilic groups on the reactivity of the end CH_2-groups[9]. The activating effect of such groups as CH_3 does not appear to be due to electron donation, as they increase the reactivity of acetylenic compounds to only a very small extent. They appear to have an obstruction effect which increases the abnormal distortions of σ-electron orbits in other directions.

Other aspects of unsaturated molecules, such as bond-lengths, Pascal's constitutive correction factor λ for the multiple bonds, etc., have been discussed in terms of these concepts elsewhere[7,8].

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Infra-Red Absorption of OH Bonds in Micas

IN favourable cases, infra-red absorption spectra afford a valuable adjunct to diffraction methods in crystal structure analyses. The structures of the micas have been familiar for many years, but have never included any specification for the site of the proton in the constitutional hydroxyls.

In the biotite micas (such as phlogopite, $K_2(Si_6Al_2)Mg_6O_{20}(OH)_4$), if one assumes tetrahedral environment for oxygen, three of the tetrahedral hybrid orbitals are involved with magnesium neighbours, the bond to the proton must have its axis normal to the cleavage, and steric factors preclude that the proton has a secondary association with any other oxygen. In muscovite,

$$K_2(Si_6Al_2)Al_4O_{20}(OH)_4,$$

only two orbitals are involved with aluminium neighbours, and the O—H bond axis could be normal to the cleavage as above, or could be directed toward the unoccupied cation site, thus lying no more than 15–20° inclined to the cleavage, and probably favourably disposed for secondary association with one or both near oxygen neighbours as an O—H . . . O bond.

The efficiency of absorption in the frequencies associated with the O—H bond is a function of the angle between the bond axis and the plane of the electric vector of the light. For normal incidence on a phlogopite cleavage flake, there is no resultant along the OH bond axis and no absorption in the region of the OH stretching frequency. With increasingly inclined incidence, absorption increases regularly with the increasing resultant of the plane of the electric vector on the bond axis. The observed frequency for unmodified OH stretching is 3,710 ± 20 cm.$^{-1}$. When muscovite is examined similarly, strong absorption is observed for normal incidence at 3,620 ± 20 cm.$^{-1}$, and the absorption is not markedly sensitive to moderate tilting of the flake. It is concluded that the O—H bond axis must have one or more of the orientations near the plane of the cleavage flake for the dioctahedral composition, and that the lesser frequency may be evidence of some hydrogen bonding.

A third case illustrates the precision of observations. Lepidolites present frequent instances in which analyses suggest that a trioctahedral lithium-bearing biotite and a typical muscovite are intimately parallel grown. Spectra at normal incidence and at increasingly inclined incidence to the lepidolite illustrated show absorption at the muscovite frequency with little sensitivity to orientation and absorption at the phlogopite frequency with sensitivity to orientation as in phlogopite.

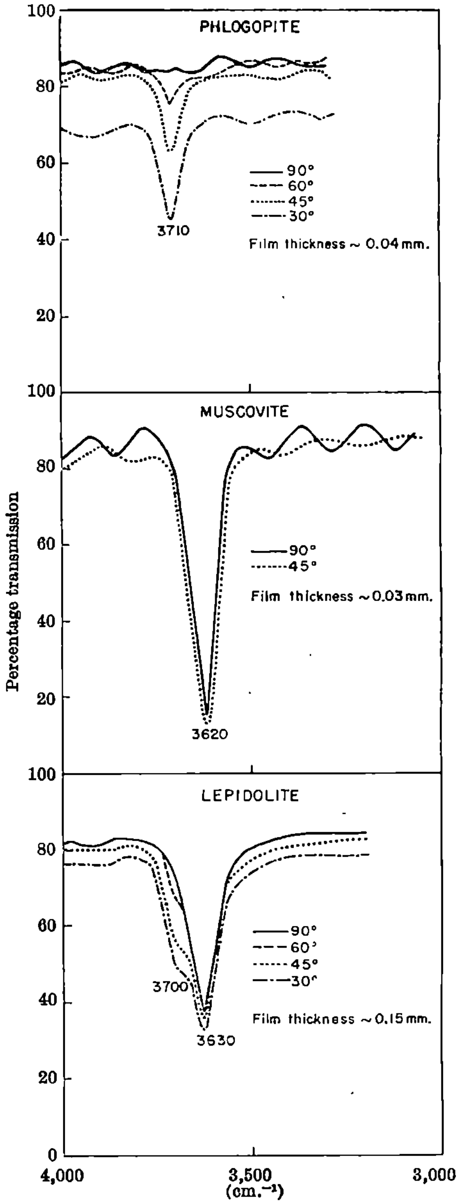

Fig. 1. Infra-red spectra of phlogopite, muscovite and lepidolite for cleavage flakes oriented at different angles to the incident beam

The spectra in Fig. 1 were recorded with a Perkin-Elmer Model 21 double-beam spectrometer with a sodium chloride prism.

We have recently learned that a more elaborate analysis, in substantial agreement with our present communication, was conducted during the War by Dr. G. B. B. M. Sutherland for the U.S. Army Signal Corps, but not published.

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The Pyridine Ring and the Problem of its Biosynthesis

THE relationships of anthranilic acid and tryptophane to nicotinic acid are well established in a number of organisms[1] and it has been suggested that in the higher plants the pyridine ring may be formed in a like manner[2]. It has been shown, however, that tryptophane-3-^{14}C is not a precursor of damascenine in *Nigella damascena* L., nor did it give rise to radioactive trigonelline when fed to pea seedlings[3]. It is possible that in the two plants studied the enzyme system necessary for the initial oxidation of tryptophane to kynurenine is lacking and that the hydroxyanthranilic acid in one case (damascenine) and the pyridine ring in the other (trigonelline) are synthesized from different precursors and by a different pathway.

These two cases, however, do not exclude the possibility that in some other plants tryptophane might be the precursor of the pyridine ring. It has been claimed that *Nicotiana tabacum* does not utilize tryptophane in the biogenesis of the pyridine ring of nicotine[4], but the location of the carbon-14 in the labelled tryptophane used was such as to make it very unlikely that it would appear in the nicotine. Since the present work has been completed, however, Leete[5] has shown that tryptophane labelled in the benzene ring at the position to which the nitrogen is attached is not utilized by *N. tabacum* in the formation of nicotine. Further, 3-hydroxyanthranilic acid, a metabolite of tryptophane, does not serve as a precursor of trigonelline when fed to excised soybean leaves[6].

It was of interest to determine whether a plant that cannot utilize tryptophane in its synthesis of the pyridine ring might be able to convert anthranilic acid (also a metabolite of tryptophane in certain moulds) into the pyridine ring since the initial oxidation of the tryptophane would be by-passed. Chemically, there is no reason why anthranilic acid as well as kynurenine could not be hydroxylated. We have now tested this point with regard to nicotine formation in *Nicotiana tabacum* var. White Mammouth fed with anthranilic acid-1-^{14}C. The carbon-14 label, however, was not transferred to the nicotine isolated from these plants.

The starting material used for the synthesis of anthranilic acid was toluene-1-^{14}C (purchased from Tracerlab Inc., Boston, Mass.). Nitration followed by oxidation of the resulting nitrotoluenes with permanganate afforded a mixture of nitrobenzoic acids from which most of the *p*-isomer was separated as its sparingly soluble copper salt[7]. Catalytic reduction of the recovered crude *o*-nitrobenzoic acid yielded anthranilic acid which was precipitated from neutral solution as its insoluble cobalt complex[8]. Treatment of the complex with hydrogen sulphide liberated very pure anthranilic acid which was isolated with ether, sublimed and crystallized from water from which it separated as needles, m.p. 144–145°.

The tobacco plants were grown from seed in soil for two months and then transferred to a nutrient solution prepared as described by Leete[9], but modified by substituting ferric tartrate as the source of iron. The nutrient solution was aerated continually and changed weekly. It was necessary to add further quantities of ferric tartrate (4·0 mgm. per l.) twice a week to suppress signs of iron deficiency in the plants. After three weeks, five plants were each suspended in a quantity of the nutrient solution and anthranilic acid-1-^{14}C (300 mgm.) of specific activity $1 \cdot 1 \times 10^7$ disint. per min. per m.mol. was divided equally between the five solutions. After 10 days of contact the nutrient solutions (total activity $1 \cdot 65 \times 10^6$ disint. per min.) were discarded and replaced by fresh solution (without labelled material). Eighteen days after feeding the anthranilic acid the plants were harvested, extracted with dilute hydrochloric acid and the nicotine separated from this extract (total activity $4 \cdot 8 \times 10^6$ disint. per min.) by distillation from alkaline solution[10] followed by precipitation as the dipicrate. Nicotine dipicrate crystallized from 30 per cent dimethylformamide as yellow needles, m.p. 223–224°, unaltered by mixture with an authentic sample. A quantity of the dipicrate was converted to the diperchlorate separating from the ethanol as needles, m.p. 207–208° either alone or in admixture with an authentic sample. Paper chromatography[11] showed nicotine to be the only pyridine base detectable in the crude plant extract. The nicotine salts showed no significant radioactivity.

From Leete's work[9] there is no doubt that the tobacco plant synthesizes nicotine at the stage of growth at which the present experiments were performed. Hence anthranilic acid does not function as a precursor of the pyridine ring of nicotine. Surprisingly, lysine does not give rise to the pyridine ring of nicotine either[9], nor is it the precursor of the α-pyridone ring of ricinine (Reist, E. J., and Marion, L., unpublished results). A body of evidence is, therefore, accumulating according to which it seems improbable that in the higher plants the pyridine ring would have its source in either tryptophane or lysine, which appeared to be the two most plausible precursors. It is true that according to Dawson *et al.*[12] the preformed pyridine ring (nicotinic acid) can be utilized by the plant in the synthesis of nicotine; but this does not seem to have much bearing on the initial formation of the pyridine structure. It now appears likely that the pyridine ring might be built directly from smaller units arising from alanine and glycine, or possibly from non-nitrogenous precursors, and ammonia. In micro-organisms where tryptophane functions as the precursor of nicotinic acid, the pyridine ring must arise by ring closure of an oxidative intermediate compound, which in the higher plants might be built up at a much faster rate from smaller units than it can be formed from the metabolites of tryptophane. The fact that nicotinic acid takes part in the biogenesis of nicotine[12], whereas tryptophane does not[5], lends support to this possibility, which is being investigated.

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A Quantitative X-Ray Study of Alpha-Beta Transformation in Keratin

The first X-ray diffraction studies of the α–β transformation in keratin were made by Herzog and Jancke[1] and Astbury and Street[2]. Since then it has occupied a pivotal position in all attempts to determine the molecular structure of proteins. Recently, Bendit[3] has reported the variation of the peak intensity of the 5·1 A., 4·6 A. and 9·8 A. reflexions against percentage extension for Lincoln wool and concluded therefrom that Astbury's hypothesis of a molecular transformation based on a 1 : 1 correspondence of the intensity variation of the first two reflexions is not tenable. However, no quantitative X-ray study of the degree of order introduced with extension has been yet reported.

The outstanding reflexions in the alpha-photograph of human hair are the meridional strong arc of spacing 5·15 A., made up of (020) flanked on either side by (120), and the composite equatorial reflexions (001), (101), (300) and (201), spread over 3 A. and having a mean spacing of 9·8 A. The (100) reflexion, because of its proximity to the centre and poor definition, does not lend itself to an easy evaluation and is therefore omitted. During the course of transformation from alpha to beta, which sets in at about 30 per cent extension, the meridional arc begins to close up while there appears on the equator a new spot of 4·65 A., and the overall definition of the photograph also improves. However, the dark arc never completely disappears. If we denote the total intensity of the meridional and equatorial spots by I_m and I_e, respectively, then the degree of order, Ω, may be defined by the relation :

$$\Omega = \frac{I_e - I_m}{I_e + I_m} \times 100$$

This expression has the advantage of being independent of all exposure factors.

In order to carry out an experimental determination of this degree in three different varieties, X-ray photographs, using copper K_α radiation, monochromatized by reflexion from a calcite crystal, were taken of bundles of human hair well-combed to ensure parallelism and held taut between two pin-vices one of which was movable and carried a screw-gauge to measure extension. The fibres were always stretched in water at room temperature and supercontracted by stretching first in steam and later allowing them to recover in steam itself. Intensity measurements were made by Moll's recording-type microphotometer and they were reduced to the same scale. The results obtained are shown in Table 1.

These results show that the change is exponential. Initially there is a rapid rise in the degree of order, but from 60–70 per cent extension the change is not very large. The behaviour of golden hair is much nearer to that of black than to that of white. The difference may be due to the presence of air bubbles in white hair. On treatment with cuprammonium hydroxide it was found that the fibre-pattern disappeared completely because of the contraction arising from an extra folding of the chains induced by co-ordination of the absorbed copper with appropriate groups in the keratin chain. A study of this 'reversible super-contraction' produced on washing with dilute sulphuric acid is also being made, and a detailed account of the work will be published elsewhere.

Table 1

Variety	Super-con-tracted	Un-stretched	Stretched (per cent)			Treated with cuprammon-ium hydroxide
			40	60	70	
Black	38·13	43·97	51·9	53·19	54·09	0
Golden	37·58	41·8	48·01	50·12	51·12	0
White	34·21	37·03	43·82	45·83	46·60	0

I am indebted to Prof. K. Banerjee for his guidance and encouragement in this work.

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Fibrous Structure in Cheese Curd

In the manufacture of Cheddar cheese the curd granules fuse under gravity into solid blocks, usually 6–12 in. in thickness. At the same time some spreading or flow of the blocks takes place. This flow appears to be responsible for the characteristic fibrous texture in the 'cheddared' curd. In designing a curd-fusing or cheddaring machine Czulak and Hammond[1] took account of this fact and arranged, following initial compression into a solid block, to submit the curd to pressure in a longer chamber, thereby giving flow in one direction. Curd cheddared in this machine has a greatly increased longitudinal fibrous structure, strips of curd some 20 in. in length being readily torn from the block.

Microscopic examination by fluorescence methods of sections of the curd cut parallel to the direction of flow shows a network of long casein fibrils of a minimum thickness of 0·1μ. The picture at a magnification of about 1,400 resembles that of coagulated blood fibrin as shown in the electron photomicrograph of Wolpers and Ruska[2]. In sections cut transversely to the direction of flow, or in curd

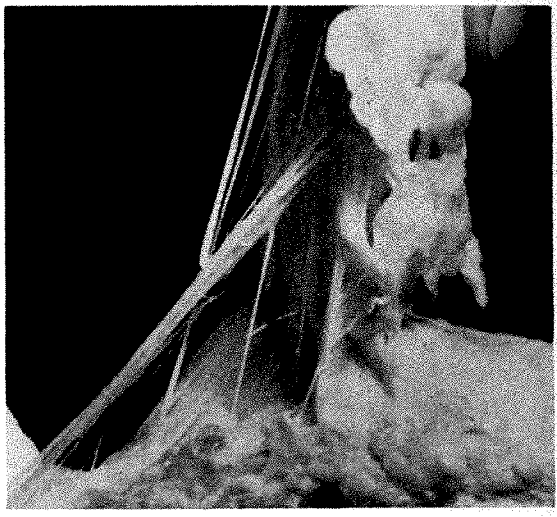

Fig. 1

which has not been submitted to flow, few of these fibrils appear.

The electron micrographs of Imhof and Hostettler[3] show that, following a linear aggregation of casein micelles (each micelle containing about 1,000 casein molecules) at the initial coagulation of the milk by rennet, fusion of the micelles occurs during the later stages of the cheesemaking process. The electron micrographs of Baud, Morard and Pernoux[4] seem to indicate the formation of appendages which afterwards serve to join the micelles during coagulation. The fibril formation which we have observed could be explained by the orientation of the separate casein molecules (axial ratio about 8 : 1) and their more or less end-to-end attachment, or more readily by some uncoiling of the polypeptide chains. The flow of the curd mass could itself contribute to this uncoiling, since proteins may be denatured by mechanical shearing action.

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First and Second Cycle Casein in Milk

The component of the casein complex which, according to Waugh and Von Hippel[1], is responsible for the colloid chemical stability of the casein micelles in milk is *k*-casein. The same authors have also given its preparation, as follows. The casein in skim milk is precipitated by addition of calcium, and by subsequent removal of calcium from the precipitate a solution of the so-called 'first cycle casein' is obtained. This first cycle casein contains β-casein and the α/*k*-complex. Reprecipitating first cycle casein with 0·25 *M* calcium chloride at 37° C. results in the splitting of the α/*k*-complex and hence in the chemical instability of the casein micelles in the colloid. The precipitate was named 'second cycle casein', and it no longer contains the protective *k*-casein in stabilizing quantities. The latter can be isolated from the remaining supernatant of second cycle casein. In its physico-chemical properties, such as electrophoretic mobility, diffusion and ultracentrifugation characteristics, *k*-casein was shown to resemble α-casein closely.

The present communication deals with an electrophoretic study of first and second cycle caseins both with and in the absence of the milk-clotting enzyme rennin.

From an earlier investigation by Nitschmann and Lehmann[2] with acid-precipitated casein it is known that the rennin action electrophoretically is characterized by the splitting of the α-peak into two distinct components, namely, α_1- and α_2-casein, with nearly the same mobilities. We have repeated the Nitschmann/Lehmann experiment both with first and second cycle casein.

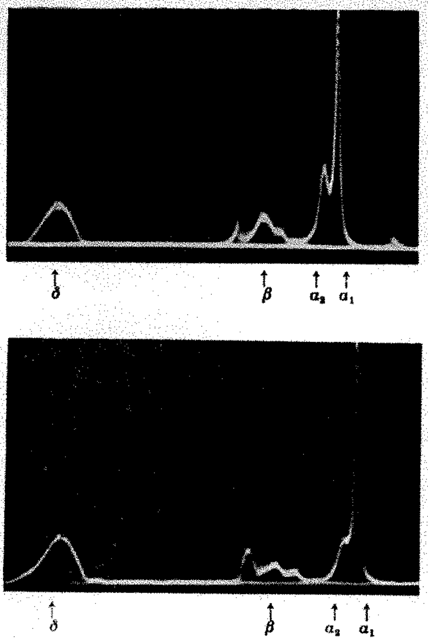

Fig. 1. Ascending electrophoretic patterns of first and second cycle caseins after 4,800 sec. Conditions of experiment: protein concentration, 1·7 per cent; Michaelis buffer *p*H = 7·3, Γ/2 = 0·1; field strength, 9·75 V./cm.; 2° C. Above: first cycle casein, active rennet solution added; below: second cycle casein, active rennet solution added

Table 1

Exp.	Substrate	Rennet	α_1/α_2 split	α_2 (per cent)	$\mu_{\alpha_1} \times 10^5$ (cm.²/V./sec.)
A	First cycle casein	Heat-inactivated	Occasionally	27	8·98
B	Second cycle casein	Heat-inactivated	Unseparated	13	10·90
C	First cycle casein	Active solution	Very pronounced	29	9·05
D	Second cycle casein	Active solution	Pronounced	14·5	10·70

The caseins were incubated at 35° C. with a solution of commercial rennet powder (1 : 100,000) of the N.V. Chemische Industrie Van Hasselt, Amersfoort, Holland. The rennet concentration was chosen such that 10 mgm. rennet were added per gram of casein. In this way its concentration is too low to be distinguished electrophoretically. For comparison heat-inactivated enzyme was also added to first and second cycle casein. The experiments were repeated several times. A typical set of experiments are summarized in Fig. 1 and Table 1, which show that α_2-casein is much less abundant in second cycle than in first cycle casein. These results suggest that α_2-casein is closely related to the *k*-casein of Waugh and Von Hippel: possibly the two components are actually identical.

Additional support for this conclusion is found in a comparison of the mobilities of the α_1-component in first and second cycle casein (Table 1, column 6). The mobility of the α_1-casein is considerably higher in second ($10 \cdot 80 \pm 0 \cdot 1 \times 10^{-5}$ cm.²/V./sec.) than in first cycle casein ($9 \cdot 02 \pm 0 \cdot 03 \times 10^{-5}$ cm.²/V./sec.). Obviously this mobility increase is due to the decrease in α_2-content in the second cycle and the accompanying decrease in α_1/α_2-interaction.

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Arylsulphate Synthesis and the Arylsulphatases

DURING the course of studies on the synthesis of sulphate esters an opportunity was taken to obtain evidence to support the suggestion[1] that the type II mammalian arylsulphatases (arylsulphatases *A* and *B*)[2] were unlikely to be directly involved in the synthesis of arylsulphates by particle-free mammalian liver preparations. It has already been pointed out[3] that the type I arylsulphatase of mammalian livers (arylsulphatase *C*) cannot be directly involved in this synthetic process since the enzyme is microsomal in origin and highly insoluble. Similar considerations do not apply to the type II enzymes, however, since although they are mainly associated with the so-called 'light mitochondria', appreciable amounts are always present in preparations of the soluble components of the liver cell[4].

The arylsulphate-synthesizing system of mammalian livers is known to involve at least two main steps; the production of an active form of sulphate (3′-phosphoadenosine-5′-phosphosulphate) and the subsequent transfer of the sulphate group of this compound to a phenolic acceptor via the agency of a specific transferase enzyme. Particle-free rat-liver preparations[5] of this synthetic system contained appreciable amounts of the type II arylsulphatases. The average activity of the dialysed preparations was such that 1 ml. liberated 2 μmole nitrocatechol/hr. at 37·5° from 0·005 *M* dipotassium 2-hydroxy-5-nitrophenyl sulphate (nitrocatechol sulphate) in 0·5 *M* acetate buffer, *p*H 5·0 (conditions favouring arylsulphatase *A* activity) and 4 μmole nitrocatechol/hr. from 0·02 *M* nitrocatechol sulphate in 0·5 *M* acetate buffer, *p*H 6·0 (conditions favouring arylsulphatase *B* activity). For various reasons[2] these values can only be regarded as approximations. When fortified[6] with adenosine triphosphate and magnesium and sulphate ions and incubated in the presence of 0·05 *M* phosphate buffer, *p*H 7·0, the dialysed preparations were capable of synthesizing approximately 0·1 μmole *p*-nitrophenyl sulphate, nitrocatechol sulphate or *p*-acetylphenyl sulphate/hr./ml. from the respective parent phenols.

Further purification of the system by ammonium sulphate fractionation according to the directions of Segal[5] concentrated both the synthetic and the arylsulphatase activities. However, no loss in type II arylsulphatase activity occurred when the system synthesizing 3′-phosphoadenosine-5′-phosphosulphate was destroyed by treatment with glycylglycine[6] or when the enzyme system responsible for transfer of sulphate from 3′-phosphoadenosine-5′-phosphosulphate to the phenolic acceptor was inactivated by heat treatment[6]. Purified samples of mammalian arylsulphatases *A* and *B* also showed no loss in activity when subjected to these inactivation procedures. Addition of these purified samples to the arylsulphate-synthesizing system decreased the activity of the system slightly, while addition of the purified soluble type I arylsulphatase of *Alcaligenes metalcaligenes*[7] strongly inhibited the synthetic process. This is not surprising, since the hydrolytic activity of this bacterial enzyme is unaffected by the phosphate and sulphate ions present in the synthesizing incubation mixture whereas the hydrolytic activity of the type II mammalian arylsulphatases is considerably inhibited by these ions.

It seems probable, therefore, that the arylsulphatases cannot be directly concerned in the synthesis of arylsulphates via 3′-phosphoadenosine-5′-phosphosulphate, and these conclusions are supported by the recent observation (Spencer, B., personal communication) that incubation of purified samples of mammalian arylsulphatases *A* and *B* with *p*-nitrophenol in the presence of 3′-phosphoadenosine-5′-phosphosulphate did not effect any sulphate synthesis.

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Effect of Chymotrypsin on Cæruloplasmin

INTEREST has been shown in the blue, copper-containing, serum oxidase cæruloplasmin, in particular because of its absence from the blood of subjects with hepatolenticular degeneration[1]. The copper of cæruloplasmin is firmly bound, being non-dialysable at neutral *p*H [2]. As part of a study of the mode of linkage of copper to the apo-enzyme, the effect of chymotryptic digestion on cæruloplasmin was investigated.

Cæruloplasmin was prepared from the *G*2 plasma fraction of Kekwick and MacKay[3] using a modification of the method of Kominz[4]. The final blue material had a broad absorption peak with maximum at about 610 mμ. Copper content was determined by a diethyldithio-carbamate method[4] and cæruloplasmin content calculated from Holmberg and Laurell's[2] finding of 0·34 per cent copper in cæruloplasmin. Purity was about 70 per cent. An amount of the material containing 20 mgm. cæruloplasmin was digested with 3 mgm. 'Armour' chymotrypsin in 10 ml. 0·05 *M* *p*H 7·5 sodium phosphate buffer—0·10 *M* sodium chloride at 37° for 22 hr. At intervals during digestion, optical density at 610 mμ was measured and aliquots taken to which tetra-ethyl pyrophosphate was added to inhibit chymotrypsin. Oxidase activity was determined colorimetrically using N,N-dimethyl *p*-phenylene diamine as substrate (see caption to Fig. 1). Non-dialysable copper was also determined on three aliquots. Results are shown in Fig. 1. Enzymic activity and the blue 610-mμ peak decreased during digestion until after 22 hr. they were negligible. (The residual absorption at 610 mμ after 22 hr. was no longer a peak and was part of a spread of the normal protein 280-mμ peak into the visible range. This spread seems characteristic of copper proteins[5]. The 610-mμ peak of cæruloplasmin is destroyed by ascorbic acid[2], but the 610-mμ optical density after 22 hr. digestion was found to be unaffected by ascorbic acid.) Non-dialysable copper also decreased during digestion, but after 22 hr. it was about half that of the original cæruloplasmin.

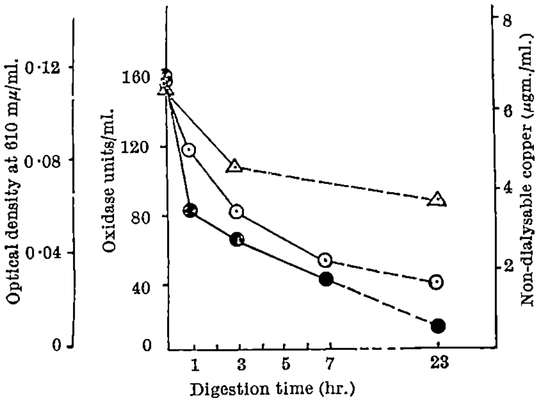

Fig. 1. Effect of chymotryptic digestion on cæruloplasmin oxidase activity, optical density at 610 mμ and non-dialysable copper. ●, Oxidase activity; ⊙, optical density at 610 mμ/ml.; △, non-dialysable copper.

Oxidase activity was determined by adding 2·0 ml. 0·2 *M* *p*H 5·5 sodium acetate–acetic acid buffer to 1·0 ml. cæruloplasmin solution in 0·10 *M* sodium chloride and incubating at 37° for 15 min. with 1·0 ml. fresh aqueous 0·025 per cent N,N-dimethyl *p*-phenylene diamine dihydrochloride. The oxidase reaction was stopped by 2·0 ml. 0·05 per cent aqueous sodium azide and the red colour measured at 550 mμ on a *SP*600 spectrophotometer. A blank was run simultaneously. A unit of enzymic activity was taken as the activity of an amount of cæruloplasmin which gave under the above conditions an optical density of 0·10/cm. light path. There is a linear relationship between amount of cæruloplasmin and optical density in the density range 0–0·15

Three further cæruloplasmin samples were digested with chymotrypsin. In all cases blue colour disappeared and non-dialysable copper after digestion was about half the original cæruloplasmin copper (Table 1). In digestion 4, after 65 hr. digestion, an aliquot of the non-dialysable material was taken, the original amount of chymotrypsin present doubled and digestion at 37° allowed to proceed for a further 23 hr. Non-dialysable copper after this second period was 99 per cent of that after 65-hr. digestion.

The results suggest that of the eight atoms of copper[3] in the cæruloplasmin molecule, four only are in a region that is attacked by chymotrypsin. During digestion, proteolysis of this part of the cæruloplasmin molecule occurs together with loss of blue colour and enzymic activity. The apparent resistance of the other part of the cæruloplasmin molecule to chymotryptic attack may be quite unrelated to its copper component. However, it is known that the iron- or copper-binding protein conalbumen is resistant to chymotrypsin, but only in the iron- or copper-containing forms[6]. Thus it is possible that half the atoms of copper in cæruloplasmin are bound in such a way that they confer chymotrypsin resistance on a portion of the cæruloplasmin molecule.

It is of interest that other workers[7] have recently shown that in the presence of ascorbic acid, half the copper in cæruloplasmin is exchangeable with copper-64. This also implies an accessibility of one half only of cæruloplasmin copper.

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Table 1. NON-DIALYSABLE COPPER IN CHYMOTRYPTIC DIGESTS OF CÆRULOPLASMIN

Digestion Exp. No.	Cæruloplasmin (mgm.)	Chymotrypsin (mgm.)	Digestion time (hr.)	Per cent copper non-dialysable after digestion
1 (see Fig. 1)	20·1	3	22	56
2	7·0	1	22	52
3	9·0	3	22	49
4	11·8	2	65	55

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*Iso*leucine and Allo-*iso*leucine

DURING our investigations on amino-acid analysis on ion exchange resins using Moore and Stein's method[1], it was seen that in a synthetic mixture of 13 amino-acids (Hoffmann-LaRoche, mostly in the *l*-configuration) the 'methionine' recovery was always too high (120–150 per cent of the theoretical amount) and the '*iso*leucine' recovery always too low (65–70 per cent of the theoretical amount).

On analysing a single sample of '*l*-*iso*leucine' we found two peaks on the chromatogram, the main one in the usual *iso*leucine position and a smaller one at the methionine position (Fig. 1, *B*). According to Piez[2], who succeeded in separating chromatographically a commercial sample of *dl*-*iso*leucine into *d*-*iso*leucine and *d*-allo-*iso*leucine, the 'impurity' is the stereoisomeric allo-*iso*leucine. Piez also found the allo-*iso*leucine coming out of the column at the methionine position.

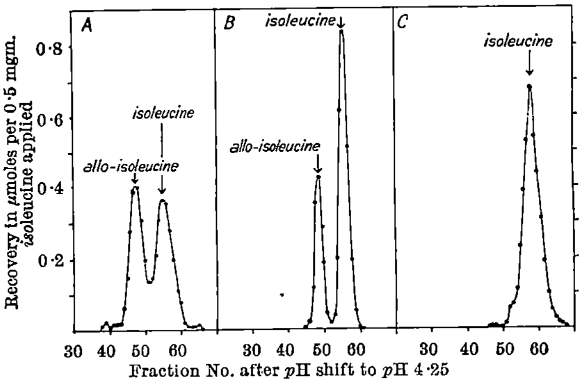
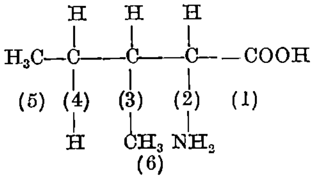


Fig. 1. Chromatograms of samples of: *A*, 0·201 mgm. of *dl*-*iso*leucine (Nutr. Biochem. Corp.); *B*, 0·312 mgm. of *l*(+) *iso*leucine (Hoffmann–La Roche); *C*, 0·530 mgm. of *l*(+) *iso*leucine (Mann Res. Lab.) applied on 100-cm. ion exchange columns containing 'Dowex 50' (*A* and *C*) or 'Zeokarb 225' (*B*). Elution first with 170–200 ml. citrate buffer at *p*H 3·42 ($t = 37·5°$ C.) and then with citrate buffer at *p*H 4·25 ($t = 50·0°$ C.). 1-ml. fractions were collected

*Iso*leucine has two asymmetric C-atoms (Nos. 2 and 3):



$$\begin{array}{ccccc} & \mathrm{H} & \mathrm{H} & \mathrm{H} & \\ & | & | & | & \\ \mathrm{H_3C}- & \mathrm{C} - & \mathrm{C} - & \mathrm{C} - & \mathrm{COOH} \\ & | & | & | & \\ (5) & (4) & (3) & (2) & (1) \\ & | & | & | & \\ & \mathrm{H} & \mathrm{CH_3} & \mathrm{NH_2} & \\ & & (6) & & \end{array}$$

and consequently has 4 stereoisomeric configurations. These are called *l-iso*leucine, *d-iso*leucine (stereoisomeric with the *l*-configuration at carbon atom 2), *l*-allo-*iso*leucine (stereoisomeric with *l-iso*leucine at carbon atom 3) and *d*-allo-*iso*leucine. In this connexion it may be pointed out that an allo-configuration is also possible for hydroxyproline, hydroxylysine and homoserine (erroneously called threonine by Shulgin[3]), which also contain 2 asymmetric carbon atoms. These allo-configurations have been found by Piez[2], Witkop[4], Hamilton[5] and Shulgin[3].

After chromatographic separation on both 'Zeokarb 225' and 'Dowex 50', with the ninhydrin procedure developed by Moore and Stein[6], for the different analysed *iso*leucines we obtained the following results :

Applied	Ion exchange resin	Found Allo-*iso*-leucine	 *Iso*leucine
0·201 mgm. *dl-iso*leucine (Nutr. Bioch. Corp.)	'Dowex 50'	0·103 mgm.	0·108 mgm. (Fig. 1,*A*)
0·505 mgm. *l*(+) *iso*leucine (Hoffm.–la Roche)	'Dowex 50'	0·132 mgm.	0·331 mgm.
0·312 mgm. *l*(+) *iso*leucine (Hoffm.–la Roche)	'Zeokarb 225'	0·095 mgm.	0·201 mgm (Fig. 1,*B*)
0·502 mgm. *l*(+) *iso*leucine (Nutr. Bioch. Corp.)	'Zeokarb 225'	—	0·475 mgm.
0·530 mgm. *l*(+) *iso*leucine* (Mann Res. Lab.)	'Dowex 50'	—	0·516 mgm. (Fig. 1,*C*)
0·546 mgm. *l*(+) *iso*leucine* (Mann Res. Lab.)	'Zeokarb 225'	—	0·504 mgm.

* Offered as 'allo-*iso*leucine free'

It can be seen that two of the four analysed *iso*leucine preparations consist of a mixture of the two stereoisomers *iso*leucine and allo-*iso*leucine. One sample, which contains no allo-*iso*leucine, was offered as 'allo-*iso*leucine free'. So certainly most of the commercial *iso*leucine samples which give no indications about their allo-*iso*leucine content (and probably all of the *dl* samples) will contain this allo-*iso*leucine in considerable amounts.

Though it is known that out of the four stereoisomeric *iso*leucines only *one* (*l-iso*leucine) can be used by the organism[7], the allo-*iso*leucine content of the commercial *iso*leucine is often neglected in human and animal feeding experiments with *iso*leucine.

We also studied the influence of acid hydrolysis, as used in the analysis of proteins[8], on the stereochemic configuration of *l*(+) *iso*leucine.

We found that hydrolysis with 6 *N* hydrochloric acid does not change the configuration of *iso*leucine. This could be demonstrated by boiling a sample of *iso*leucine free from allo-*iso*leucine (Mann Res. Lab.) for 22 hr. in 6 *N* hydrochloric acid followed by chromatography on 'Zeokarb 225'. The results were :

Applied	Found Allo-*iso*leucine	 Leucine
0·394 mgm. *l*(+) *iso*leucine Mann (Hydr. I)	—	0·371 mgm. (= 94 per cent)
0·134 mgm. *l*(+) *iso*leucine Mann (Hydr. II)	—	0·130 mgm. (= 97 per cent)

There was only one peak, in the *iso*leucine position, and the *iso*leucine recovery was nearly quantitative. No racemization to allo-*iso*leucine took place under these conditions.

In the chromatographic analysis of protein hydrolysates following acid hydrolysis according to Schram[8], the values for *iso*leucine and methionine are not influenced by allo-*iso*leucine formation.

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Enzymic Synthesis of Nitrogen-containing Disaccharides by α-Galactosyl Transfer

SEROLOGICAL and enzymic inhibition tests with simple sugars and oligosaccharides of known structure have in recent years given valuable indications about the sugars which are most important for specificity in the complex mucopolysaccharide materials possessing blood-group activity[1]. Di- and tri-saccharides of known structure which are composed of the sugars present in the blood-group substances are required in order to extend these observations ; the enzymic syntheses of two such disaccharides which have not previously been described, α-D-galactosyl-(1→6)-N-acetyl-D-glucosamine (1) and α-D-galactosyl-(1→6)-N-acetyl-D-galactosamine (2), are reported here.

Synthesis of β-linked disaccharides containing amino-sugars was achieved using β-galactosidase preparations from *L. bifidus* var. Penn[2] and *E. coli*[3]. For the present work the α-galactosidase which occurs, with many other glycosidases, in saline extracts of autolysed *Trichomonas foetus* organisms[4] was used as the synthesizing enzyme. Chromatographic examination of the reaction mixtures obtained when melibiose or phenyl-α-galactoside were incubated with *T. foetus* extracts in the presence of large quantities of D-glucose, D-galactose, D-mannose, N-acetyl-D-glucosamine or N-acetyl-D-galactosamine revealed the formation of reducing disaccharides which were absent from the mixture before incubation ; these disaccharides had presumably been synthesized by the enzymic transfer of the α-galactosyl residue from melibiose or phenyl α-galactoside to the second sugar present in the reaction mixture. In the digests containing amino-sugars higher oligosaccharides, which gave positive reactions in tests for N-acetyl hexosamines, were detected in addition to the disaccharides, when melibiose was used as a substrate. In view of the possible use in blood-group studies of the disaccharides containing N-acetylglucosamine and N-acetylgalactosamine these two compounds were prepared on a larger scale for isolation and identification. Melibiose (5 gm.) and N-acetylhexosamine (3 gm.) in 50 ml. of 0·1 *M* phosphate buffer *p*H 6·8 were added to 50 ml. of a freshly prepared *T. foetus* extract and incubated for 18 hr. at 37°. The two disaccharides (1) and (2) were separated from their respective reaction mixtures by chromatography on charcoal : 'Celite' (1 : 1) columns ; each was finally obtained as an amorphous white powder which gave only one spot when examined chromatographically in three different solvent mixtures. The yields were about 600 mgm. of the compound containing N-acetylglucosamine, disaccharide (1), and about half this amount of disaccharide (2). The high positive rotations ((1)$[\alpha]_D$ + 118° ; (2) $[\alpha]_D$ + 142°) supported the belief that the disaccharides possessed α-linkages.

Chromatographic evidence for the constitution of the disaccharides is as follows : enzymic hydrolysis showed that each contained galactose and an N-acetylhexosamine. Reduction with potassium borohydride demonstrated that the compounds were galactosides because on hydrolysis of the reduced disaccharide both (1) and (2) gave galactose and the alcohol of the amino-sugar component. In amyl alcohol : dioxan : water : acetic acid (43 : 34 : 23 : 0·6) solvent mixture, compounds (1) and (2), (R_{glucose} values 0·68 and 0·65 respectively), ran slightly faster than β-galactosyl-(1→6)-N-acetylglucosamine[5] (R_{glucose}, 0·61) and more slowly than β-(1→3)-[6] or β-(1→4)-[7] galactosyl-N-acetylglucosamine (R_{glucose}, 0·75). An α-compound would be expected to run slightly faster than the corresponding β-compound, and this behaviour therefore suggested that (1) and (2) contained α-(1→6) linkages. This suggestion was supported by the colour reaction given with the benzidine–trichloroacetic acid spray reagent[8]. The two new disaccharides each gave a purple-brown spot which was similar in colour to that given by the β-(1→6) compound, but which differed markedly from the golden-brown colour given by the β-(1→4) compound and the greenish-brown colour observed with the β-(1→3) disaccharide. On spraying with alkali followed by Ehrlich's reagent[9] (*p*-dimethylaminobenzaldehyde) (1) and (2) both gave a purple colour indicating a (1→3) or a (1→6) linkage since N-acetylhexosamines which have no free reducing group, or which are substituted at C-4, fail to react with this reagent[10]. Pretreatment of the disaccharides with 0·05 *N* sodium carbonate for 4 min. at 100° before the chromatograms were run resulted mainly in the formation of the disaccharide chromogen without decomposition into the component sugars; this behaviour is similar to that of the β-(1→6) compound[11] and differs from the β-(1→3) which when heated under identical conditions is hydrolysed completely and gives only the chromogen of N-acetylglucosamine. The chromatographic evidence therefore points to the identification of (1) as α-galactosyl-(1→6)-N-acetylglucosamine and (2) as α-galactosyl-(1→6)-N-acetylgalactosamine. The results of periodate oxidation experiments were consistent with these structures since each compound rapidly consumed three molecules of periodate during the first hour of oxidation with a further uptake of three molecules during the next 24 hours, as would be expected for a galactosyl-(1→6)-*N*-acetylhexosamine.

A full account of this work, including the behaviour of these disaccharides in serological inhibition tests, will be given elsewhere.

I am indebted to Dr. Muriel Robertson for generous supplies of *T. foetus* organisms.

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Peculiar Distribution of the Diego Factor among the Warrau

THE Warrau are a tribe of South American Indians occupying the Orinoco delta and the adjacent swampy regions of the coast of British Guiana. They have been living in this region since prehistoric times. Being a group of about 9,000 people with a culture fundamentally marginal, they belong to the earliest inhabitants as yet traceable in South America[1].

Two different expeditions were undertaken to the Orinoco delta, in the course of which blood samples were collected from two different Warrau communities: Guayo and Winikina. Genealogical and demographic studies which were executed after we had studied the blood of the Guayo–Warrau group made us suspect that these Indians had some admixture with other Indians, a fact which we then expected to account for the low incidence of the Diego factor among this group. Our expectations were realized after we had tested the Winikina. They are a subgroup stemming from a Warrau subtribe which has been living in complete isolation until very recently.

The present communication is based on 153 blood samples which we had the opportunity of collecting among the Warrau. Genealogical tables at our disposal proved the individuals not to be related with each other. As stated above, the samples were taken from two different Indian communities which are separated from each other by a distance of about 100 km.

Table 1 shows the incidence of ABO, MN, Rh, Duffy and Diego systems of both populations. The blood samples of the Winikina group were also tested with anti-U and anti-Tj^a sera.

The frequencies of ABO and Rh_0 grouping as listed in the chart proved to be in general accordance with previous findings[2]. The frequency of the Fy^a gene coincides with its high occurrence among most of the American Indians. It was a surprise, however, to find both populations with a low incidence of the gene *M*. So far, the Warrau seem to be the only tribe of American Indians known to carry the gene *M* in such a low percentage[3]. The U and Tj^a antigens were positive in all samples of the Winikina subtribe.

The outstanding result of this study was the low incidence of the Di^a antigen among the Guayo–Warrau and the complete negative finding of it among the Winikina–Warrau. The very low occurrence in the first group and negative incidence in the second group cannot be explained by interbreeding with caucasoids or negroids (among whom the Di^a antigen was found to be absent)[4] because the Warrau tested have a frequency of 100 per cent of gene *O* and a negative incidence of the *cde* and *cDe* chromosomes. It is reasonable to assume that the Diego antigen originally has been absent among these Indians and that the positive cases in the Guayo–Warrau were introduced by admixture with Indians carrying the gene; such as the Arawak and Carib, with whom the peripheral Warrau have been in contact since prehistoric times.

Besides the Eskimos[5], the Warrau are the second American tribe which so far seem to lack the Di^a antigen.

Since the incidence of ABO, Rh, Duffy and other blood groups in a great number of American Indian tribes has not shown any significant difference, it is very difficult to determine the interbreeding of two or more tribes from the point of view of blood group-

Table 1. FREQUENCY OF ABO, MN, RH, DUFFY, DIEGO, TJ^a AND U IN THE WARRAU TRIBE

Warrau sub-tribes	No. tested	ABO system				MN system					Duffy system			
		Phenotypes (per cent)				Phenotypes (per cent)			Genes (per cent)		Phenotypes (per cent)		Genes (per cent)	
		A	B	AB	O	M	MN	N	*M*	*N*	Fy(a+)	Fy(a−)	*Fy^a*	*Fy^b*
Guayo	81	0	0	0	100	28·39	44·44	27·16	50·61	49·38	91·35	8·64	97·07	2·93
Winikina	72	0	0	0	100	15·27	43·05	41·66	36·79	63·18	97·22	2·77	98·34	1·66

Warrau sub-tribes	Rh system								Diego system				Tj^a factor		U factor	
	Phenotypes (per cent)					Chromosomes (per cent)			Phenotypes (per cent)		Genes (per cent)		Phenotypes (per cent)		Phenotypes (per cent)	
	CCDE	CCDee	CcDE	CcDee	ccDE	*CDE*	*CDe*	*cDE*	Di(a+)	Di(a−)	*Di^a*	*Di^b*	Tj(a+)	Tj(a−)	U(+)	U(−)
Guayo	2·46	45·67	45·67	3·70	2·46	1·79	67·58	30·63	3·69	96·31	1·9	98·1	Not tested	—	Not tested	—
Winikina	11·11	44·41	38·88	2·77	2·77	7·89	66·62	25·49	0	100	0	100	100	0	100	0

ing. However, the peculiar incidence of the Diego factor (negative in two, low or high in others[4]) makes it likely that this antigen could be used in future work to determine the rate of interbreeding among them. It is probable that such variable frequency might occur also in Asiatic mongoloid populations.

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Hæmoglobin E and the Diego Blood Group Antigen in Sarawak and Burma

A CONSIDERABLE number of simple genetical characters—blood groups and hæmoglobins—are known which distinguish between negroids and caucasoids, but very few have been found which are characteristic of mongoloids. The genes for the Diego (Di^a) blood-group antigen and for hæmoglobin E seem, however, to fall into the latter category.

Hæmoglobin E is characteristic of the peoples of south-east Asia and, as has been shown in preliminary surveys[1,2], the Burmese have the highest known frequency of carriers in the population (15·3 per cent, mainly heterozygotes). With the Burmese may be classed the Siamese[3] with 13·6 per cent, and the Malaysian Malays from eastern Malaya[4] with 13·1 per cent. A second group with lower frequencies includes the less-pure Malaysian Malays from other parts of Malaya[4] (5·0 per cent), the Indonesians[5] (2·6 per cent), and the Veddas[1] of Ceylon, the Bengalis[6] and the Gurkhas[7], among whom only a few instances have been recorded. Among the Chinese, however, extensive surveys have so far failed to show any hæmoglobin E at all. Relatively little work has been done on the hæmoglobins of American Indians, and no abnormal hæmoglobins have been reported in those of unmixed ancestry.

The Diego blood-group antigen was first found in a Venezuelan man[8], later shown to be probably partly of South American Indian ancestry[9]. Owing to the absence of the antigen from any of the white North Americans tested it was at first regarded as a rare familial one, but it was afterwards found to be common in Venezuelan Indians[9] and, later, in other populations. Layrisse and Arends[10] have recently reviewed the literature; combining data from papers cited by them and from other papers[11] we find the antigen to be present in 21 per cent of South American Indians, 10 per cent of North American Indians, 14 per cent of Japanese and 5 per cent of Chinese. It was not found in surveys covering 2,600 caucasoids of various nationalities, but was discovered in a Pole[12] whose wife developed the corresponding antibody through pregnancy immunization. No one with the antigen was found among 35 American Negroes, 156 Eastern Canadian Eskimos, 80 Eastern Polynesians, 162 Australian Aborigines, 23 Eastern Papuans and 74 natives of New Britain.

We have recently examined 185 specimens from Sarawak, 101 from Land Dyaks and 85 from Sea Dyaks (Iban). The Land Dyak specimens were collected from six separate longhouses (villages). The Sea Dyak ones were from recruits to the Sarawak Regiment, coming from numerous longhouses. So far as possible first degree relatives of other subjects tested were avoided. When they were examined for abnormal hæmoglobins all those from Sea Dyaks and all but one from Land Dyaks were found to contain only normal adult hæmoglobin (hæmoglobin A). The exception contained 73 per cent of hæmoglobin A and 27 per cent of a hæmoglobin having the electrophoretic properties of hæmoglobin E. The proportion of the hæmoglobin-A_2 fraction, present in minute amounts in normal blood and electrophoretically indistinguishable from hæmoglobin E, is raised in thalassæmia[13]. In the present instance, however, fœtal hæmoglobin was absent, the red cells were of normal appearance, and, as already indicated, the proportion of apparent hæmoglobin E was more than 20 per cent. From these facts, and the considerations put forward by Aksoy, Lehmann and Lie-Injo Luan Eng[14], it is virtually certain that the sample came from an *AE* heterozygote and not from a case of thalassæmia.

All the Sea Dyak specimens were tested for the Di^a-antigen, the results all being negative; most of them were tested for other blood-group antigens as well. Only 61 of the Land Dyak specimens were in a suitable state for blood grouping, and three of these were found to carry the Di^a-antigen. The full blood grouping results will be published separately.

We have also recently carried out a study of the hæmoglobins and blood groups of the Burmese, the full results of which will be published separately. Some preliminary hæmoglobin results[1,2] have been mentioned above; the full series shows the even higher frequency of hæmoglobin-E carriers of 16·3 per cent. When the main samples were collected, however, we did not have any anti-Di^a serum and we have, therefore, more recently tested a further ten specimens with this serum, with one positive result.

The two characters under consideration, though both, broadly speaking, are confined to mongoloids, have quite different distributions. The Burmese are at or near the centre of the highest frequency of hæmoglobin E, but apparently on the western fringe of the distribution of the Diego antigen. The Land Dyaks, however, from the point of view of the two characters under consideration, may perhaps be regarded as transitional, lying near the eastern margin of distribution of hæmoglobin E but probably, like the Burmese, near the western margin of the Diego area.

The main Diego centre appears to be much farther east, but despite the small numbers tested, our results extend its known area of distribution considerably westward. It is clearly an important indicator of mongoloid ancestry, but its very high frequency among South American Indians and its apparent absence among Eskimos are surprising features which suggest that it may perhaps turn out to be an index of earliness of dispersal from some centre of mongoloid evolution. It is important that tests for this antigen should be carried out on many more Asiatic and Pacific Island populations as well as on larger numbers of Eskimos from all parts of the extensive territory in which they live. In particular, its possible extension to the west of Sarawak and Burma needs to be sought.

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Passage of Serum Albumins from the Mother to the Fœtus

IT has long been recognized that mammals transmit antibodies to their young before the latter are capable of making their own. In current opinion, antibodies are accorded a special status denied to other proteins, and indeed to macromolecules generally, for only antibody protein is generally conceded to pass through the layers of cells separating the maternal and fœtal circulations without undergoing metabolic degradation.

In the rabbit, antibodies are passed to the young during intra-uterine life, a transfer which occurs mainly, perhaps exclusively, via the yolk sac rather than the placenta[1]. Even before a circulation has developed, all the main plasma proteins identified by electrophoresis are present in the yolk-sac fluid, having presumably been transferred as proteins from the maternal blood. The fate of these proteins, whether they are degraded in the yolk sac or afterwards passed into the embryonic blood or tissues, is not known. However, preliminary experiments indicated that bovine serum albumin, or some material of similar antigenicity, appears in the fœtus within twenty-four hours after intravenous injection of the protein into the mother on the nineteenth day of gestation[2]. We have now confirmed this with both bovine and human serum albumins, and have found that proteins retain their original electrophoretic characteristics after passage through several layers of maternal and fœtal tissue. Our observations also indicate that serum albumin can pass directly from the uterine lumen into the exocoele, by-passing the circulation of the yolk sac.

Dutch rabbits (2–2·7 kgm. body-weight) were injected intravenously on the nineteenth or twenty-fourth days *post coitum* with 62·5 mgm. of albumin per kgm. body-weight. Samples of maternal and fœtal blood, and of various other fœtal fluids, were taken with the aid of 'Nembutal' and ether at 1, 6, 24 and 48 hr. after injection. Maternal blood was taken from a uterine vessel, fœtal blood from a vitelline artery or the heart. The fœtal membranes were rinsed with warm saline, dried at one point so that a fine capillary showed no uptake of fluid, and a pipette inserted at the dry point. All fluids were centrifuged to remove cells and tested in two-fold dilutions with specific rabbit antisera. Samples of the fœtal fluids were subjected to electrophoresis on Whatman No. 1 filter-paper strips in veronal buffer (pH 8·6, μ 0·1) for 16 hr. at a constant current of 30 m.amp. One strip was stained with bromphenol blue, and segments of a duplicate strip were squeezed out and the fluids tested with antisera.

Substances with the antigenicity of bovine and human albumins were regularly found in the fœtal sera and migrated with the original mobility of these proteins in close proximity to the fœtal albumin (Fig. 1). Since these substances also formed precipitates with their specific antisera, it is highly probable that the two albumins were not greatly modified as a result of their passage from the mother to the fœtus and through the several fœtal compartments.

The albumins were detectable as early as one hour after injection of the mother and generally increased in concentration during the first 48 hr. (Fig. 2). Blood samples taken at 24 and 48 hr. consistently showed higher titres for the human albumin. This is in accord with the work by Brambell and his associates on the passage of human and bovine antibodies in the rabbit and support their suggestion of a selective mechanism which favours the uptake of human over bovine antibodies. However, human albumin does not appear to be better adapted to penetrate fœtal tissues than bovine albumin. In the fluids of the exocoele, amnion, allantois, and stomach the bovine titres were generally equal to the human titres. Even the apparent selective uptake indicated for the blood vessels may be illusory, the outcome of selective elimination of bovine albumin from the blood into the exocoele. This is suggested by the blood and exocoele titres of the younger fœtuses (19 day series) at 24 and 48 hr., the drop in blood titres being accompanied by a rise in the exocoele.

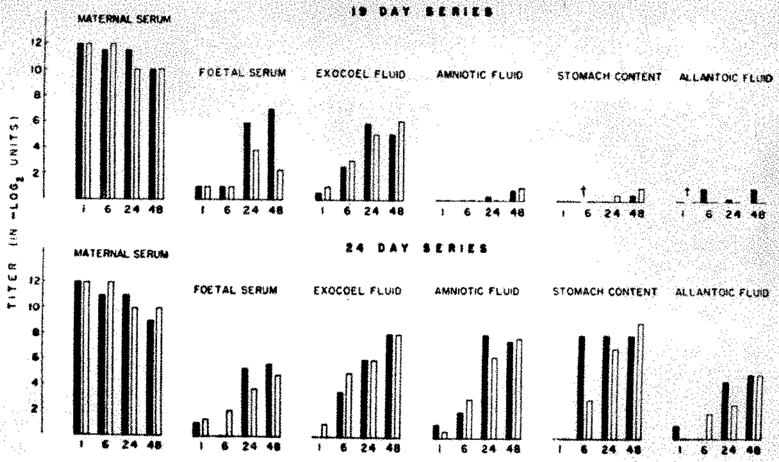

Fig. 2. Foreign albumins in maternal and fœtal fluids at 1, 6, 24 and 48 hr. after intravenous injection of the mother. Titres for human albumin (black bars) and bovine album in (white bars) were obtained with antisera showing a titre of 1 : 1,024 when tested with standards containing 1 mgm. albumin/ml. Each bar represents the average of three to seven samples. A cross indicates no sample tested

A striking difference between the two fœtal stages was found in the fluids of the amnion, allantois and stomach (Fig. 2). In the younger fœtuses these compartments showed little or no foreign protein, whereas the older ones usually had titres as high as, or frequently exceeding, those of the blood. Whatever the means by which the proteins enter or leave these compartments, it is apparent that a radical change in the permeability of the fœtal membranes must occur between the nineteenth and twenty-fourth days of gestation.

When the vitelline vessels were ligated before injection of the mother, the fœtal blood showed only traces of foreign albumin; titres in the other fœtal compartments were essentially unaffected. It is apparent that albumin, like antibodies, must to a large extent pass from the maternal into the fœtal blood via the vitelline vessels. On the other hand, the albumins can enter the exocoele and other compartments without the participation of a functional yolk-sac circulation. Direct passage into the exocoele is also supported by the observation that exocoele titres at one hour after injection were frequently higher than the blood titres, and in some instances the exocoele fluid was positive when the blood was still negative. The importance of the exocoele in the transfer of antibodies was indicated by the recent work of Brambell and Halliday[3] on the passage of anti-*Salmonella* into the rat fœtus close to term. These antibodies appear to pass successively from the uterine lumen into the exocoele, amniotic cavity, stomach and blood. Such a pathway, with the possible exception of entry into the blood, is consistent with our findings on the albumins in the 24–26 day rabbit fœtus, but not in the 19–21 day fœtus, in which the amniotic and stomach fluids showed no foreign protein or only traces at best. In both stages, however, the exocoele and the yolk-sac vessels seem to serve as primary reservoirs for the albumins taken up by the yolk sac.

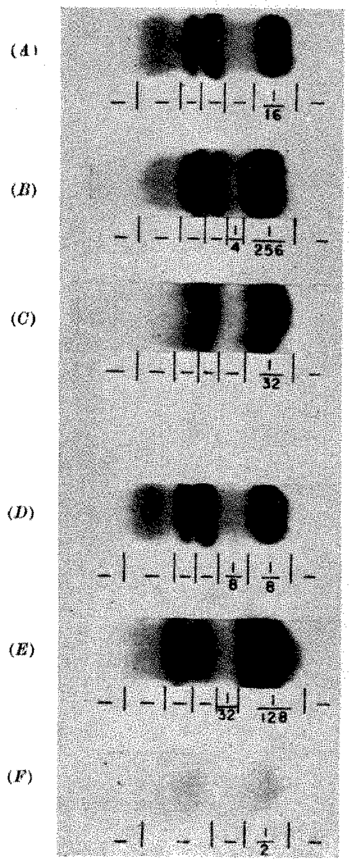

Fig. 1. Paper electrophoresis patterns of fluids from fœtal rabbits after injection of human or bovine serum albumins into pregnant females on the nineteenth or twenty-fourth days of gestation. Fractions under each pattern indicate titres for the foreign proteins, obtained from duplicate strips cut into segments (vertical lines). A dash indicates negative titre with fœtal fluid diluted 1/2. The volume of fœtal fluids subjected to electrophoresis and the proteins injected into the mother are: *A*, serum, 40 µl., human albumin, 24 days gestation; *B*, stomach contents, 100 µl., human albumin, 24 days gestation; *C*, exocoel fluid, 200 µl., human albumin, 19 days gestation; *D*, serum, 40 µl., bovine albumin, 24 days gestation; *E*, amniotic fluid, 100 µl., bovine albumin, 24 days gestation; *F*, allantoic fluid, 300 µl., bovine albumin, 24 days gestation

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Antibody Production by Lymphocytes after *in vitro* Contact with Bacterial Antigen and Transfer to New-born Rabbits

There is as yet no direct evidence of antibody formation in lymphocytes. Neither descriptions of cytological changes of lymphocytes in lymphatic tissues during antibody production[1], nor the proof of release of γ-globulin from lymphoid cells[2], nor the demonstration of antibodies in tissue cultures of pure lymphocytes immunized *in vivo*[3] could reveal whether lymphocytes are producers or only carriers of antibodies. An attempt was made, therefore, to obtain antibody production after contact of lymphocytes from rabbit lymph with antigen *in vitro*.

We used the method of cell transfer to 2–5-day-old rabbits, which are not capable of active antibody response[4]. 2–4 ml. of lymph were collected under sterile conditions from the cisterna chyli of adult rabbits (1,500–3,000 gm.). With three exceptions, cells from each donor separately were washed three times with Hank's solution, suspended in 1–2 ml. of this solution and mixed with bacterial antigen (to *Brucella suis*, *Salmonella paratyphi B*) in the proportion of 2–6 microbes to each cell. 2×10^6 to 80×10^6 viable cells (according to the trypan-blue test) were injected intraperitoneally into each recipient. The differential counts of ethanol-fixed smears stained with methyl green–pyronine from thirteen donors showed the following estimate of the constitution of transferred lymph: blasts (probably lymphoblasts) 8·78 ± 0·95 per cent; prolymphocytes 17·41 ± 1·13 per cent; lymphocytes 72·59 ± 1·38 per cent; macrophages and monocytes 0·76 ± 0·22 per cent; granulocytes 0·46 ± 0·17 per cent. In five recipients splenectomy was performed 5 hr. before cell transfer.

In order to exclude possible participation of the recipient's tissues and to enable quantitative analysis of cell changes, in some cases the lymph cells in Hank's solution were transferred in diffusion chambers ('Plexiglass' cylinders with bases of 'Millipor' membranes of 0·8-μ porosity, content 0·4–0·6 ml.). These chambers were placed in the peritoneal cavity of recipient rabbits under ether anæsthesia.

New-born rabbits of the same litters served as controls. They received: (1) isolated spleen cells with antigen under the same conditions; (2) lymph cells without antigen; (3) cell-free lymph supernatant with antigen and (4) antigen alone in corresponding quantity. Thirty-two test animals and thirty-one controls from sixteen litters were used.

It was found that after transfer of lymph cells, antibodies appear in about 90 per cent of intact recipients (Table 1) after 2–4 days, the peak being attained after 5–8 days. There is a direct relation between the quantity of transferred cells and the antibody titre. Results on splenectomized animals suggest that, after direct injection of cells into the peritoneal cavity, antibody formation is due mainly to cells localized in the spleen. Cells in a diffusion chamber give relatively lower titres in the serum, but antibodies persist for a longer period and in higher titres inside the chamber (20 days, 1 : 16). Spleen-cell transfer results in 100 per cent antibody formation.

Other animals were examined histologically. Proliferation of the lymph cells injected directly occurs chiefly on the omentum and in the spleen within a few days. A prompt reaction of macrophages develops, together with granulation and fibrous tissue formation in the surrounding area. Clumps of immature and mature plasma cells and pyroninophil reticular cells are formed in the marginal zones of layers of transferred cells. The average spleen weight in test animals from the fifth to the twelfth day after transfer is 1·336 ± 0·104 gm./kgm. (ten rabbits), in controls with antigen only 0·939 ± 0·098 gm./kgm. (ten rabbits). In the chambers during the initial proliferation a rapid fall in the number of blast cells and shedding of cytoplasm of lymphocytes was observed. There is a definite increase in macrophages (22 per cent in 8 days), pyroninophil cells resembling reticular cells (up to 1·6 per cent), immature and mature plasma cells (up to 3·2 and 4 per cent in 4–8 days), cells crowded with Russel bodies and eosinophil crystals (up to 28·8 per cent in 8 days). In controls without antigen a slight degree of plasma cell development occurred. After 45 days, only macrophages and eosinophil crystals can be found in the chambers. Details will be given elsewhere.

Table 1

Mode of transfer	No. of cells ($\times 10^6$)	No. of recipients	Distribution of agglutinating titres						
			0	2	4	8	16	32	64
Lymph cells intraperitoneally	2–20	5	1	1	1	2	—	—	—
Lymph cells intraperitoneally	20–80	13	2	—	1	3	2	4	1
Lymph cells in diffusion chambers	2–20	9	—	—	4	2	3*	—	—
Lymph cells intraperitoneally after splenectomy	20–80	5	5	—	—	—	—	—	—
Spleen cells intraperitoneally	20–80	16	—	—	1	3	5	4	3
Lymph cells intraperitoneally without antigen	20–80	6	6	—	—	—	—	—	—
Antigen alone or with cell-free lymph supernatant	—	9	9	—	—	—	—	—	—

* 75×10^6 cells in two cases

It is concluded that lymphocytes from cisterna chyli can form antibodies after transfer to new-born animals, the metabolic change being connected or followed by morphological transformation of some of the less-mature cells into the macrophage and plasma-cell types which, however, may not be responsible for the amount of antibodies formed.

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Surface Antigens of *Haemophilus pertussis*

It has been shown by Frappier and Guérault[1,2], and Frappier, Guérault and De Repentigny[3], that the antigen of *Haemophilus pertussis* which protects mice against intracerebral infection could be washed off the bacteria by saline (0·85 per cent sodium chloride). As this protective effect in the mouse is accepted as an indicator of the efficiency of vaccines in protecting children against whooping-cough it would appear that saline washings afford a ready means of obtaining the immunizing antigen of the organism free from the bulk of the bacterial cell. The washings were obtained from bacteria grown in a fluid medium, they were practically devoid of toxicity and stimulated agglutinin production in rabbits.

We have in general confirmed these findings using cultures from Bordet Gengou (*BG*) medium. Further observations showed that washings contained the histamine sensitizing factor of *H. pertussis* and that rabbit antiserum prepared against washings neutralized the histamine sensitizing factor and protected mice passively against intracerebral and intratracheal infection with *H. pertussis*.

The properties enumerated for washings were demonstrated also with an extract of *H. pertussis* obtained by treating the organisms with a mixture of solvents, consisting of thiourea, urea and formamide, according to a method employed by Dr. B. W. Lacey (personal communication). The extract so obtained had a high protective value for mice.

Extraction by a mixture of thiourea, urea and formamide removed more material than treatment with saline. The dry weight of the extract was greater than that for washings. Extracted bacteria were devoid of the histamine sensitizing factor whereas it was present in saline-washed bacteria. Although extracted bacteria still had agglutinogen and protected mice against intra-cerebral challenge, rabbit antiserum prepared against them was weak in passive protection of mice.

These findings raise the problem of the identity of the immunizing antigen of *H. pertussis* and its possible relationship with the histamine sensitizing factor or agglutinogen. The absence of the histamine sensitizing factor in extracted bacteria which retained their agglutinogen and their ability to protect mice (although probably somewhat reduced) might be interpreted as dissociating the antigen responsible for histamine sensitization from the agglutinogen and immunizing antigen. This may eventually be proved to be the case; but the result just noted could be due to differences in the threshold for detecting different biological effects rather than the operation of different entities.

We have found that serum from persons hyperimmunized with commercial pertussis vaccines contained anti-histamine sensitizing factor as well as agglutinin and mouse protective antibody.

For chemical examination of the antigens concerned it is desirable to prepare washings or extracts as free as possible from extraneous material. With *BG* medium bacterial growth was contaminated with antigenic material from the medium as was demonstrated by precipitin reaction in agar gel. This source of impurity was reduced by growing cultures on 'Cellophane' disks applied to the surface of *BG* medium, and this technique has been adopted throughout our investigations. In cultures grown on bare *BG* medium the histamine sensitizing factor diffused into the medium, but this was largely prevented by using 'Cellophane'. Bacteria grown on 'Cellophane', and washings from them, had more histamine sensitizing factor than was obtained from growth on the bare medium. Some mouse protective antigen escaped into the medium without 'Cellophane', and this too was avoided if 'Cellophane' was used, but the amount was not enough to make a detectable difference in the capacity of the bacteria to immunize mice against intracerebral challenge.

These findings suggest that the histamine sensitizing factor, agglutinogen and protective antigen may be surface components of the cell. Direct support for this view has been obtained by De Repentigny and Frappier[4], who found that fluorescent antibody against washings reacted with the surface of *H. pertussis* from liquid or solid media.

Examination of the washings by ultra-violet spectroscopy showed an absorption maximum at 265 mμ corresponding with nucleic acids or purine–pyrimidine constituents. These materials were removed by dialysis from the washings which then had an absorption spectrum similar to that of proteins. The dialysed washings retained their histamine sensitizing and mouse protective properties.

Paper chromatography of hydrolysates of the dialysed washings and extract showed an amino-acid composition typical of proteins. Glucosamine, often present in protein–lipid–carbohydrate complexes of bacterial origin was also found. Freeze-dried preparations gave a total nitrogen value of 9·5–14 per cent. Reducing substances accounted for 5–10 per cent of the weight of dialysed extract. Small amounts of glucose and galactose were detected. These results were consistent with the presence of a protein–lipid–carbohydrate complex in the dialysed washings or extract.

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Antigenic Formulæ for the Genus *Clostridium*

ANTIGENIC formulæ for *Clostridium sporogenes*, *Clostridium histolyticum* and *Clostridium parabotulinum* were devised by Mandia and Bruner[1] and by Mandia[2–4]. These were restricted to the heat-labile antigens and excluded the *O*- and the spore- (*S*-) antigens.

It is, however, no longer possible to ignore the antigenicity of the spore which was demonstrated by Defalle[5] as early as 1902. Howie and Cruickshank[6] confirmed this antigenicity with a relatively pure suspension of *Cl. sporogenes*, and laid down the principles of setting separate spore and vegetative antigen–antibody systems.

These principles have been used for devising spore and vegetative agglutination and agglutinin-absorption tests, using 37 *Clostridium septicum* and 35 *Clostridium chauvoei* strains isolated in Britain, France and the United States. The two organisms appeared to share a common spore (*S*)-antigen, and no cross-agglutination occurred between their vegetative antigens. All *Cl. chauvoei* strains shared the same *O*-antigen, but possessed two different *H*-types. There was complete identity between the *O*-antigens of types I and III and types II and IV of *Cl. septicum*, and varying cross-agglutination, but no agglutinin-absorption, between their 5 *H*-types.

These results explain earlier contradicting reports on varying cross-agglutination between *Cl. septicum* and *Cl. chauvoei*. The antigenicity of the spore, previously attributed to the vegetative forms, no doubt depended on the degree of sporulation of the cultures and the methods used by the different workers in preparing the antigens. Fuerth[7] and Conradi and Bieling[8] have, however, described a 'spore' as well as a 'vegetative cycle' for *Cl. septicum* and *Cl. chauvoei*; and Kreuzer[9] affirmed the presence of a common heat-stable antigen between them.

I am of the opinion that all classification within the genus *Clostridium* should be firmly based on antigenic characters. These are the most reliable, and the more stable, of all the criteria we now possess. The use of antigenic formulæ comprising the *S*-, the *O*- and the *H*-antigens would simplify their identification, as well as overcome any difficulty of antigenic overlapping between the different species.

Similar investigations are now being made to extend the work to other *Clostridia*.

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An Improved Technique for Spot Testing, using a 'Cellophane' Membrane

If the coloured compound in a spot test is allowed to form within a 'Cellophane' membrane instead of on filter paper, the colour can be seen much more clearly, and colour comparison is greatly facilitated. The procedure is described below for the formation of salicyloylhydrazones by aldehydes and ketones[1], but is of general application.

A test-tube containing a few drops of the carbonyl compound (if it is volatile) is covered with a sheet of 'Cellophane' previously moistened with 5 per cent aqueous acetic acid, and the 'Cellophane' is firmly secured with a rubber band. A drop of a saturated solution of salicyloylhydrazide in 5 per cent acetic acid is put on the 'Cellophane', through which it permeates to meet the carbonyl compound penetrating from the other side by volatilization. Interference from non-volatile substances is avoided, and, since the volatile substance is virtually sealed in, contamination of neighbouring tests is prevented. Excess reagent can be removed by simply wiping the outer surface of the 'Cellophane' with a damp cloth.

The method can be used for non-volatile substances, for example, oxosteroids, by placing a 5 per cent aqueous acetic acid solution of them in the 'Cellophane'-capped tube. The test-tube is inverted so that the lower surface of the 'Cellophane' is wetted, and a drop of reagent put on the top surface as before.

The new technique can be applied to all colour reactions which take place in aqueous solution. Non-waterproofed 'Cellophane' must, of course, be used.

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Generation and Propagation of Impulses during Refractoriness in a Pacinian Corpuscle

Deformation of mechano-receptors gives rise to generator potentials which in turn eventually set up propagated potentials. In order to analyse generator potentials it is desirable to block the propagated potential. In the Pacinian corpuscle this may be done by the aid of drugs, by changing the ionic environment of the receptor[1] or, as here reported, by taking advantage of differences in duration of the refractory period of generator and propagated events. Generator potentials alone are obtained when the deformation of the receptor occurs during the refractory period of the propagated potential.

Pacinian corpuscles of the cat's mesentery were isolated, together with a length of afferent axon[2,3], and set up in a bath containing an oxygenated Krebs's solution covered with mineral oil. The electric activity of the sense organ was led off between the Krebs's–oil interface, serving as fluid electrode, and a platinum electrode placed on the axon at some distance from the corpuscle. For recording of generator potentials, the interface was adjusted to lay at the site of the axon's emergence from the corpuscle. Graduable mechanical stimuli were provided by the deflexions of a piezo-electric crystal, applied to the corpuscle by a glass stylus[3]. The stylus's movements were followed photo-electrically, and were found to follow up to 1,000 pulses/s. with fidelity.

When two mechanical stimuli of threshold strength are successively delivered to the corpuscle at an interval longer than 10 msec. (relative refractory period), each stimulus causes the firing of a propagated potential. Upon progressive reduction of stimulus interval the threshold for setting up a propagated response rises[3–5]. At the same time, the propagated potential falls gradually to 75 per cent of its resting magnitude, and finally becomes abruptly blocked within the corpuscle. A non-propagated all-or-nothing potential, presumably corresponding to activity of the first intracorpuscular node of Ranvier, is then detected. This potential declines gradually as the interval is progressively shortened, and finally vanishes leaving a graded potential (generator potential) as the only response to mechanical stimuli. This potential increases as a function of stimulus strength, without changes in latency.

A generator potential leaves a refractory state behind, so that the amplitude of a second generator potential falling on its refractory trail is directly related to the time elapsed after the first. Unlike the propagated potential, the generator potential decreases gradually to zero as the stimulus interval is progressively shortened, revealing no sign of absolute refractoriness. Furthermore, the amplitude of a refractory generator potential is inversely related to the magnitude of the preceding generator response[1]. However, the size of the generator potential is independent of the refractory state left by a preceding propagated potential. For example, the amplitude of a generator potential in response to the second stimulus belonging to a pair of stimuli, remains the same whether preceded by a generator potential or a four times greater propagated potential. Had the latter been an equally large generator potential, the second generator potential would have become considerably reduced. This independence between generator and propagated events may be regarded as a further argument for spatial and functional differences in their origin[4,6].

For a given stimulus interval the minimal amplitude of generator potential at which firing of propagated potentials occurs (firing height) is fairly constant. The firing height increases progressively as the interval is shortened during the relative refractory period. The increase in firing height and the reduction in amplitude of the refractory generator potential determine the threshold rise during the corpuscle's relative refractory period.

The generator potential set up in response to a single mechanical stimulus decays to zero in 4–8 msec. The decay time is constant for a given receptor and is independent of duration of stimulus. However, the spontaneous decay of generator potential is not due to the receptor's incapacity for sustaining a generator potential, since with repetitive mechanical stimulation of the corpuscle at, for example, the rate of 900 stimuli per second a generator potential is built up which shows no decline over 100 msec. of observation. A mechanical component in adaptation[7] may account for the spontaneous decline in generator response.

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Variations in Axonal Diameters of Myelinated Nerve Fibres: Apparent or Real?

IN a paper read to the Anatomical Society of Great Britain and Ireland on November 29, Miss B. Higgs, of the Royal Free Hospital School of Medicine, put forward clear evidence that fixatives may affect the relative diameters of a nerve fibre in the nodal and internodal regions. Although readily accepting her findings, which provide at least a partial explanation for the differences in axonal diameters seen in fixed material, it is obvious that such a fixation artefact cannot explain the apparent diameter variations recorded as existing in living nerve fibres by de Renyi (1929).

It had occurred to me that the highly refractile myelin sheath might act as a lens and magnify the internodal portions of axon, making them seem abnormally wide in comparison with the uncovered axon in the nodal regions. To illustrate this point, on the same day I showed to the Society a lantern slide depicting a simple piece of apparatus which I had made. This consisted of a black rod (axon) partially enclosed in a water-filled glass tube (myelin sheath). The enclosed portion of rod presented a diameter some 30 per cent greater than the un-enclosed portions (Fig. 1). It may well be that a myelin sheath would indeed act in this way in living tissue, and it is possible that 'fixed' myelin may have an even higher refractive index and produce even greater magnification of the internodal portions of the axon.

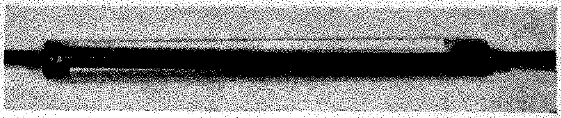

Fig. 1

Since nerves are extensile structures then they must possess the ability to recoil. This property may be invested, in part at least, in the myelin sheath; and, in teased preparations, the myelin sheaths, by virtue of this recoil mechanism, may cause actual shortening and broadening of the internodal axoplasm without exerting a similar effect on the nodal axoplasm.

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QUANTITATIVE histological methods are employed in the study of the myelinated fibre population of peripheral nerve and frequently a histogram is constructed to demonstrate the myelinated fibre diameter size frequency distribution. For this purpose fibres are grouped according to calibre, based upon measurements of diameter of the whole fibre, including the myelin sheath. Within any fibre group the relation of the axonal diameter to that of the total fibre is thought to be relatively constant. Thus, for fibres of 10–12μ, the proportion of axonal to external diameter is usually considered to be 0·7 : 1. This ratio was obtained by Donaldson and Hoke[1], and later workers[2,3], using stained transverse sections of fixed nerve, and by de Rényi[4] using intact, unfixed fibres. The results of both these techniques need correction, the former for distortion inherent in the fixation and subsequent processing, and the latter for optical effects.

When fresh teased preparations of peripheral nerve are examined microscopically, measurements of axon diameter are affected by the optical properties of the highly refractile myelin sheath and of the immersion medium. At the mid-internodal region the basic problem is that of an axon within a cylindrical convex lens of myelin surrounded by immersion fluid. The interfaces to be considered are: (i) myelin – immersion medium; and (ii) immersion medium – air.

Experiments were conducted using normal saline as the immersion fluid and lecithin as the lens matrix, the optical properties of lecithin being comparable to those of the myelin sheath[5]. Determinations of the individual refractive indices of these media gave the following values for the effective indices operative at the interfaces when considering an emergent beam: interface i, 0·89; interface ii, 0·75.

Sample measurements made on a preparation of mammalian nerve teased in normal saline: external diameter, 11μ; apparent axon diameter, 8μ. The receiving angle of the objective used, under the conditions of the experiment, was 45°. Theoretical consideration of the myelin lens system and the appropriate refractive indices, involving the construction of scale diagrams, showed that the virtual images produced by the axonal margin lie on a curve. If the most lateral point on this curve is considered, the magnification of the system is 20 per cent. Thus the corrected value for the axon diameter would theoretically be 6·7μ and the ratio of the axonal to the external diameter, 0·6 : 1. However, experiments in which nerve fibres were immersed in fluids of different refractive indices suggest that the refractive index of myelin considered in relation to a radial optic axis is rather higher than that of lecithin, and therefore the corrected ratio would be even lower.

This low ratio, at variance with that obtained for fibres of similar size in fixed preparations, receives confirmation from the work of one of us (P. L. W.). Measurements of axonal and external diameter have been made using thin transverse sections of fresh, unfixed peripheral nerve. In such preparations, using orthodox forms of illumination, fibres in the range 10–12μ show a ratio of axonal to external diameter of 0·45–0·60 : 1 (mean 0·51 : 1). However, preliminary observations using interference and polarizing techniques indicate that even this ratio may need further reduction. Details of the technique used and full results will be published elsewhere.

The problem thus far has been simplified; it is in fact much more complex. The ultra-structure of myelin, and thus its optical properties, vary[5]. In addition one must consider the possible effects of the immersion medium on the properties of myelin[5,6]. The thickness of the myelin sheath varies not only with fibre diameter[2,3,7] but also in different regions of the same fibre. Differences in thickness and curvature are most obvious in the paranodal region[8].

It is hoped to evolve a correction factor of more general application.

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Apparatus for Stimulation of Insect Sense-Organs by Air Puffs

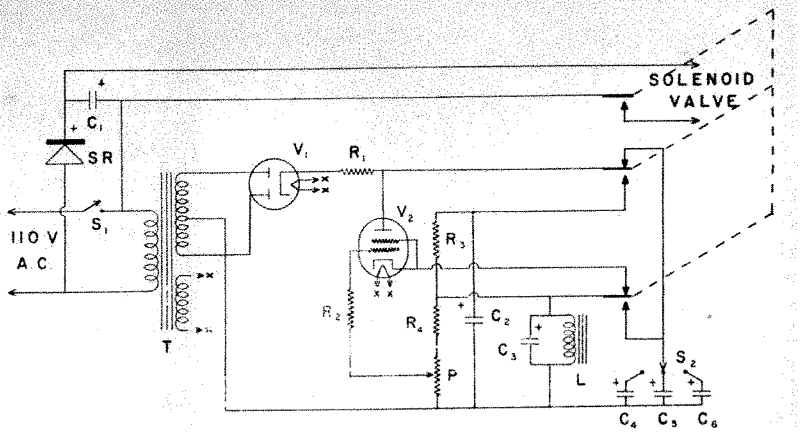

Fig. 1. Electronic time-switch for solenoid valve

C_1	80 mfd. electrolytic 150 w.v.	*SR*	Selenium rectifier 250 m.amp.	130 V.
C_2	20 mfd. electrolytic 250 w.v.	*XX*	6·3 V.	
C_3	2 mfd. electrolytic 250 w.v.	R_1	250 ohms	5 watts
C_4	10 mfd. electrolytic 250 w.v.	R_2,R_3	100 K.ohms	½ watt
C_5	20 mfd. electrolytic 250 w.v.	R_4	33 K.ohms	½ watt
C_6	40 mfd. electrolytic 250 w.v.	*P*	100 K.ohms	potentiometer
T	'Hammond 269*B*', 150–0–150 V.	V_1	6*X*5	
L	'Guardian' relay, 5,000 ohms, 4 PDT	V_2	2*D*21	

During work on the relation of acetylcholine to nervous activity in insects[1,2] an apparatus was devised for the stimulation of the sensillæ of the cerci of *Periplaneta americana* L. by puffs of air. Since the apparatus allows separate control of strength, duration and frequency of the puffs of air, it is felt that it might find applications in other problems. The apparatus consists of an electronic switch controlling a solenoid valve through which compressed air is led to the point of application. A pressure regulator in the air line determines the strength of the puffs of air, while the duration and frequency are determined by the electronic switch. The operation of the electronic switch (Fig. 1) is as follows. Firing of the thyratron V_2 causes a surge of current through the relay L, depressing the three contacts. This activates the solenoid valve, charges condenser C_2, cuts out V_2 and allows C_5 (or C_4 or C_6, according to the setting of S_2) to discharge through L. The relay armature remains in this position for a period determined by the LC_5 time-constant and then returns to its normal or upper position, closing the solenoid valve, recharging C_5 and reconnecting V_2. The voltage on C_2 now leaks off through R_3, R_4, P and L, producing a slowly decaying bias on V_2 (which may be altered by the setting on P) until V_2 again fires, repeating the cycle. Thus the setting on P determines the time during which the solenoid valve is closed, while the capacity of the condenser selected by S_2 determines how long it is open. The potentiometer P provides intervals from 0·45–8·0 sec., the calibrated scale being slightly expanded in the lower range, while with S_2 times of 0·13, 0·25 and 0·56 sec. were obtained. Other time-intervals are possible by altering the capacity of condensers C_2 to C_6.

Smoother and quieter operation of the Skinner electric solenoid valve (supplied by Minneapolis-Honeywell Regulator Co., Philadelphia 4, Pennsylvania) results from the use of direct current supplied by the selenium rectifier *SR*. Noise from valve operation, which in itself causes sensory stimulation, is eliminated by encasing the valve assembly in a rubber-mounted wooden box lined with two inches of fibre glass.

In a typical experiment puffs of air were led by a plastic tube to a glass tip mounted behind the roach cerci. Nerve activity was recorded with a 'Tektronix' Type 512 oscilloscope and a 'Fairchild' camera. The control unit for the camera was activated through a fourth contact on relay L, thereby synchronizing the camera operation with a puff of air.

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Silicate in the Metabolism of *Azotobacter vinelandii*

MOLYBDENUM complexed as silico-molybdate has been shown to be very active in the re-activation of aldehyde oxidase from which the molybdenum has been removed by dialysis[1]. Other reports have implicated silicate, phosphate and other anions as agents which increase the activity of molybdate-dependent enzymes[2,3]. Jacobs and Sanadi[4] suggested that a silico-molybdate complex was involved in a terminal electron transport system that was coupled with phosphorylation. It was shown by Glenn and Crane[5], however, that the *in vivo* functioning of aldehyde oxidase was probably not dependent on silico-molybdate even though it did greatly enhance the activity of the *in vitro* system.

It has already been shown that *A. vinelandii* is capable of incorporating into molybdo-protein as much as 100 times more molybdate than is required for optimum rate of growth[6].

We were led to consider the possible relationship of silicate and molybdate in the metabolism of *Azotobacter* by the observation that 100 p.p.m. germanium (as germanate) inhibits the growth of *Azotobacter* by 30–50 per cent. Because germanium is in the same chemical group as silicon it seemed possible that germanium was acting as an inhibitor of a silicate function much as tungstate inhibits molybdate function[6].

We therefore measured the uptake of silicate directly by the use of silicon-31 prepared from reagent grade silica gel (Mallinckrodt) by neutron bombardment. (Reactor facilities were provided by the Battelle Memorial Institute.) The irradiated silicon-31 was fused with sodium carbonate in a platinum crucible according to standard methods[7,8]. Half-life determinations showed the material to be about 99·9 per cent radiochemically pure.

Under culture conditions (in Burk's[9] nitrogen-free medium) such that *A. vinelandii* cells would take up nearly all the 1 p.p.m. molybdenum added to the culture, only 0·2 p.p.m. silicon-31 was taken up and only one-fourth of this was retained when the whole cells were washed thoroughly. When the molybdate-level of the medium was decreased so that the quantity of molybdate taken up decreased by a factor of 100, there was no change in the uptake of silicon-31. Furthermore, germanium at a level of 100 p.p.m. had no influence on the uptake of silicon-31, or molybdenum-99. Silicate concentrations also had no effect on the uptake of molybdenum-99.

The distribution of the silicon-31 retained by the cells in centrifugal fractions of these cells after sonic disruption was examined. In contrast to the published[10] distribution of molybdenum, in which both the highest total (more than 65 per cent) and highest specific activity of molybdenum-99 are found in a fraction sedimentable at 144,000*g*, only 5 per cent of the retained silicon-31 was found in the corresponding sedimentable fraction. The supernatant fraction contained 85 per cent of the total silicon-31, and the specific activity was 3½ times greater in the supernatant fraction than in any other.

As a result of the lack of correlation between the behaviour of silicon-31 and molybdenum-99 in these uptake and distribution studies in *Azotobacter vinelandii*, it is concluded that silicate is not involved in the molybdate metabolism of these cells as a silico-molybdate complex anion. Further, even though germanate does inhibit the growth of *Azotobacter*, it has no effect on the uptake of silicate.

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Absorption and Distribution in Rats of Radioactive Phosphorus biologically incorporated in Food

IN this investigation absorption and distribution of phosphorus-32, biologically incorporated into fish muscle and bean leaves, was compared with its absorption after feeding as inorganic phosphate. Within limits of error, no differences were detected.

The experimental animals were 179 young adult female Sprague–Dawley rats (wt.-range 190–304 gm.: mean wt. 238 gm.) maintained *ad lib.* upon a Purina Lab Chow diet. The following solutions and suspensions containing radioactive phosphorus were administered orally to these animals:

(1) *Inorganic phosphorus*: 100 rats received 1 ml. of a *p*H 2 solution containing 25 μc. phosphorus-32 ($Na_2H^{32}PO_4$) and less than 0·6 μgm. of non-radioactive sodium hydrogen phosphate.

(2) *Fish protein phosphorus*: 51 rats received 2 ml. of a water/whitefish muscle homogenate (1/1, w/w) which had a concentration of a 0·5 μc. phosphorus-32 per ml. The muscles were derived from a fish which 72 hr. previously had received an intraperitoneal injection of 10 mc. of inorganic phosphorus-32.

(3) *Plant leaf phosphorus*: 28 rats received 1 ml. of a water/bean leaf homogenate (1/1, w/w), which contained 3·3 μc. phosphorus-32 per ml. It was prepared from leaves of young red kidney bean plants grown in an appropriate nutrient culture medium containing radioactive phosphorus-32.

Excreta were collected individually from each of eight animals of the inorganic phosphorus-32 group over a period of 40 days following the feeding. In the other two experimental groups, excreta were collected from each of eight animals up to 20 days following feeding.

The experimental animals were killed in groups of four at time-intervals ranging from 3 hr. to 40 days following radioisotope administration. The concentrations of phosphorus-32 in aliquots of blood, femur, liver, and excreta were determined. In order to measure the overall distribution of phosphorus-32 and total inert phosphorus[2] in the entire skeleton and teeth, a $Na_2H^{32}PO_4$ solution was orally administered to 17 additional young female rats. Three of these

Table 1. DISTRIBUTION OF PHOSPHORUS-32 FOLLOWING ORAL ADMINISTRATION

Tissue / Day	Administered dose/tissue (per cent)			
	Blood*	Liver	Fæces†	Urine
1	0·7	3·6	28·2	6·9
5	0·3	1·7	36·0	12·8
10	0·2	0·9	39·8	15·6
20	0·1	0·4	43·6	18·7
40	0·1	0·1	46·9	21·7

* Total blood percentages are calculated on the basis of total rat blood volume of 5 per cent body-weight.

† Excreta are cumulative totals through experimental day indicated.

animals were killed at 6 days, and fourteen were killed 12 days after the feeding. These time differences did not appear to influence the phosphorus-32 concentrations of bones and teeth.

Although statistical analysis of the radioactivity values, corrected for decay and self-absorption, showed significant differences between groups of rats fed radioactivity from the same food source, none could be assigned to the effects of the radioactive food source itself. Real differences among results obtained from animals receiving the same treatment may have masked inter-treatment differences for the intra-treatment variations appeared to be related to the time when the experiments were performed. The lack of any effects ascribable to differences in the food forms in which phosphorus-32 was fed strongly suggests that phosphorus derived from animal or plant sources is absorbed and utilized very similarly to phosphate ion. For this reason results from each feeding group were combined and are summarized in Table 1. After the first ten days of the experimental period the rate of excretion of phosphorus-32 in fæces was equal to that in urine. Assuming that this equality was closely related to excretion of *absorbed* phosphorus-32 the earlier excess of phosphorus-32 in fæces, as compared to urine, was taken as the *unabsorbed* fraction of the fed dose. On this basis about 75 per cent of the administered phosphorus-32 was absorbed—a confirmation of results of other investigations[3]. Table 1 shows that by the tenth day more than 95 per cent of the unabsorbed phosphorus-32 had appeared in the fæces, while a combined total of more than 50 per cent of the total fed was excreted in urine and fæces together.

No statistically significant changes with time in deposition and retention of phosphorus-32 by bones and teeth were found, and mean values are summarized in Table 2. The total skeletal concentration of phosphorus-32 was 13·5 per cent of the administered dose, a value from 40 per cent to 70 per cent less than those reported previously[3–5]. Comparison of the total skeletal phosphorus-32 to the phosphorus-32 content of the relatively accessible femur yields a factor of 24·6 ± 1·2. The mean concentration of phosphorus-32 in bone was more than twice that of the molar teeth, but less than a third that of the incisors. The average of 10·8 per cent stable phosphorus-31 in bone is considerably higher than the 8 per cent reported for rat bone in a previous study[6], but is close to a 10·4 per cent reported for human bone[7]. The non-radioactive phosphorus content of the teeth types was higher than the bone value, but accords with the 13 per cent reported previously for rat incisor[8], and is also within the range of values reported for human enamel and dentin[7]. These differences between bone and tooth concentrations of phosphorus-32 and phosphorus-31, reflected in their phosphorus-32/phosphorus-31 ratios, may be accounted for by differences in growth-rates of these tissues[9].

Table 2. DISTRIBUTION OF PHOSPHORUS IN BONE AND TEETH

Tissue / Isotope	Bone*	Molars	Incisors
Phosphorus-32 (per cent dose/gm.)	0·9 ± 0·05†	0·4 ± 0·1	3·4 ± 1·0
Phosphorus-31 (gm./100 gm.)	10·8 ± 0·6	13·3 ± 0·9	13·5 ± 1·2
Phosphorus-32/phosphorus-31 (per cent dose/gm.)	8·3 ± 0·04	3·0 ± 0·6	25·2 ± 6·7

* Total phosphorus-32 of skeleton amounted to 13·5 per cent of administered dose. Femur contained a total of 0·55 ± 0·04 per cent of dose.

† Values are means ± standard deviation.

We gratefully acknowledge our debt to J. H. Rediske and R. C. Pendleton for supplying the phosphorus-32 labelled bean leaves and whitefish muscle; to Joan Hess, Alma Crosby, and members of the Biology Control Operation for skilled technical assistance; and to H. T. Norton and D. W. Gaylor for statistical analysis of the experimental results.

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Hydrogen Peroxide and Tumour Therapy

TEN rats were implanted with Walker tumour and on the same day and succeeding days of the experiment the drinking water was replaced by 0·45 per cent hydrogen peroxide as described by Holman[1]. They all died at the same time (13–14 days) with tumours of the same weight (25–34 gm.) as in the ten control rats. Another transplantable tumour, the Sheffield *Rd*/3 sarcoma, was also used in an exactly similar experiment except that there were 6 rats per group. In the peroxide group all died at 16–21 days (tumour-weight 38–46 gm.) and in the control group receiving tap water there was one natural regression and the remaining 5 died at 16–21 days (tumour-weight 32–39 gm.). We have had a long experience with the actions of possible chemotherapeutic agents on these tumours, and they are responsive to some of them. We can assert confidently that in the environment of the University of Sheffield Field Laboratories this particular treatment is completely ineffective.

Much earlier experiments, made for other reasons, in which spontaneous and transplanted tumours were injected intratumorally with various concentrations of commercial hydrogen peroxide at intervals from an early stage of growth, were all essentially negative.

Holman makes no reference to the behaviour of his tumour when implanted into control untreated rats. From our own experience we know that even normally highly transplantable tumours occasionally pass through phases when the incidence of natural tumour regression is substantial. In view of this we feel that the 'cures' obtained by Holman may have been, in fact, natural tumour regressions.

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Development of Eggs before the Final Moult in *Pratylenchus*

Among nematodes separated from soil about the roots of Grenache vines in February 1957 were females of *Pratylenchus* which carried eggs at their tails, outside the body but within a partly cast cuticle. Six specimens were recovered from a few pounds of soil. The life-cycle of a typical *Pratylenchus*[1] includes four moults from egg to adult, the first moult occurring in the egg, where the second-stage larva may be distinguished by the appearance of a well-defined buccal spear. In each of these specimens the egg contained a clearly differentiated second-stage larva. The cuticle of the nematode was detached at the head region and at the rear of the body from a point anterior to the vulva. Many normal specimens of *Pratylenchus* were also present, and one apparently larval female carried an egg with a second-stage larva in the oviduct.

Three of the specimens with eggs at the tail were kept in a dish of water. Two died within a few days, but the third emerged about half-way from the old cuticle before death.

Ten similar specimens were recovered from samples taken at the same site about a month later. One of these carried two fully differentiated eggs within the old cuticle. Two specimens showed no differentiation in the eggs—just a number of cells. All showed displacement of the cephalic cap, which indicated commencement of moulting. One specimen which started to emerge from the old cuticle was transferred to a slide, and under the slight pressure of the cover-glass the nematode completed the moult in a few minutes, surviving for about a week on the slide. The egg with cast cuticle was retained for more than a fortnight in water, but did not hatch.

It appears that females of this species may, in certain circumstances, produce eggs before the final moult takes place. Eggs thus produced cannot be laid in the normal way as there is no adequate aperture at the vulva for them to pass the larval cuticle. The eggs are retained in the body, and may undergo considerable development, until the final moult commences. When the cuticle begins to separate from the body, the egg can pass the vulva, and finds its way to the tail within the cuticular sac. Completion of moulting releases the egg. Although the one egg obtained free from these specimens did not hatch, these eggs may normally be viable. However, the fact that so many of the eggs observed were at an advanced stage of development suggests perhaps that hatching has been inhibited.

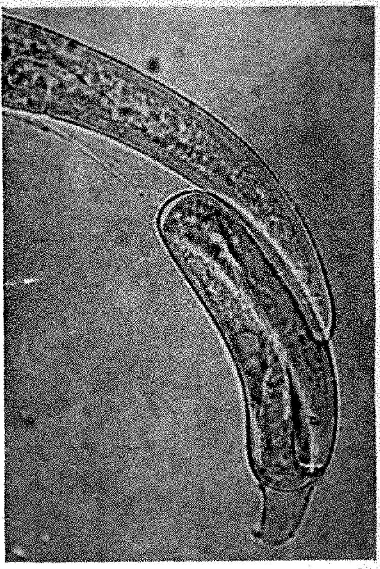

Fig. 1. Tail of *Pratylenchus minyus* showing egg retained by partly cast cuticle

Little is known of the mechanisms which control development in plant parasitic nematodes. It cannot be judged whether development of the reproductive system has been accelerated, or whether moulting has been retarded in these specimens, but the two processes are obviously not interdependent. No treatment other than normal vineyard practice has been applied to the area from which these nematodes were taken.

The species concerned is morphologically similar to *Pratylenchus minyus* Sher and Allen[2], but no males have been found.

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Light Reactions of Littoral Gastropods

Molluscan behaviour has attracted the attention of many workers, and the literature contains several references to the homing ability and direction finding in various gastropods[1]. Light is acknowledged as an important factor in such mechanisms in numerous invertebrates, and recently the plane of polarization of light has been shown to be an operative factor in the orientation of *Eupagurus bernhardus*[2], the xiphosuran *Limulus*[3], some hymenopterous and lepidopterous larvæ[4], and various insects[5].

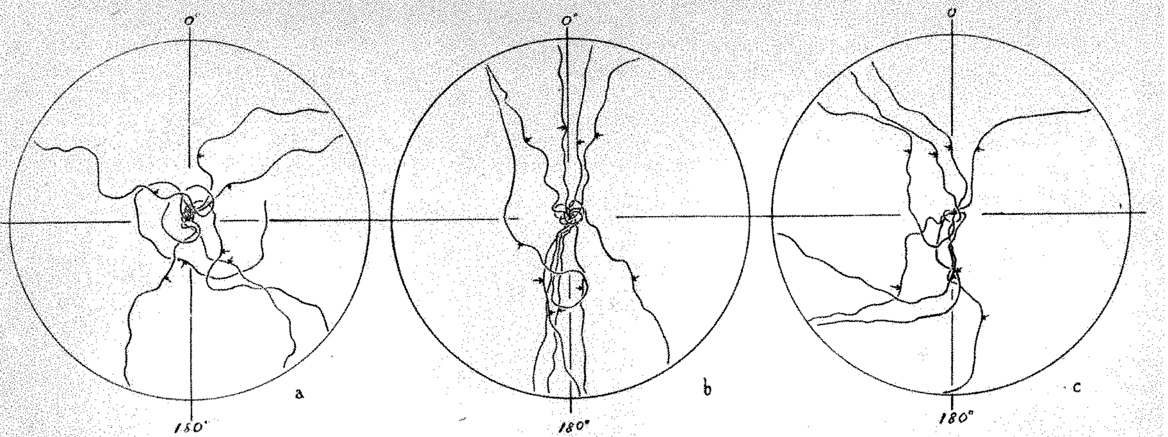

Fig. 1. Tracks under sea water: (*a*) non-polarized light, ← rotation of 'Polaroid' holder; (*b*) polarized light, 'Polaroid' momentarily turned through 90° and back again, ← rotation of 'Polaroid'; (*c*) polarized light, 'Polaroid' turned through 90° and left there, ← rotation of 'Polaroid'

During an investigation of the behaviour of several species of *Littorina* to various stimuli, it was found that *Littorina littoralis* (L.) (=*obtusata*) gave a very strong light compass reaction. This species was then tested with plane polarized light as follows. A disk of 'Polaroid' some 4 in. in diameter was mounted in front of a 500-W. source of light fitted with a heat filter. The whole apparatus was aligned with the optical axis vertical to the plane upon which individual specimens of *Littorina* were allowed to crawl. The plane of polarization was freely adjustable by rotation of the 'Polaroid' disk. Experiments were carried out on more than 150 specimens moving in air and under water. The track of each specimen was plotted as it moved, so that all its movements from the instant of illumination were recorded.

Three experimental conditions were applied: (*a*) The plane of polarization of the light was maintained along the reference axis. After the animal had traversed a standard distance from the starting point, the plane of polarization was momentarily rotated through 90° and returned to its original direction; (*b*) the plane of polarization was rotated through 90° from the reference axis after the animal had traversed the standard distance, and left in its new position; (*c*) the same as for (*a*) and (*b*) but with non-polarized light.

Fig. 1, *a–c*, shows a random selection of tracks obtained under water by the above treatments. A comparable series was obtained in air.

The results are summarized in Tables 1 and 2. All the angles indicated are angles of deviation of the tracks from the reference axis. These results were shown to be highly significant by the χ^2 test and prove that *L. littoralis* orientates itself along the plane of polarization of light falling on it from above.

Further experiments are planned to investigate how the eye detects the plane of polarization of light

Table 1. *Littorina littoralis* (L.) IMMERSED IN SEA WATER

Angles given are deviations from the original plane of vibration of light (reference axis)

Treatment	0– 30° 150–180° 180–210° 330–360°	30– 60° 120–150° 210–240° 300–330°	60– 90° 90–120° 240–270° 270–300°	No. circling	Total No. tested
Group *A*. Plane of vibration constant along 0–180° reference axis					
First half of track before rotation through 90°	37	6	1	6	50
Second half of track after rotation through 90°	40	3	1	6	50
Group *B*. Plane of vibration rotated through 90°					
First half of track before rotation through 90°	35	9	—	6	50
Second half of track after rotation through 90°	7	18	19	6	50
Group *C*. In non-polarized light	10	17	10	13	50

Table 2. *Littorina littoralis* (L.) IN AIR

Angles given are deviations from the original plane of vibration of the light (reference axis)

Treatment	0– 30° 150–180° 180–210° 330–360°	30– 60° 120–150° 210–240° 300–330°	60– 90° 90–120° 240–270° 270–300°	No. circling	Total No. tested
Group *A*. Plane of vibration constant along 0–180° reference axis	81	7	2	—	90
Group *B*. Plane of vibration rotated through 90°					
First half of track before rotation through 90°	83	6	1	—	90
Second half of track after rotation through 90°	13	26	51	—	90
Group *C*. In non-polarized light	24	30	25	11	90

and the relationship of this reaction with the other light reactions that this species exhibits.

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Neuro-Anatomical Site in Tick Paralysis

Previous studies[1] have shown that tick paralysis, induced in mongrel dogs by applying the wood tick *Dermacentor andersoni* Stiles, is due to failure in transmission at the neuro-muscular junction because: (*a*) the anterior tibial muscle in a paralysed dog responded to direct but not to indirect stimulation through the peroneal nerve; (*b*) the motor nerve fibres conducted an impulse.

More recent investigations have demonstrated the following: The muscle contracts on rapid close intra-arterial injections of acetylcholine; neostigmine does not facilitate transmission in a fully paralysed muscle and causes only a slight improvement in a partially paralysed one; neither cathodal nor anodal current facilitate transmission in a fully paralysed muscle; the paralysis is intensified by curare, but is uninfluenced by pentamethonium; tetanization via the nerve slightly facilitates transmission of subsequent individual pulses in both the partially and completely paralysed muscle and in the former the tetanus is well maintained. These results indicate that the neuro-muscular block is dissimilar to that produced by the competitive and depolarizing blocking agents and anticholinesterases.

Functional activity of the end-plates is indicated by (*a*) contraction of the muscle on close intra-arterial injection of acetylcholine, (*b*) their depolarization by succinylcholine.

Table 1 shows the response of the normal, partially and completely paralysed anterior tibial muscle to close intra-arterial injections of acetylcholine. Increasing paralysis apparently produces an increasing sensitivity of the muscle to acetylcholine, the paralysed muscle behaving like a denervated one.

End-plates could be located in the paralysed anterior tibial muscle by sweeping its undersurface with a wick electrode after an injection of succinylcholine, the technique being similar to that described by Burns and Paton[2]. Usually four or more end-plate regions could be located in this way. The depolarizing effect of the succinylcholine was then permitted to wear off. In an apparently paralysed muscle, usually one or more muscle fibres contracted on nerve stimulation and the site of minimum latency of the action potential corresponded to only one of the located end-plate regions. Neither action nor end-plate potentials could be detected at the other located end-plate regions. The findings suggest that the probable mechanism for the paralysis is due to failure in the liberation or synthesis of acetylcholine at the nerve terminals.

Table 1. Sensitivity of Anterior Tibial Muscle to Rapid Close Intra-arterial Injection of Acetylcholine

Anterior tibial muscle	No. of experiments	Approximate average dose (μgm.) of acetylcholine to produce	
		Threshold contraction	Contraction = maximal muscle twitch
Normal	4	5	50
Partially paralysed	3	1	·15
Fully paralysed	1	?	1

In an attempt to localize exactly the site of the neuro-muscular block, the anterior tibial muscle was stimulated directly in a completely paralysed animal before and after the administration of curare. No difference could be detected in the magnitude of the mechanical responses indicating that the block is probably located at the nerve terminals in contradistinction to that in botulism poisoning, where the block is evidently proximal to the terminals[3].

The only effective method, known to date, of producing tick paralysis is by applying the wild ticks. When a saline extract (1 gm./ml.) of 128 engorged female ticks removed from paralysed dogs was injected intra-arterially (3 ml. × 1 ml.) and intravenously (1, 10 and 10 ml.) into a normal anæsthetized dog, it produced no detectable effect on the mechanical response of the anterior tibial muscle during indirect stimulation. Evidently continuous secretion of a 'toxin' by the ticks is necessary to produce paralysis because rapid recovery occurs on removal of the ticks.

As the tick 'toxin' appears to interfere with the liberation of acetylcholine at the neuro-muscular junction, one might expect that it would also interfere with acetylcholine liberation at other sites, for example, ganglionic and neuro-effector cholinergic junctions. Stimulation of the central end of the cervical sympathetic, proximal to the superior cervical ganglion, resulted in a normal dilation of the pupil and retraction of the nictitating membrane in a paralysed dog and stimulation of the peripheral end of the vagus in the neck caused normal cardiac slowing. In addition, if acetylcholine liberation in sympathetic ganglia was diminished in a paralysed animal one might expect to find a low blood pressure. The blood pressure in five paralysed dogs were within normal limits (130, 150, 100, 170 and 190 mm. mercury). Evidently the tick 'toxin' exhibits a specific predilection for the neuro-muscular junction.

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Anthocyanins in Blackcurrant Fruits

Robinson and Robinson[1] investigated the anthocyanin pigments of the fruit of the blackcurrant (*Ribes nigrum*) and stated that the skins contained a cyanidin-3-bioside. Cyanidin was the only aglycone found; but it was thought possible that small amounts of delphinidin were present. Fouassin[2] has recently examined blackcurrant pigments by paper

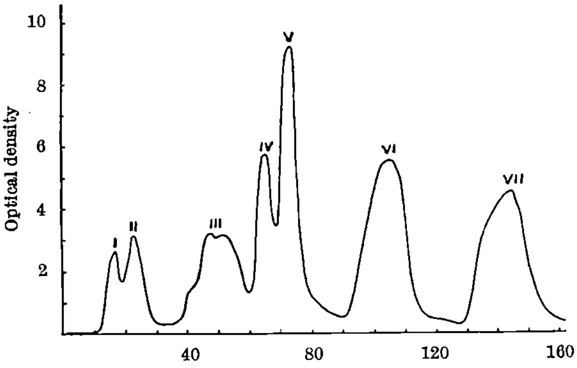

Fig. 1. Optical density at 545 mμ of blackcurrant anthocyanins eluted from a cellulose column

chromatography and has found two glycosides of cyanidin and two glycosides of delphinidin.

In the present investigations, extracts of blackcurrants in methanol containing 1 per cent hydrochloric acid have been shown to contain seven pigments, separable by cellulose column chromatography, using the organic phase of butanol/2*N* hydrochloric acid (1 : 1) as solvent. Whatman standard-grade cellulose powder, sieved to obtain the fraction larger than 200-mesh and smaller than 100-mesh, was packed in the solvent to give a column 50 × 4·4 cm., using a stainless-steel tamper to ensure even packing. The crude anthocyanin, approximately 0·7 gm., precipitated by ether from the methanolic extract, was dissolved in 40 ml. of the solvent, and this concentrated solution fed to the top of the column. The eluate was collected automatically in 10 ml. fractions. The graph of optical density at 545 mμ plotted against the tube number (Fig. 1) shows the presence of seven distinct bands.

To concentrate the slower-running bands (Fig. 1, IV, V, VI and VII), each eluate was mixed with an equal volume of acetone and adsorbed on to another cellulose column. The original solvent was washed off with acetone and the anthocyanins eluted with 0·1 per cent methanolic hydrochloric acid which was then readily removed under vacuum. The faster-running bands (Fig. 1, I, II and III) were not held tenaciously enough by the column to permit this procedure. Therefore, basic lead acetate was added to each eluate to form the lead complex which was then decomposed with methanolic hydrochloric acid and the solution filtered and evaporated to dryness. The residues were dissolved in 1 per cent hydrochloric acid and concentrated hydrochloric acid was added to make the final concentration 20 per cent. The solutions were stored in the refrigerator, and after several days the precipitated pigments were recovered.

Band I appeared on the column as a brownish front to band II, and it is considered to be a degradation product. The other bands fell into two groups of three on the basis of visual colour, bands II, IV and V being scarlet and bands III, VI and VII crimson. By comparison with known samples on paper chromatograms it was found that the material from band II was cyanidin, and the anthocyanins from bands IV and V yielded cyanidin on hydrolysis. Similarly, band III was found to be due to delphinidin and bands VI and VII to delphinidin glycosides.

After hydrolysis of the mixed anthocyanins from blackcurrants, glucose was the only sugar detected by paper chromatography. The anthocyanin from band V was shown to be chromatographically identical with chrysanthemin (cyanidin-3-glucoside) isolated from the petals of mauve chrysanthemums[3] and purified by passage through the cellulose column. The other cyanidin glucoside from band IV, after partial hydrolysis by boiling in 5 per cent hydrochloric acid for 30 min., was converted to a pigment chromatographically identical with chrysanthemin. Since a test[1] for acyl groups was negative it appears that the anthocyanin from band IV is a cyanidin diglucoside, possibly a 3-bioside as proposed by Robinson and Robinson[1] or the 3,5-diglucoside although its R_F values (Table 1) do not agree with those given by Bate-Smith[4].

Table 1. R_F VALUES OF BLACKCURRANT PIGMENTS

Band	Solvent system			
	Butanol/acetic acid/water (ref. 4)	Butanol/2 *N* hydrogen chloride (ref. 4)	*m*-Cresol/acetic acid/water (ref. 4)	Forrestal solvent (ref. 5)
II	Fades	0·74	Fades	0·47
III	Fades	0·44	Fades	0·30
IV	0·38	0·31	0·38	0·75
V	0·40	0·28	0·47	0·71
VI	0·25	0·19	0·14	0·67
VII	0·18	0·14	0·17	0·62

Partial hydrolysis of the delphinidin glucoside from band VI converted it into an anthocyanin identical with that from band VII. The R_F values (Table 1) of these two anthocyanins do not correspond with published values[4], but it is probable that they are a mono- and di-glucoside respectively of delphinidin. It is hoped to confirm the structure of these glucosides and the cyanidin diglucoside by synthesis.

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Selective Uptake of Radiochemical Impurities by Mitochondria

WHEN using potassium-42 to trace the exchange of potassium in a suspension of non-metabolizing mitochondria from rat liver, specimens were obtained in which the specific activity of mitochondrial potassium appeared greater than the specific activity of the separated labelling medium. The radioactive material used was spectroscopically pure $^{42}K_2CO_3$, which had been irradiated for one week at the Atomic

Table 1

	Potassium (μequiv./ml.)	Radioactivity (counts/min./ml.)	Apparent specific activity (counts/min./μequiv.)
Suspending medium	136·5	$1·77 \times 10^7$	$1·30 \times 10^5$
Washed mitochondria	0·098	$1·92 \times 10^4$	$1·96 \times 10^5$

Mitochondria were prepared by differential centrifugation in 0·25 *M* sucrose + 0·025 *M tris* buffer at *p*H 7·0. After suspension in 0·15 *M* KCl + ^{42}K for 60 min. at 0° C., mitochondria were washed three times with sucrose-*tris*.

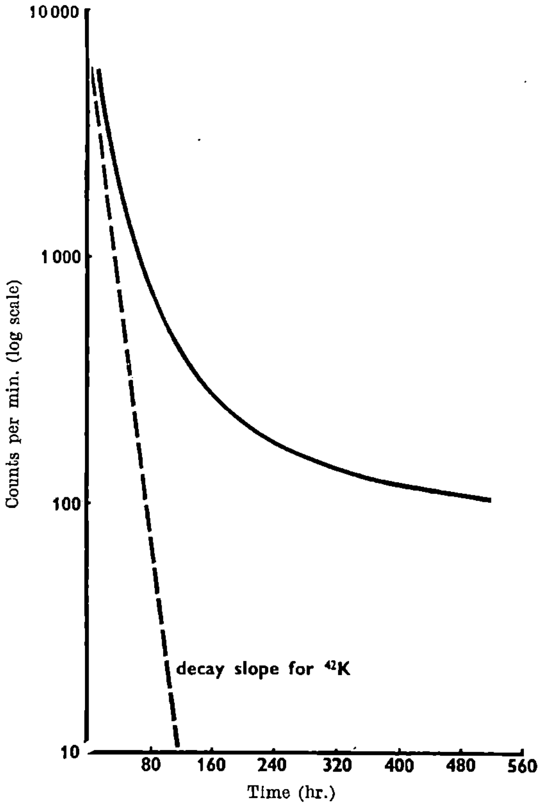

Fig. 1. The unbroken line represents the radioactive decay of the contaminants 'bound' to the mitochondria

Energy Research Establishment, Harwell. When measured on a *M*6 ('20th Century Electronics') Geiger–Müller counter, the apparent specific activity (counts/min./μequiv. potassium) of potassium on the labelled mitochondria was 1·5 times as great as that of potassium in the labelling solution (Table 1). On further investigation it was found that the decay of activity on the mitochondria corresponded to a half-life greater than 12·4 hr. (see Fig. 1).

The $^{42}K_2CO_3$ was found to contain several isotopes of half-life greater than 12·4 hr. The major contaminant has a half-life of approximately 30 hr. and occurs to the extent of 1 part in $2 \cdot 6 \times 10^4$ as measured by the *M*6-counter at the time of removal of the $^{42}K_2CO_3$ from the pile. Several other radioactive isotopes, of half-life between 10 and 25 days, were detected, and these amounted to 1 part in $6 \cdot 4 \times 10^5$. Slater[1] has shown that isolated muscle mitochondria have a high affinity for calcium: and the selective adsorption of the long-life isotopes by the liver mitochondria (Table 2) suggested that the contaminants were multivalent cations. This was confirmed by their behaviour on a column of cation exchange resin.

Table 2. RATIO OF POTASSIUM-42 TO RADIOACTIVE CONTAMINANTS

Suspending medium	10,000 : 1
Washed mitochondria	1 : 1

The available evidence strongly suggests that the contaminant of 30-hr. half-life is barium-135 and this should be removed from a solution of ^{42}KCl by adding barium chloride and a stoichiometric amount of sulphuric acid. This technique fails to remove other contaminants, and has the additional disadvantage of introducing trace amounts of Ba^{2+} (0·02 mequiv./l.) and SO_4^{2-} into the solution. A more satisfactory separation was achieved by eluting the potassium-42 from a cation exchange resin *IR* 120 (*K*) with 0·15 *M* potassium chloride.

A column (10 cm. × 1 cm.) of *IR* 120 (*H*) was treated with 20 ml. of 30 per cent potassium chloride (KCl) to convert it to the *K*-form. After washing with 200 ml. of distilled water, 60 ml. of 0·15 *M* ^{42}KCl was put down the column at 0·8 ml./min. The column was rewashed with 30 ml. of distilled water to remove anionic isotopes present and then treated with 300 ml. of 0·15 *M* potassium chloride solution. This brings off virtually all the potassium-42, and the most active fraction has about 70 per cent of the specific activity of the original material; 90 per cent of the original activity was recovered in 120 ml. of the eluate. Mitochondria labelled with this material showed no measurable deviation over a period of 40 hr. from the decay expected of potassium-42.

It is possible that biological material other than mitochondria may selectively accumulate substances present as impurities. The effect may be quite striking; in labelled mitochondria the ratio of contaminant to potassium-42 was ten thousand times greater than in the suspending medium. It is therefore desirable that radiochemical purity should be checked by observation of the labelled biological material itself and not merely of the original stock of radioisotope. This investigation was supported by the Endowment Fund of the Manchester Royal Infirmary and by the Rockefeller Foundation.

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Some Effects of Carbon Dioxide-Bicarbonate Mixtures on the Oxidation and Reduction of Cytochrome c by *Ricinus* Mitochondria

THE observation that the succinic oxidase system of *Ricinus* mitochondria is inhibited by concentrations of carbon dioxide above about 20 per cent[1] has led us to investigate the effects of carbon dioxide on components of the respiratory chain.

Mitochondrial preparations from the endosperms of germinating castor oil beans[2] were diluted 8–10 times with ice-cold demineralized water and incubated at 0° for 30 min. to render the mitochondrial oxidase and reductase systems accessible to cytochrome *c*. In the resulting preparations the activities of succinic cytochrome *c* reductase, reduced diphosphopyridine nucleotide cytochrome *c* reductase and cytochrome *c* oxidase were determined by spectrophotometric measurement at 550 mμ of the oxidation and reduction of cytochrome *c*. The concentrations of carbon dioxide in the reaction mixtures were regulated[3] by the addition of the calculated amounts of a 0·32 *M* solution of sodium bicarbonate which had been equilibrated against a gas mixture containing 90 per cent carbon dioxide and 10 per cent oxygen at 25°, at which temperature all measurements were made. The *p*H of the carbon dioxide–bicarbonate mixture was 7·4. We shall refer the reaction rates simply to the carbon dioxide concentrations. This is convenient, since the results to be recorded may help to explain certain metabolic disturbances and growth responses of plant organs placed in atmospheres enriched with carbon dioxide. However, some of the effects may be due to the equilibrium concentration of bicarbonate ion.

For the measurement of succinic cytochrome *c* reductase activity, spectrophotometer cells contained 0·1 ml. of enzyme, 0·1 ml. of 2-amino-2-hydroxymethylpropane-1 : 3-diol (*tris*) buffer (20 per cent w/v, *p*H 7·4), 0·1 ml. of cytochrome *c* ($9{\cdot}4 \times 10^{-4}$ *M* in 1 per cent *tris* buffer, *p*H 7·4), 0·1 ml. of cyanide (2×10^{-3} *M*, *p*H 7·4), 0·05 ml. of succinate (1·2 *M*, *p*H 7·4), and the required amount of 90 per cent carbon dioxide–bicarbonate mixture in a total volume of 3 ml. The reaction was started by the addition of succinate. For the measurement of reduced diphosphopyridine nucleotide cytochrome *c* reductase, succinate was replaced by 0·05 ml. of reduced diphosphopyridine nucleotide ($8{\cdot}4 \times 10^{-3}$ *M*). For measurement of cytochrome *c* oxidase activity the reaction mixture was composed of 0·1 ml. of enzyme, 0·1 ml. of *tris* buffer, the required volume of 90 per cent carbon dioxide–bicarbonate mixture, and 0·2 ml. of reduced cytochrome *c* ($4{\cdot}7 \times 10^{-4}$ *M* in 1 per cent *tris* buffer) in a total volume of 3 ml. The reaction was started by the addition of reduced cytochrome *c*. Readings were taken at 15-sec. intervals for 2 min. It was not considered necessary to equilibrate the final reaction mixture with an atmosphere containing the appropriate concentration of carbon dioxide as it had been previously ascertained that for the short period of the experimental measurement the error resulting from the diffusion of carbon dioxide was negligible.

In Table 1 the rates of each of the three reactions studied at different concentrations of carbon dioxide are given as percentages of the rates in air. The control rates in air were 10·4 μmoles cytochrome *c* reduced/hr./gm. of fresh tissue for succinic cytochrome *c* reductase; 15·8 μmoles cytochrome *c* reduced/hr./gm. of fresh tissue for reduced diphosphophyridine nucleotide cytochrome *c* reductase; and for cytochrome *c* oxidase, *k* the first-order velocity constant, was 7·54/hr./gm. of fresh tissue. Cytochrome oxidase was stimulated at the lower concentrations of carbon dioxide, with a maximum rate at about 20 per cent carbon dioxide, and was inhibited at the higher concentrations. Using different experimental conditions, Miller and Evans[4] have examined the effects of bicarbonate on cytochrome oxidase of root mitochondria. They obtained similar results, although the stimulation at low concentrations was less marked. They found larger increases in rate with sodium chloride, nitrate or sulphate, which suggests that the stimulation at low bicarbonate (or carbon dioxide) concentrations is a non-specific salt effect.

Table 1. ACTIVITIES IN THE PRESENCE OF CARBON DIOXIDE RELATIVE TO THOSE IN AIR

Carbon dioxide concentration (per cent of 1 atmosphere)	Succinic cytochrome *c* reductase	Reduced diphosphopyridine nucleotide cytochrome *c* reductase	Cytochrome *c* oxidase
0·05 (air)	100	100	100
1·7	—	101	109
4·3	102	110	118
8·7	75	102	135
13·0	—	—	193
17·3	38	108	265
26·0	22	88	248
43·3	14	75	124
60·7	3	44	56
78·0	—	33	25

Low concentrations of carbon dioxide had little effect on reduced diphosphopyridine nucleotide cytochrome *c* reductase, but there was inhibition at higher concentrations. This inhibition was found to be non-competitive with respect to reduced diphosphopyridine nucleotide.

In contrast, the reduction of cytochrome *c* by the succinic system was strongly inhibited by concentrations of carbon dioxide as low as 17 per cent. This inhibition was found to be competitive with respect to succinate, which with spectroscopic and other evidence indicates that the inhibition is of succinic dehydrogenase.

The inhibitions of all three systems were reversible.

The strong inhibition of succinic dehydrogenase can account for the accumulation of succinate in preparations of *Ricinus* mitochondria fed with Krebs-cycle acids in the presence of about 20 per cent carbon dioxide[1]. It can also account for the accumulation of succinic acid in plant organs which are stored in atmospheres containing about 20 per cent carbon dioxide[5,6].

In addition to the increased inhibition of succinic dehydrogenase, the inhibitions of reduced diphosphopyridine nucleotide cytochrome *c* reductase and cytochrome oxidase by concentrations of carbon dioxide above about 40 per cent could be factors contributing to the rapid induction of carbon dioxide zymasis[7] in intact plant organs stored in atmospheres with plenty of oxygen but also containing carbon dioxide in concentrations approaching 50 per cent[7-9].

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Mycobacillin, a New Antifungal Antibiotic produced by *B. subtilis*

DURING the studies on the distribution of antifungal organisms in Indian fruits, vegetables and soils, a strain of *Bacillus subtilis* (characterized according to Bergey[1]), highly active against widely different groups of fungi, namely, skin pathogens, plant pathogens, rice-spoilage organisms, etc., was isolated[2].

The optimum cultural conditions for the formation of the antibiotic were studied[3] and the highest yield was obtained in a medium consisting of potato extract, casein hydrolysate, beef extract and glucose. The antibiotic was extracted from the fermentation broth and isolated in a pure state following the method of Babad *et al.*[4]. Ultimately a light-brown mass was obtained which crystallized on cooling and evaporation from 70 per cent alcoholic solution as needle-shaped crystals.

The active substance was chromatographed by a simple one-dimensional strip technique using different developing solvents, and, in all cases, only a single active spot was detected by bio-autographic technique. Several common methods of homogeneity studies also indicated the absence of any inactive impurity in the antibiotic.

The substance was soluble in lower alcohols, acetone, acetic acid, caustic soda, conc. hydrochloric acid, pyridine and in water above *p*H 7·0, but insoluble in water between *p*H 2–7 and also in ether, chloroform, etc. It gave negative Molisch and ninhydrin tests, but positive tests for Millon's reagent, biuret reaction, Folin's phenol reagent and xanthoproteic acid reaction. The substance was more heat-stable in acidic than in alkaline *p*H. The antibiotic contained no sulphur or halogens, and its nitrogen content was 11·9 per cent. Its molecular weight as determined by diffusion method was found to be of about 1,800. It has no activity against *E. coli, Staphylococcus aureus, Streptococcus fœcalis*, etc.; but it possesses a wide antifungal spectrum and it inhibits the growth of *A. niger* at 0·02 mgm./ml. in solid agar medium. Paper partition chromatography of an acid hydrolysate of the antibiotic with two-dimensional method using phenol–water as the first solvent and *n*-butanol–acetic acid–water (4 : 1 : 1) as the second solvent indicated the presence of seven amino-acids, namely, aspartic acid, glutamic acid, serine, alanine, tyrosine, leucine and proline—aspartic acid being present predominantly. The antibiotic is a ninhydrin-negative cyclic polypeptide and is somewhat different from the other known antifungal antibiotics[5] like bacillomycin, bacillomycin *B*, *C*, etc., as regards the nature and number of amino-acids present. This new antifungal antibiotic has, therefore, been designated as 'mycobacillin'.

A more detailed report will be published elsewhere.

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Maceration of Plant-tissues with Ethylene-diamine-tetra-acetic Acid

For many years plant anatomists have used macerating techniques[1-3] which subject plant-tissues to either destructive oxidizing agents (usually chromic acid), concentrated acid or alkali, or high temperature. These procedures can cause change in volume of the cells. Macerating media containing chromic acid have been found to destroy cell-walls[3] and the other media referred to above would also be very damaging to plant-cells.

The chelating agent, sodium ethylene-diamine-tetra-acetate, has been found to macerate effectively under conditions (*p*H 7–10, 37–45° C.) which are much milder than those mentioned above. This reagent should be particularly useful for maceration of tissue composed of easily damaged cells and for maceration without change in cell-volume. The macerating action of sodium ethylene-diamine-tetra-acetate is attributed to the ability of the reagent to dissolve the insoluble salts of pectic and low-methoxyl pectinic acids which appear to form a large part of the middle lamella.

The macerating power of sodium ethylene-diamine-tetra-acetate was markedly affected by changes in *p*H. The optimum *p*H for maceration of matured apple-tissue at 45° C. was 10·3. At *p*H 7 and *p*H 11·3 the macerating activity was about 50 per cent of that at *p*H 10·3. Increase in temperature greatly accelerated the rate of maceration. Although the macerating action of the reagent (0·07 *M*; *p*H 10) was appreciably weaker than that of 5 per cent chromic acid, when compared at 37° C. sodium ethylene-diamine-tetra-acetate was 250–300 times more effective than 0·07 *M* ammonium oxalate—an established macerating agent showing appreciable activity only at 100° C. If the osmotic pressure of the 0·07 *M* solution of sodium ethylene-diamine-tetra-acetate was adjusted by addition of sucrose to equal the diffusion-pressure deficit of the cells, maceration of cortical apple tissue could be achieved at 37° C. and 45° C. without detectable change in cell-volume.

For maceration of apple tissue with this reagent the two conditions found most satisfactory are described below. Mid-cortical tissue (1 gm.; cork-borings of 4–5 mm. diameter and length 4–10 mm.) was added to 50 ml. of 0·07 *M* reagent (*p*H 10·7–11·0; adjusted to the correct sucrose-concentration, 0·25–0·40 *M* depending on fruit-maturity). After being shaken continuously for 6 hr. at 45° C., the mixture was left for 16 hr. at 45° C., reshaken by hand and blended at low speed (4,000 r.p.m., M.S.E. micro-homogenizer) for up to 3 min. The blending time required varied with maturity of the fruit. Ripe fruit required no blending. The blendor-blades were covered with water-proof adhesive plaster, and the blendor-cup had baffles inserted into the bulb. The *p*H of macerates was about 10·3. Damage due to sampling of the tissue with the cork-borer accounted for all the damaged cells in the macerates. In macerates of ripe fruit, 80 per cent of the total cells were present as single cells. This procedure was satisfactory for maceration without change in cell-volume.

Maceration with sodium ethylene-diamine-tetra-acetate at 75° C. for 6 hr. with occasional shaking, followed by blending for 1–4 min. has been used for determining the number of cells in apple tissue. In these macerates 88–95 per cent of the total cells were present as single cells.

Carrot-root and potato-tuber tissue (length × diameter of borings = 3 mm. × 5 mm.) can be macerated by the above procedures (the reagent at *p*H 10). The numbers of single cells (expressed as a percentage of total cell-number) in macerates of these tissues obtained by the first method (three-minute blending) are listed below.

Carrot (central cylinder)	66
Carrot (cortex)	27
Potato (tuber)	92

Aggregates composed of more than four cells were seldom found in these or in apple macerates.

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Culture of *Nitrosomonas europaea* in Media Free of Insoluble Constituents

SINCE Winogradsky's discovery of *Nitrosomonas* in the latter part of the nineteenth century, members of this genus have been grown in a variety of culture media containing insoluble constituents, the most common of these being calcium carbonate. This component serves as a means of pH control necessary because of the accumulation of large amounts of nitrous acid and also can provide the inorganic carbon source necessary for the autotrophic metabolism of these bacteria. Eventually, it was tacitly assumed that these micro-organisms require adsorption to particulate medium ingredients in order for active proliferation to occur[1,2]. This phenomenon takes on practical significance for soil nitrification in view of the demonstration that substrate ammonium apparently must first be adsorbed before oxidation can commence[3].

In our studies of the biochemical properties of the nitrifying bacteria, it became readily evident that it would be a difficult procedure to separate the cellular material once it became embedded in the excess of insoluble carbonates and phosphates. In order to obtain quantities of cells free of chemical contamination and to determine if there was some obligate adsorption requirement, studies of the growth of these bacteria were initiated using a medium all of the constituents of which were soluble. *Nitrosomonas europaea* was grown in a 30-litre fermentor similar to that described by Johnson[4]. Air sterilized by filtration through sterile cotton or glass wool was dispersed through a 'Selas 01' candle filter. The medium contained 3·0 gm. ammonium sulphate as the energy source, 500 mgm. potassium hydrogen phosphate, 50 mgm. hydrated magnesium sulphate, 4 mgm. hydrated calcium chloride, 100 μgm. chelated iron (Chel–138–HFe, Geigy Chemical Company, New York), and 50 μgm. cresol red in a litre of redistilled water. Additional ammonium–nitrogen was added aseptically in increments as needed. After autoclaving, the medium was brought to pH 8·0 with a sterile potassium carbonate solution, and the culture was maintained at that reaction during the growth-cycle by continuous addition of a sterile 50 per cent potassium carbonate solution, the indicator simplifying this operation.

In the growth-cycle, a lag phase of 10 hr. was observed when a 5 per cent inoculum was used. Following the initial lag, the culture grew at a logarithmic rate for 60 hr. with a generation time of 11 hr. The final nitrite-level at 96 hr. was 1,160 p.p.m. and the corresponding viable count was $1\cdot9 \times 10^8$ cells per ml. The problem of pH control is indicated by the fact that the acid produced in the last 24-hr. period required 6·3 gm. potassium carbonate per litre of medium for neutralization. The relatively short generation time observed and the accumulation of nitrite in concentrations greater than that usually found in media with insoluble carbonates demonstrate that the bacterium can develop at an optimal rate in clear media. Thus, it is evident that these organisms can grow without being adsorbed on to insoluble materials.

The bacterial cells can be separated from the medium by passage through a Sharples centrifuge with the resultant residue consisting of cells devoid of chemical impurities. The cell paste obtained represents a dry-weight yield of about 72 mgm. per litre of culture medium. The colour of this paste is deep red, probably resulting from the presence of a strong cytochrome absorption band. A more complete account of this work will be reported elsewhere.

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Effect of Plasmolysis on the Rate of Respiration of a Green Alga

IN some recent experiments to be reported more fully elsewhere, the effect of plasmolysis and of temperature on the rate of respiration of the green alga *Scenedesmus quadricauda* has been investigated. The results may be summarized as follows: (1) At 25° C. there is a highly significant (probability 0·1 per cent or less) decrease in the rate of respiration on plasmolysis, with subsequent recovery on deplasmolysis. (2) At 7° C. there is no effect of plasmolysis on the rate of respiration. (3) Between 5° and 15° C. the activation energy for respiration is of the order of 21,000 cal./mole. (4) Between 15° and 35° C. the activation energy for respiration is of the order of 5,600 cal./mole. These results are independent of the presence or absence of glucose, though above 15° C. the rate of respiration is increased on the addition of glucose, whereas the rate is unaffected below this temperature.

The values of the activation energies suggest that below 15° C. a chemical reaction is limiting the rate of respiration; but above this temperature the rate is limited by the diffusion of a respiratory intermediate. In this case the effect of plasmolysis must be on the diffusion path.

Plasmolysis involves a dehydration of cellular material, and loss of water may occur either from the vacuole or from the protoplasm, or from both. Even if the total loss of water is from the vacuole, the excreted water must pass through the protoplasm, the water content of which may vary until equilibrium is regained. This will be especially true if the permeabilities of the plasma membrane and the vacuolar membrane to water are different. Further, if the plasma membrane and the vacuolar membrane both act as semi-permeable membranes towards the water in the protoplasm and the vacuole, and if there is no movement of solute across the membranes, one would expect water to be lost from both the protoplasm and the vacuole. In cells without or with only very small vacuoles (such as *Scenedesmus quadricauda*) there is likely to be a greater loss of water from the protoplasm in hypertonic solutions than in fully vacuolated cells.

Dehydration of the protoplasm will result in an increase in its viscosity, and this has been demonstrated by Fritsch and Haines[1] for terrestrial algae drying in a desiccator. Under the same conditions, Fraymouth[2] has demonstrated a decrease in the rate of respiration. After centrifuging *Scenedesmus quadricauda* cells for 45 min. at 4,000 r.p.m., a number of larger particles were found to be displaced in normal cells but not in plasmolysed cells, indicating that some increase in viscosity had taken place in the plasmolysed cells.

The equations of Sutherland[3] and of Einstein[4] show that when the radius of the diffusing molecule is large in comparison with the radius of the solvent molecule, the rate of diffusion is proportional to the viscosity of the medium. Stiles[5] held that experimental data disproved these equations, but the data he quoted refer to the diffusion of ions in aqueous solution, and this state of affairs lies outside the Sutherland–Einstein equations. Hitchcock[6] has shown that for diffusion in aqueous solution a molecule will obey the theoretical equations provided that it is no smaller than a hexose molecule.

It is therefore suggested that the decrease in the rate of respiration observed on plasmolysis under conditions where diffusion is limiting the rate of respiration, is caused by a reduction in the rate of diffusion brought about by an increase in the viscosity of the protoplasm. There appear to be two main points in the respiratory mechanism where diffusion in the protoplasm could limit the rate of respiration. The first is diffusion of glucose-1-phosphate, formed by hydrolysis of starch, from the starch grains to the glycolytic system; and the second is the diffusion of the product of glycolysis to the mitochondria. With regard to this suggestion it is interesting to recall that an increase in the viscosity of homogenates has been found to decrease their rates of respiration[7].

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Escape Responses of Herbivorous Gastropods when stimulated by Carnivorous Gastropods

Bullock[1] reported that many Californian Gastropoda respond to being touched by tube feet of starfish by crawling rapidly away from the starfish. He also showed that the response differs in details between genera, and between species of a genus; and that some species do not respond at all, or only occasionally. In some species of *Acmaea*, and in *Haliotis cracherodii* Leach 'mushrooming' (raising of the shell well clear of the substratum on the fleshy stalk of the visceral hump) accompanied by lateral swinging of the shell occurred before the animals crawled away; in others, notably the trochid *Tegula*, the animals merely glided rapidly away from the source of stimulation.

Comparable responses may be produced by stimulating herbivorous gastropods with carnivorous ones. This was first observed in Nature on a dry rock surface which had recently been left by the receding tide. A thaisid whelk, *Lepsia haustrum* (Martyn) crawled towards a trochid *Melagraphia aethiops* (Gmelin), and as soon as contact was made between the soft parts of the two the shell of the trochid was lifted well clear of the substratum and swung violently several times through an arc of 180°. The trochid then set off across the rock at two to three times the normal crawling speed. The thaisid did not follow. This has been observed several times. Occasionally, swinging of the shell to left and right is sufficiently violent not only to break contact, but also to dislodge the carnivore, which is several times larger than the trochid.

Similar results were obtained using the starfishes *Coscinasterias calamaria* (Gray) and *Astrostole scabra* (Hutton) as stimulators. The common New Zealand littoral starfish *Asterina regularis* Verrill does not elicit any response. Since making the first observations under natural conditions, many encounters have been 'staged' in tidal pools and in laboratory aquaria. It has been found that freshly collected animals respond in a more marked fashion than those kept in aerated sea water for a few days. As in Bullock's work the vigour of the response varied somewhat between species. The more vigorous reaction involving mushrooming does not always occur; the most common reaction being an abrupt turning away from the point of stimulation, and rapid crawling away from the carnivore. If an animal is stimulated on the right side it turns left and moves away in that direction, and *vice versa*. When contact is frontal the herbivore backs away a short distance before turning to one side and crawling rapidly away. If stimulated repeatedly the herbivores used in the experiments crawled out of the pools or up the sides of the aquarium.

The reactions described here differ from those usually evoked by mechanical stimulation with a needle or human finger. These and other objects cause the animal to lower the shell and cease crawling. Similarly, response to being touched by other herbivores is weak, often causing retraction of a tentacle and a little or no retraction into the shell, but never flight. Carnivores likewise show little or no reaction to being touched by other carnivores.

Herbivorous gastropods found to be sensitive to touch stimuli from carnivorous gastropods are *Melagraphia aethiops*, *Zediloma digna* Finlay, *Z. arida* Finlay, *Z. atrovirens* (Phil.), *Trochus viridis* (Gm.), *Anisodiloma lugubris* (Gm.), *Haliotis iris* Martyn, *Cellana radians* (Gm.), and *C. ornata* (Dillwyn). The fissurellid *Scutus breviculus* (Blainville) and the turbinid *Lunella smaragda* (Martyn) show no response. This may perhaps be explained by the copious covering of mucus on the former, and the heavy calcareous operculum of the latter. The carnivorous gastropoda used as stimulators were *Lepsia haustrum*, *Lepsiella scobina* (Q. & G.), *Buccinulum strebeli* (Suter) and *Cominella maculosa* (Martyn). There appears to be no correlation between sensitivity to different carnivores and position occupied on the shore by carnivores and herbivores. *Lunella smaragda* shows no reaction to *Cominella maculosa*, which lives in the same zone (about mean low water springs), while *Zediloma digna*, which is found at the level of mean high water springs, reacts violently to being touched by *C. maculosa*, which it must rarely, if ever, meet in Nature.

A single specimen of *Lepsia haustrum* was ground up in a pestle and mortar with ground glass and a few ml. of sea water. This was allowed to settle, the supernatant liquor drawn into a pipette, and a few drops placed on the side of the foot of *Melagraphia aethiops*. This evoked a weak reaction. A similar extract of *Mytilus planulatus* Lam. produced no visible results. This tends to support Bullock's view that the stimulus which evokes these reactions is chemical in nature.

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A Spurious Significance in Genecological Trials

ATTENTION has been directed[1] to the fact that reduplication of individual genotypes in population sampling gives rise to spuriously low values of the standard error, and hence misleadingly high significance of difference between populations. This naturally leads one to wonder whether reduplicated genotypes are at all frequent in population samples. Further work on perennial plants of hill grazings has now suggested that the risk of reduplication is very high in some cases.

Detailed morphological examination of plants isolated from the wild has revealed numerous cases of strikingly similar isolates, and these are always from points relatively close together; isolates from greater distances apart never being so similar. In a few cases the separate isolates within a similar group have been cloned and laid out in a replicated trial, and it is found that they cannot be distinguished by any scored character: a block of twelve isolates each replicated ten times appears like a block of 120 ramets of a single plant. (In cases where an apparently similar yet distinct isolate has been included in a trial, that one can be picked out in every replication.) It is very tempting to regard such a group of similar isolates as being of a single genotype. Clearly such an assertion can never be proved, but the results of certain lines of investigation have no other simple interpretation. For example, it is found that virtually self-sterile isolates set no more seed on crossing with an apparently identical isolate than they do on selfing; yet they set seed freely when crossed with recognizably distinct isolates. If the interpretation is correct, then the experimental results give a clear impression of the extent and abundance of individual genotypes in natural communities, and an indication of the chances of genotype reduplication in sampling.

One genotype of *Festuca rubra* appears to have a spread of 250 yards, and over this range it is abundant, forming 70 per cent of the isolates from central parts falling to 3 per cent at one point on the margin: over some nine acres one-third of the tillers isolated belong to this one clone. At one part of the range a separate collection was made of nearly 1,500 tillers, isolated at 9-in. intervals from within a 10-yard square quadrat. Approximately 47 per cent of the tillers were referable to this one clone. Other 'large' cones accounted for 12, 6 and 4 per cent of the tillers respectively. A further 39 clones were isolated less than 25 times (1·7 per cent) each, while 105 isolates remained ungrouped and possibly represent genotypes isolated only once each. This clearly suggests a log distribution[2]. The second and the third largest clones, both of which were markedly localized within the quadrat, have not been found elsewhere. The fourth largest clone, however, which was scattered over the quadrat, has a total spread of at least 100 yards. If this picture of genotype distribution is typical of the species in general, then population sampling in *Festuca rubra* at a higher rate than one plant per acre is likely to lead to spurious significance.

In *Holcus mollis* (the pentaploid form) the picture appears to be slightly different in that only 'large' genotypes occur. In an area of 300 yards across only three genotypes seem to be present, each of them widespread and isolated many times. This suggests that new genotypes are not being established.

It appears the clones of *Festuca ovina* do not often exceed four yards in diameter. This comparatively meagre spread is in fact a surprising performance when one considers its growth habit: the age of such a clone is probably to be measured in hundreds of years. It seems likely that in this species spurious significance can be avoided by adopting a suitably restrained sampling technique. In fact, genotype reduplication might not occur to a serious extent in normal sampling procedure, and it may be instructive to reflect that in this species no difference has been found between populations from neighbouring but ecologically distinct sites[1].

The assumed age of some genotypes in all three species is not without its genecological interest. The most recent products of breeding and selection are apparently no more suited to the prevailing environment than their forebears of scores of generations back. Furthermore, the territories concerned are non-uniform and in spreading outwards single genotypes of both *F. rubra* and *H. mollis* have been able to enter, and compete successfully in, any habitat which does not actually exclude that species, suggesting that there is little genecological specialization present.

Finally, it should be pointed out that, since it is unlikely that any two seedlings are identical in genotype, one way of avoiding genotype reduplication is to raise population samples from seed. Unfortunately, however, this need not avoid spurious significance since the variance between the seed progeny of a single plant is almost certainly lower than that between plants of different parentage.

A complete account of this work is being prepared for publication elsewhere.

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Roslin, Midlothian.

Oct. 18.

[1] Harberd, D. J., *New Phytol.*, 56, 269 (1957).

[2] Williams, C. B., *J. Ecol.*, 42, 1 (1954).

FORTHCOMING EVENTS

Monday, January 13

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Monsieur M. Brichler: "Classification of the Population by Social and Economic Characteristics".

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. I. J. Good: "Could a Machine Make Probability Judgments?"

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Use of Electricity in the Garden by Amateurs", opened by Mr. M. M. Harvey.

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. Duncan Carse: "South Georgia Survey".

Tuesday, January 14

Institution of the Rubber Industry, London Section (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. F. N. B. Bennett: "Modern Testing Methods and Equipment"; 7 p.m.—Mr. W. S. Penn: "New Synthetic in Cables".

Institution of Mechanical Engineers, Automobile Division (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. T. P. Hoar: "The Prevention of Corrosion in Car Bodies".

Wednesday, January 15

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. Stanley Gooding: "Modern Research into Bees and Bee-Keeping".

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

Institute of Physics, London and Home Counties Branch (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Dr. B. F. J. Schonland. F.R.S.: "Physical Research in the Research Group of the Atomic Energy Authority".

Institute of Metals (at 17 Belgrave Square, London, W.C.1), at 6.30 p.m.—Dr. David Turnbull: "The Mechanism of Clustering and Precipitation in Metals".

Royal Institute of Chemistry, London Section (joint meeting with the London Section of the Society of Chemical Industry, at the College of Preceptors, 2 and 3 Bloomsbury Square, London, W.C.1), at 6.30 p.m.—Prof. W. E. Garner, F.R.S.: "Recent Advances in Catalysis".

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. T. P. Hoar and Mr. J. G. Hines: "Stress Corrosion Cracking".

Thursday, January 16

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. A. S. Besicovitch: "Sharpening some Lebesgue Theorems".

Chemical Society (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Prof. D. H. R. Barton, F.R.S.: "Some Aspects of Sesquiterpenoid Chemistry" (Inaugural Simonsen Lecture).

Royal Society of Tropical Medicine and Hygiene (at 26 Portland Place, London, W.1), at 7.30 p.m.—Symposium on "Onchocerciasis".

Friday, January 17

Royal Society of Medicine, Epidemiology and Preventive Medicine Sections (at 1 Wimpole Street, London, W.1), at 5 p.m.—Symposium on "Weather and Disease".

Institute of Navigation (at 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. J. R. Saxton: "The Influence of Atmospheric Conditions on Radar Performance".

Saturday, January 18

British Psychological Society (in the Psychology Department, Birkbeck College, Malet Street, London, W.C.1), at 2.30 p.m.—Dr. R. Melzack (University of Oregon Medical School): "Some Recent Experiments on the Problem of Pain".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Biochemist, Basic grade (with a science degree)—The Group Secretary, Doncaster Hospital Management Committee, Doncaster Royal Infirmary, Doncaster (January 18).

Lecturer in Electrical Engineering—The Registrar, University College, Singleton Park, Swansea (January 18).

Head (well qualified graduate of a British university) of the Electrical Engineering Department—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11 (January 20).

Chair of Botany tenable at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 29).

Lecturer in Inorganic Chemistry at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, January 31).

Lecturer in Mathematics at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (January 31).

Lecturer in Physics at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 31).

Reader in Organic Chemistry at King's College, Strand, London, W.C.2—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 1).

Lecturer in Chemistry at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 8).

Lecturer (with a knowledge of mathematical statistics) in Pure Mathematics—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (February 8).

Lecturer (preferably with experience of virus work) in Bacteriology; and a Georgina McRobert Fellow, to investigate the cause, prevention and treatment of cancer—The Secretary, The University, Aberdeen (February 14).

Imperial Chemical Industries Research Fellows in Physics, Chemistry, Engineering, Metallurgy and Pharmacology or any related subjects—The Registrar, The University, Liverpool (February 15).

Senior Lecturer in Numerical Analysis at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 15).

Imperial Chemical Industries Research Fellows (4) in Chemistry, Physics, Physical Chemistry, Biochemistry, Chemotherapy, Pharmacology, Pharmacy, Colloid Science, Metallurgy, Engineering, Geology or Agricultural Science—The Registrar of the University of Wales, University Registry, Cathays Park, Cardiff (March 8).

Turner and Newall Research Fellow in Engineering, Inorganic Chemistry or Physics or other allied science—The Registrar, The University, Leeds 2 (April 12).

Assistant Lecturer (Grade B) in Chemistry—The Principal, Royal Technical College, Salford 5.

Assistant (man or woman, with a good reading knowledge of Russian) for abstracting scientific papers in economic entomology—The Director, Commonwealth Institute of Entomology, 56 Queen's Gate, London, S.W.7.

Bacteriologist (with the Ph.D. degree) to undertake research on the physiology and biochemical activities of bacteria and to supervise the maintenance of a culture collection—Dr. G. A. Ledingham, Director, Prairie Regional Laboratory, National Research Council, Saskatoon, Saskatchewan, Canada.

Chair of Psychology—The Registrar, The University, Bristol.

Entomologist (with a good honours degree in an agricultural science and at least two years postgraduate experience in entomology) in the Agricultural Department, Sierra Leone, to organize control measures for insect pests of coffee, cocoa and other crops—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/15/011.

Histological Technician (preferably with the diploma of the I.M.L.T. in histology) in the Department of Morbid Anatomy—Dr. M. Bodian, Department of Morbid Anatomy, The Hospital for Sick Children, Great Ormond Street, London, W.C.1.

Research Worker (with a degree in psychology)—The Director, Burden Institute, Stoke Lane, Stapleton, Bristol.

Scientific Officer (Chemist) (with a first- or upper division second-class honours degree in chemistry of equivalent qualification, and preferably at least two years postgraduate experience in inorganic analysis and a specialized knowledge of silicate and/or spectrographic analysis) in the Department of Geological Survey, Federation of Nigeria, for duties which include the analysis of rocks, ores and minerals in the Geological Survey Laboratories—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/14/09/T.

Technician (Associate of the Institute of Medical Laboratory Technology) in the Department of Surgery, University of Oxford—Nuffield Professor of Surgery, Radcliffe Infirmary, Oxford.

Technician (with the A.I.M.L.T. or equivalent qualification), for duties mainly consisting of assisting with research—The Secretary, Guy's Hospital Medical School, London Bridge, London, S.E.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Department of Scientific and Industrial Research. Memoirs of the Geological Survey of Great Britain (England and Wales). Geology of the Country around Sheffield. By R. A. Eden, I. P. Stevenson, and Wilfrid Edwards. (One-inch Geological Sheet 100, New Series.) Pp. ix+238+6 plates. (London: H.M. Stationery Office, 1957.) 27*s*. 6*d*. net. [1110

Building Research Station Digest No. 102 (September, 1957): Miscellany—Window-sills; Bonding Agents; Staining and Efflorescence; Half-hour Fire Resistance; Sound Insulation of Partitions; Flue-less Heaters; From Limestone to Sandstone. Pp. 6. (London: H.M. Stationery Office, 1957.) 3*d*. [1110

Report of the West African Timber Borer Research Unit, 1953–55. Pp. 44+1 plate. (London: Crown Agents for Oversea Governments and Administrations, 1957.) 5*s*. [1110

National Association for Mental Health. Annual Report, 1956–1957. Pp. 39. (London: National Association for Mental Health, 1957.) [1110

Library Association Pamphlet No. 17: Microrecording in Libraries: a Review of Present Practice. By J. Burkett. Pp. 55. (London: Library Association, 1957.) 8*s*. 8*d*. (6*s*. 6*d*. to L.A. members). [1110

Air Ministry: Meteorological Office. British Rainfall 1955: Report on the Distribution of Rain in Space and Time over Great Britain and Northern Ireland during the year 1955 as recorded by about 5,000 Observers. (Ninety-fifth Annual Volume of the British Rainfall Organization.) Pp. iv+230. (M.O. 629.) (London: H.M. Stationery Office, 1957.) 25*s*. net. [1110

Research Defence Society. Conquest Pamphlet No. 3: The Research Defence Society. By W. Lane-Petter. Pp. 14. (London: Research Defence Society, 1957.) 6*d*. [1410

British Cast Iron Research Association. Thirty-sixth Annual Report for the year ending June 30th, 1957. Pp. 16+1 plate. (Birmingham: British Cast Iron Research Association, 1957.) [1410

Forestry Commission. Forest Records, No. 33: Provisional Yield Table for Western Hemlock in Great Britain. By W. R. Evans and J. M. Christie. Pp. 20. (London: H.M. Stationery Office, 1957.) 1*s*. 9*d*. net. [1510

At the Farmer's Service: a handy reference to the various services available to Farmers in England and Wales. Pp. ii+64. (London: Ministry of Agriculture, Fisheries and Food, 1957.) [1510

Other Countries

Library of Congress—Technical Information Division. The Air Pollution Bibliography, Vol. 1. By Jack R. Gibson, Wave E. Culver, and Mary E. Kurz. Pp. vii+150. (Compiled for the Public Health Service, U.S. Department of Health, Education and Welfare.) (Washington, D.C.: Library of Congress, Technical Information Division, 1957.) [1110

Proceedings of the United States National Museum. Vol. 107, No. 3379: *Rhynobrissus cuneus*, a New Echinoid from North Carolina. By C. Wythe Cooke. Pp. 9–12 (1 plate). Vol. 107, No. 3390: Formosan Cossonine Weevils of Bamboo (Coleoptera: Curculionidae: Cossoninae). By Elwood C. Zimmerman. Pp. 13–24. Vol. 107, No. 3382: A New Species of Calanopia (Copepoda: Calamoida) from the Caribbean Sea. By Thomas E. Bowman. Pp. 39–46. Title-Page and Index to Volume 104 (Nos. 3338–3348). Pp. iv+651–694. (Washington, D.C.: Government Printing Office, 1957.) [1110

Scrimshaw: Folk Art of the Whalers. By Walter K. Earle. Illustrations by Jane Davenport. Pp. 36 (8 plates). (Cold Spring Harbor, N.Y.: Whaling Museum Society, Inc., 1957.) [1110

Imperial College of Tropical Agriculture. A Report on Cacao Research, 1955–1956. Pp. 60. (St. Augustine, Trinidad and London: Imperial College of Tropical Agriculture, 1957.) 15*s*. [1110

World Health Organization. Technical Report Series. No. 125: Expert Committee on Insecticides—Seventh Report. Pp. 31. 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars. No. 128: The Public Health Laboratory Service: Fifth Report of the Expert Committee on Health Laboratory Methods. Pp. 49. 2 Swiss francs; 3*s*. 6*d*.; 0.60 dollars. *Chronicle of the World Health Organization*, Vol. 11, No. 8 (August, 1957): Challenge of Atomic Energy. (Special Number.) Pp. 233–266. 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) [1110

Canada: Department of Mines and Technical Surveys. Publications of the Dominion Observatory, Ottawa. Vol. 14: Bibliography of Seismology No. 19, Items 9382–9627 (January to June, 1956). By W. E. T. Smith. Pp. 413+442. (Ottawa: Queen's Printer, 1957.) 25 cents. [1110

United States Department of Commerce: Weather Bureau. Research Paper No. 40: Principal Tracks and Mean Frequencies of Cyclones and Anticyclones in the Northern Hemisphere. Pp. ii+60 (72 charts). (Washington, D.C.: Government Printing Office, 1957.) 1 dollar. [1110

Osaka University: Faculty of Science. Annual Report of Scientific Works, Vol. 5, 1957. Pp. ii+148. (Osaka: Faculty of Science, Osaka University, 1957.) [1410

Fauna and Flora, No. 6, 1955. Pp. 151. (An Official Publication of the Transvaal Provincial Government.) (Pretoria: Director of Nature Conservation, P.O. Box 383. 1956.) [1410

Académie Royale de Belgique. Classe des Sciences. Mémoires, Tome 30, Fascicule 4: Méthode de Détermination Directe des Représentations Irréductibles Associées aux Harmoniques et Combinaisons de Vibrations Moléculaires. Par Camille Duculot. Pp. 90. (Bruxelles: Académie Royale de Belgique, 1957.) 80 francs. [1410

Publications de l'Observatoire de Genève. Série M: Météorologie. Fascicule 31: Résumé Météorologique de l'Année 1956 pour Genève. Par J. Ruche. Pp. 13. (Genève: Observatoire de Genève, 1957.) [1410

Annual Report of the Trustees of the Museum of Applied Arts and Sciences, Sydney. Pp. 14. (Sydney: Museum of Applied Arts and Sciences, 1957.) [1410

Bulletin of the American Museum of Natural History. Vol. 113, Article 2: A Historical Review of the Mollusks of Linnaeus. Part 5: The Genus *Murex* of the Class Gastropoda. By Henry Dodge. Pp. 73–244. (New York: American Museum of Natural History, 1957.) 2.50 dollars. [1410

Harvard University: Blue Hill Meteorological Observatory. Meteorological Radar Studies. No. 4: Advection and the Melting Layer. By Raymond Wexler. Pp. 12. No. 5: Synoptic-Physical Implications of 1.25 cm. Vertical Beam Radar Echoes. By Roland J. Boucher. Pp. 24. No. 6: Moisture Supply and Growth of Stratiform Precipitation. By Raymond Wexler and David Atlas. Pp. 19. (Milton, Mass.: Blue Hill Meteorological Observatory, Harvard University, 1957.) [1410

Union Observatory, Johannesburg. Annual Report for 1956. Pp. 6. (Johannesburg: Union Observatory, 1957.) [1410

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 117, No. 1: A Study of the Sharks of the Suborder Squaloidea. By Henry B. Bigelow and William C. Schroeder. Pp. 150+4 plates. Vol. 117, No. 2: Check List of the Reptiles and Amphibians of East Africa (Uganda; Kenya; Tanganyika; Zanzibar). By Arthur Loveridge. Pp. 151–362+xxxvi. Vol. 117, No. 3: The Spider Genera *Crustulina* and *Steatoda* in North America, Central America, and the West Indies (Araneae, Theridiidae). By Herbert W. Levi. Pp. 363–424 (156 figures). (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1957.) [1410

United States Department of Agriculture. Index-Catalogue of Medical and Veterinary Zoology. Supplement 7, Authors A to Z. Pp. ii+1789–2139. (Washington, D.C.: Government Printing Office, 1957.) 1.25 dollars. [1410

Smithsonian Miscellaneous Collections. Vol. 134, No. 11: Anatomy and Taxonomy of the Mature Naiads of the Dragonfly Genus *Plathemis* (Family Libellulidae). By Harvey R. Levine. Pp. 28. (Washington, D.C.: Smithsonian Institution, 1957.) [1410

United States Department of the Interior: Geological Survey. Bulletin 1019-E: Magnesium Resources of the United States—a Geologic Summary and Annotated Bibliography to 1953. By Robert E. David. Pp. iv+373–515+plate 2. 70 cents. Bulletin 1019-H: Selected Annotated Bibliography of High-Grade Silica of the United States and Canada through December, 1954. By Marion C. Jaster. Pp. iii+609–673. 25 cents. Bulletin 1019-I: Annotated Bibliography of High-Calcium Limestone Deposits in the United States including Alaska, to April 1956. By G. C. Gazdik and Kathleen M. Tagg. Pp. iii+675–712. 20 cents. Bulletin 1036-K: Differential Thermal Analysis of Selected Borate Minerals. By Robert D. Allen. Pp. iii+193–208. 15 cents. Bulletin 1043-B: Application of High-Order Stereoscopic Plotting Instruments to Photogeologic Studies. By C. L. Pillmore. Pp. 34. 15 cents. Bulletin 1061-A: Pennsylvanian and Permian Rocks of the Southern Inyo Mountains, California. By Charles W. Merriam and Wayne E. Hall. Pp. iii+15. 15 cents. (Washington, D.C.: Government Printing Office, 1957.) [1410

United States Department of the Interior: Geological Survey. Water-Supply Paper 1290: Quality of the Surface Waters of the United States, 1953. Parts 1–4: North Atlantic Slope Basins to St. Lawrence River Basin. Prepared under the direction of S. K. Love. Pp. xi+439. 1.25 dollars. Water-Supply Paper 1349: Surface Water Supply of Hawaii, 1953–54. Prepared under the direction of J. V. B. Wells. Pp. vi+130. 50 cents. Water-Supply Paper 1387: Surface Water Supply of the United States, 1955. Part 4: St. Lawrence River Basin. Prepared under the direction of J. V. B. Wells. Pp. ix+412. 1.25 dollars. Water-Supply Paper 1396: Surface Water Supply of the United States, 1955. Part 12: Pacific Slope Basins in Washington and Upper Columbia River Basin. Prepared under the direction of J. V. B. Wells. Pp. ix+333. 1.25 dollars. Water-Supply Paper 1404: Water Levels and Artesian Pressures in Observation Wells in the United States, 1955. Part 1: Northeastern States. Prepared under the direction of A. N. Sayre. Pp. vii+303. 1 dollar. Water-Supply Paper 1417: Geology and Ground-Water Resources of the Paducah Area, Kentucky. By H. L. Pree, Jr., W. H. Walker and L. M. Macvary. Pp. vi+214+11 plates. n.p. (Washington, D.C.: Government Printing Office, 1957.) [1410

United States Department of the Interior: Geological Survey. Professional Paper 282-C: River Flood Plains: Some Observations on Their Formation. By M. Gordon Wolman and Luna B. Leopold. Pp. iii+87–109+plates 1 and 2. 25 cents. Professional Paper 303-A,B.: The Paleozoic Section in the Shainin Lake Area, Central Brooks Range, Alaska. By Arthur L. Bowsher and J. Thomas Dutro, Jr. A New Upper Paleozoic Formation, Central Brooks Range, Alaska. By William W. Patton, Jr. Pp. vii+46+6 plates. n.p. (Washington, D.C.: Government Printing Office, 1957.) [1410

Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft, Berlin–Dahlem. Heft 90 (August, 1957): Über den Einfluss von Temperatur und Luftfeuchtigkeit auf den Eiparasiten *Trichogramma cacoeciae* Marchal (Eine biometrische Studie). Von Dr. Wolfgang Quednau. Pp. 63. 7 D.M. Heft 91 (September, 1957): Die blatt- und rindenbewohnenden Pilze der Pappel unter besonderer Berücksichtigung der Krankheitserreger. Von Dr. H. Butin. Pp. 64. 7 D.M. (Berlin-Dahlem: Biologischen Bundesanstalt für Land- und Forstwirtschaft, 1957.) [1510

Food and Agriculture Organization of the United Nations. FAO Nutritional Studies. No. 15: Calorie Requirements—Report of the Second Committee on Calorie Requirements. Pp. viii+68. (Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1957.) 3*s*. 9*d*.; 0.75 dollars. [1510

A History of Lake Rukwa and the Red Locust. By D. L. Gunn. Pp. 19. (Dar-es-Salaam: Tanganyika Notes and Records; Abercorn: International Red Locust Control Service, 1956.) [1510

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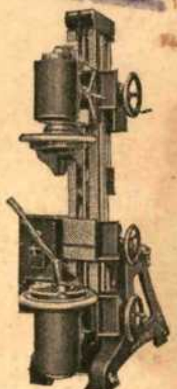

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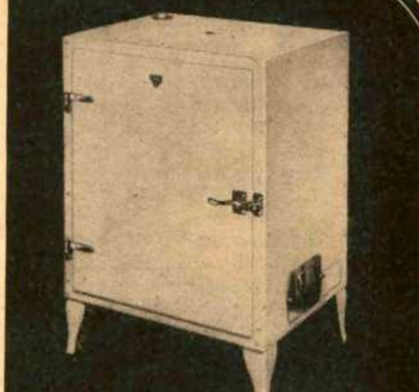

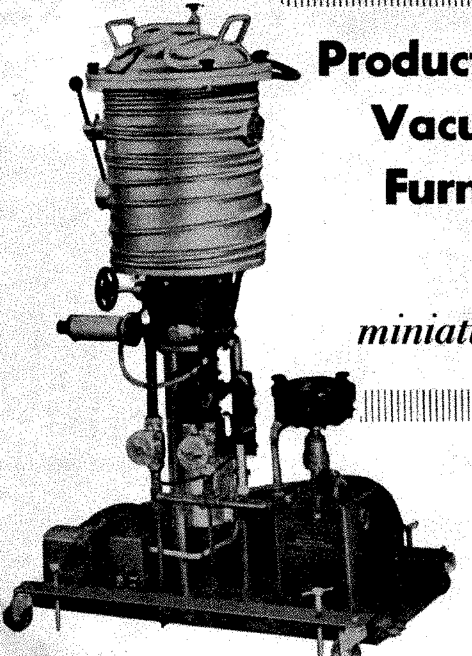

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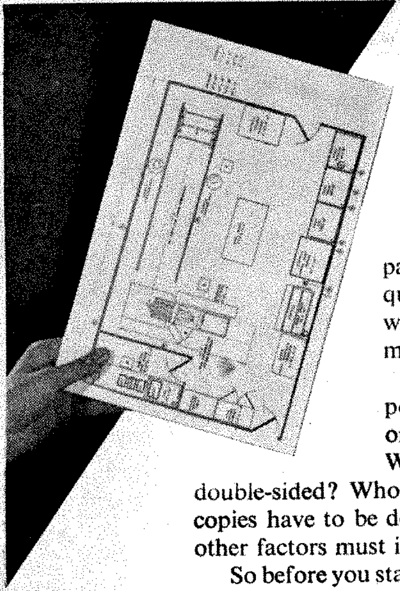

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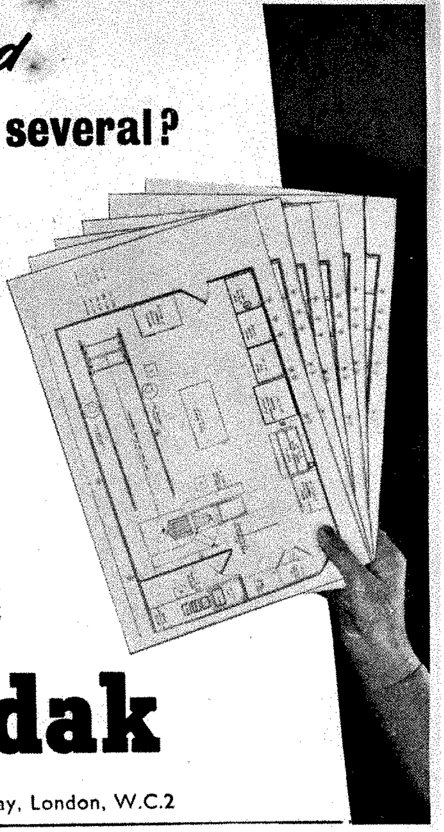

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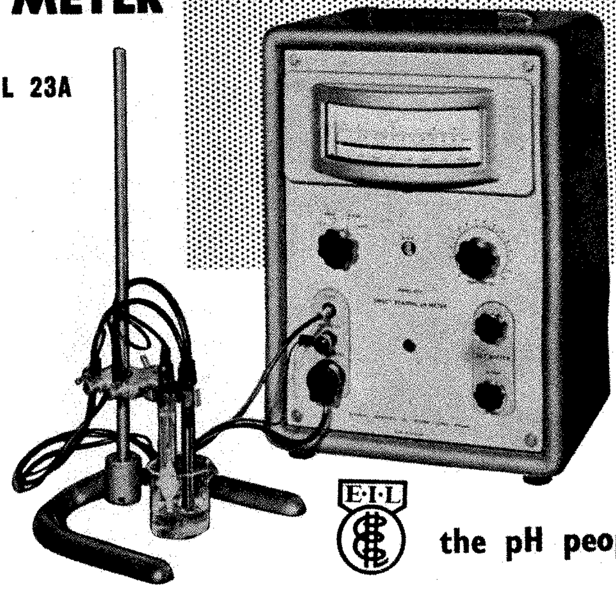

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PROBLEMS OF GOVERNMENT IN THE MODERN WORLD

For something like two decades at least, it has been widely recognized in Britain that Ministers and the higher Civil servants have been seriously overworked. Indeed, the Haldane Report on the Machinery of Government in 1918 urged the importance of more provision for investigation and thought as a preliminary to action, and this is the proper approach to a problem that in recent months has been described as one of reducing the burden on Ministers.

It was suggested to the Prime Minister in April last that he should appoint a Select Committee to review and inquire into the working of the present system of government with the view of reducing the burden on Ministers and also securing the more efficient working of Parliament. After studying the suggestion, Mr. Macmillan invited a small group of Privy Councillors with long experience of the House of Commons to make a preliminary informal study of these problems under the chairmanship of Lord Attlee. Their report was presented early last autumn, and Mr. Macmillan stated on November 5 in the debate on the address from the Throne that he was satisfied that no further inquiry is required and that the problem is one of adapting existing practices to the best advantage. He said further that it is not easy for Ministers in charge of departments to retain full responsibility, as they must, and at the same time take complete advantage of the help that Parliamentary Secretaries and Ministers of State can give. If such Ministers are really to be regarded as deputy Ministers they must be recognized as having such authority, and he thought that this might be the biggest single contribution to the reduction of the burden on senior Ministers. Mr. Macmillan suggested that members of the House might accept such Ministers as the spokesmen of their Departments. Independently of this, the Prime Minister was specifically challenged on October 29 about the responsibilities of the Lord President of the Council. The Opposition was plainly dissatisfied at the combination of the major departmental responsibilities for the nation's scientific effort with party political duties; but the matter was raised in too partisan a manner to bring out the real reasons for concern.

Those reasons appear much more clearly in a survey by a study group of the Royal Institute of Public Administration which has been published under the title "The Organization of British Central Government, 1914–1956"* since the Committee of Privy Councillors began its inquiry. Particularly in its chapters on the central administration, the central co-ordination of Government and the handling of administrative change, it supplies the background for fruitful discussion of the current problems of government, while the chapter on scientific research provides a coherent picture of the organization in Britain for research. This is of special importance at the present time in view of the survey on which the Advisory Council for Scientific Policy is already engaged, and also because of its bearing on effective scientific co-operation with the United States, to which the Prime Minister and President Eisenhower have committed us.

The Prime Minister, however, made two remarks in referring to the accident at Windscale which are profoundly significant in this connexion. In replying to questions arising out of his statement on November 8, he remarked that on the purely technical atomic aspects of the accident, he had chosen Sir Alexander Fleck to be chairman of the three committees because he had sufficient scientific knowledge of a general character. Secondly, when asked on November 12 whether, in view of the fact that responsibility for nuclear energy matters involves much detailed study of highly technical problems, he would consider transferring that responsibility from himself to a senior Minister in the House of Commons, he replied that he thought the existing arrangement is the most suitable at the present time. Pressed again that in principle it was wrong that the Prime Minister should be burdened with detailed affairs that are bound to arise from time to time in an organization such as the Atomic Energy Authority, Mr. Macmillan admitted that there are disadvantages. Nevertheless, he thought that, for the present, when the various uses of nuclear power are so much in the field that the Prime Minister of the day must in any event have them under his control, there are advantages, and that on the whole the system works well. In the detailed work he was much helped by the Paymaster-General.

Now there are at least three implications in these remarks that bear profoundly both on the whole conduct of government and on its organization in relation to the nation's scientific and technological effort. Implicit in the reason given for his choice of Sir Alexander Fleck and in his reason for retaining as Prime Minister special responsibility for nuclear energy is the fundamental importance of some personal understanding of science and technology on the part of Ministers and of their chief permanent advisers. Consciously or unconsciously, Mr. Macmillan underlined the vital point which Sir Henry Tizard made in his Haldane Memorial Lecture. Without such understanding of science on the part of Ministers and members of the administrative class of the Civil Service, there cannot to-day be secured that effective relation between knowledge and power, and between expert and responsible Minister, upon which the smooth functioning of any system of government depends.

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* The Organization of British Central Government 1914–1956: a Survey by a Study Group of the Royal Institute of Public Administration. Edited by D. N. Chester. Written by F. M. G. Willson. Pp. 458. (London: George Allen and Unwin, Ltd., 1957.) 32s. net.

The first task is thus attention to the educational system—and at all levels—not simply to secure the supply of sufficient scientists and technologists, but also of Ministers, administrators and citizens who are able to appreciate the significance of what the scientist or technologist is doing, and of scientists and technologists who are capable of taking broad views and of explaining the significance of their investigations in terms which those working in other fields can understand. This is an urgent task and of over-riding importance. While its results may well be long-term, the course of Anglo-American co-operation and Britain's security, as well as her economic future, largely depend on the vigour and vision with which it is undertaken.

Next, there is implied the necessity of considering the scientific and technical aspects of public affairs at the highest—at the policy-making—level. This is not to say that the scientist or technologist as such should be present in the Cabinet; but it does involve the presence at that level of those who are competent to evaluate at first hand the advice on such matters that their experts have given them. It is difficult to believe that the Advisory Council on Scientific Policy or the Defence Research Policy Committee has failed for the past ten years to present its advice cogently and intelligibly, though the published reports of the former body suggest that on occasion it might have been expressed more firmly or forcibly. It is much more probable that its significance and especially the urgency of action in such matters have rarely been appreciated at Cabinet-level, and matters have usually been allowed to drift, with waste of precious resources, until some less-effective measure has had to be adopted, often with further waste and frustration.

This view is supported by the picture which is presented in the chapter on scientific research in "The Organization of British Central Government, 1914–1956". That chapter traces the development of government institutions which have been specially established to conduct—and to encourage private institutions to conduct—scientific research primarily for civil purposes; but it also discusses succinctly some of the problems which have been raised by the assumption of this new Government responsibility. Sufficient is said about the University Grants Committee to show that the arrangements for co-ordination of the resources for fundamental research are quite loose, and that without real understanding and insight at the Treasury and on the part of the Lord President of the Council, not only is overlapping possible, but also and more important, research of outstanding significance can be restricted by economy measures dictated by those with no direct responsibility for the work or appreciation of its bearing on the national welfare or economy. The importance of co-ordination is implicit in the remarks of the Prime Minister, though he did not indicate that he proposed to improve the existing arrangements.

Several types of authority have been established over the years to deal with government policy in scientific research. It seems to be generally admitted that the orthodox type of government department is not suitable where research is concerned. What stands out above all, however, is the dependence of the structure as a whole upon the vision, understanding and influence of such men as Lord Balfour and the late Lord Waverley. Where such interested and strong personalities have held the office of Lord President, the system has manifestly worked; in their absence it is difficult to believe, on this record, that a theoretically perfect organization would have yielded better results.

The conclusion is drawn from this survey that the research authorities should have a high degree of autonomy and be regarded as institutions with entirely non-political functions, the necessary minimum of control being exercised on behalf of Government and Parliament by a Minister with no departmental responsibilities and consequently no departmental prejudices—namely, the Lord President of the Council. For that reason, it would seem a sound decision to transfer to the Minister of Power the responsibilities for nuclear energy which the Lord President held from January 1954; but it is more debatable whether the responsibilities for nuclear research should also be transferred, particularly in the present situation, when the balance of research and development effort is in question. The Lord President seems better placed than any other senior Minister to determine whether the resources allocated to nuclear research and the development of nuclear energy, both under the Atomic Energy Authority and elsewhere, are excessive or not. The responsibility is immense, and the real criticism made of the structure up to April 1957 was that the Lord President was ill-provided for such responsibility either in respect of staff or spokesmen in the House of Commons; nor does it seem satisfactory that there should still be two indirect spokesmen—the Parliamentary Secretary to the Minister of Works and the Paymaster-General. The conception of a Minister of Science has been rejected for valid reasons, but the case for providing the Lord President of the Council with such an organization and staff for research and intelligence generally as the Haldane report recommended seems unanswered.

Until the outbreak of the Second World War the Lord President, despite his special responsibility for the research councils, was only slightly in evidence as a scientific co-ordinator, and the prestige which Lord Salisbury's predecessors in that office enjoyed was largely built up when Sir John Anderson, as he then was, was Lord President, from October 1940 until September 1943, and acted as chairman of two standing committees, one on economic information and one on scientific research. Later, in 1947, the economic responsibilities were relinquished and about the same time the Advisory Council on Scientific Policy and the Defence Research Policy Committee were established. Moreover, from January 1956 until April 1957, besides carrying responsibilities for the major scientific organizations, the Lord President presided over the Cabinet Committee on Atomic Energy, consisting of those Ministers who have a share of responsibility in the activities of the Atomic Energy Authority, and probably others, and he was assisted by an official committee of high Civil servants drawn from the corresponding departments.

Thus far the survey made by the Study Group of the Royal Institute of Public Administration scarcely supports the manner in which scientific policy has been handled by Government in recent years; and it points to the wisdom of a suggestion made by Sir John Anderson in his Romanes Lecture of 1946, that a section of the Cabinet Secretariat should be organized to assist the Lord President as the Minister responsible for the general aspects of scientific investigation, thus providing scientific advice at the highest level without prejudice to the work of departmental scientific staff. But the discussion of the handling of administrative change in general is even more pertinent to the question of lightening the burden on Ministers and facilitating deeper thought on policy and problems of change now under consideration by the Prime Minister. There is indeed no simple formula by application of which all problems of administrative arrangement can be solved. The structure of central government and the distribution of functions among departments is the resultant of numerous factors. Obviously, the number of Ministers will be determined ultimately by the responsibilities which the central government is required to assume, and on the whole it is remarkable, with the great increase in government activity during the past forty years, that the number of Ministers has increased no more than from twenty-one in 1914 to twenty-nine in 1956.

It would not appear from the Prime Minister's comments so far that he intends to enter on any discussion either of the two powerful forces which since 1914 have dominated this struggle about the number of Ministers, or again of the four main ways in which Government powers and activities may be grouped for administrative purposes. It could perhaps be inferred that he himself gives greater weight to the needs of co-ordination and the advantages of government by a small and well-knit body of Ministers and also that he attaches greater weight to the purpose to be served than to the kind of work to be undertaken. That again might be less important if there were evidence that Governments could count on a succession of Lord Balfours and Lord Waverleys competent both to give due weight to the scientific and technical elements in affairs of state and also authoritative enough to ensure that the conditions in which scientific research is most fruitfully pursued are preserved and that adequate resources are available.

Although the essential factors to be considered in handling changes in the administrative structure are set forth in this book with admirable lucidity and in a way that could reduce the possibility of an inefficient allocation of functions, the Study Group of the Royal Institute of Public Administration is careful not to suggest excessive attention to this aspect. On the whole, it seems satisfied with the present arrangements within the Treasury for handling such questions, and considers that the structure has been changed and extended with a fair degree of success to meet the conditions of to-day. Problems indeed remain: more use might be made of men and women of affairs outside the Civil Service, and also of students of public administration, as indeed was envisaged in a Government pledge of 1948. It also advocates the publication from time to time of a report surveying the changes in the machinery of government during the period covered, and giving as much information as possible as to the reasons for the changes and about any studies or inquiries conducted since the previous survey.

Such publicity is a pre-condition for the informed discussion which alone can put at the disposal of the Government the full range of experience and the profoundest thinking available in the nation; and it should be kept in mind by Mr. Macmillan in considering the publication of the report of the Committee of Privy Councillors, and indeed of those of the Machinery of Government Committee. Although the process of adaptation is now more conscious than formerly, and more attention is paid to the broad plan of organization on which Ministers rely for the discharge of their powers, efficiency will be promoted by constant study of the factors influencing the structure of government, subject always to the need for flexibility.

The beginning of wisdom in this context, this study affirms, is the firm rejection of any belief in the possibility of defining a rigid and comprehensive framework of organization into which every function of government can be fitted for all time. Perhaps one of the gravest dangers, as we have seen on occasion in respect of the nationalized industries, is that flexibility or other principles of sound administration may be disregarded through party political prejudice or some other partisan view.

The issues raised by the Prime Minister's statement as to the responsibilities and duties of Ministers go right to the heart of the efficiency of government. Part of the problem lies in relieving the central government of detailed work which is best carried out regionally or locally, and that in turn depends on restoring vitality and efficiency to local government. Here, too, is a problem of communication, and in that respect it would appear that we have far to go to secure really effective contact and understanding between the centre and the perimeter. Nor is this solely a matter of seeing that our rulers and administrators are appropriately educated: at least in part it is a matter of ensuring that full use is made of the possibilities of communication and interpretation now at our disposal.

The vital need at the present time is for an educational system, perhaps on the lines put forward in general terms by Sir Eric Ashby, Dr. J. Bronowski and Dr. R. P. Linstead in recent addresses, which will provide the nation with leaders capable of assessing all aspects of the problems which the modern world presents, and wise and strong enough to resist sectional pressure.

A SYNTHESIS OF GENERAL EMBRYOLOGY

Introduction to General Embryology

By Prof. A. M. Dalcq. Translated by Jean Medawar. Pp. vii+177. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 25*s*. net.

THIS "Introduction to General Embryology" is the outcome of a series of thirteen broadcast talks given by Prof. Albert Dalcq in 1951 at the request of the "Université radiophonique" of Paris. These lectures were published in French by Prof. Dalcq in 1952, under the title "Initiation à l'Embryologie générale". This small book soon became a classic for students—not only Prof. Dalcq's own, but also for those of his former students who, like the present reviewer, have the task of teaching experimental and chemical embryology in university courses. In fact, Prof. Dalcq's book is much more than an introduction to embryological problems; it is a masterly synthesis of our present knowledge in the field, as well as the expression of the scientific and philosophical ideas of one of the world's leading embryologists. The translation of Prof. Dalcq's book into English is especially welcome, since the author has brought up to date the first nine chapters of the French edition, has rewritten the remainder and added a new chapter devoted mainly to his recent important work on mammals.

Prof. Dalcq starts with a question that is puzzling for too many laymen: Why should one study embryology? After showing the importance of this science for practical (artificial insemination) and medical purposes, he emphasizes the close relationship existing between embryology and allied disciplines (cytology, genetics, study of evolution). He points out—and this is one of his favourite ideas—that the main abilities of the human mind are all inborn: the nature of psychic activity might be discovered from studies made on the embryo. It is perhaps one of Prof. Dalcq's secret hopes that a psychological analysis of the developing embryo will some time become a reality.

Chapter 2 is a clear and brief account of the history of embryology. The reader is immediately placed in the middle of the eternal preformation *versus* epigenesis controversy. The next chapter is devoted to the methods used by present-day embryologists.

In Chapter 4, the main cellular constituents, at the morphological and biochemical levels, as well as the formation of the gametes, are briefly described. The next chapter deals mainly with fertilization and parthenogenesis. The title of Chapter 6 is "A Discussion of Terminology": after describing cleavage and gastrulation, Prof. Dalcq concludes that ontogenesis begins necessarily with immediate or delayed cleavage; morphochoresis corresponds to both gastrulation and neurulation; it is followed by cytodifferentiation and growth.

The next chapters introduce the reader to the realm of experimental embryology. The classical experiments in which one of the blastomeres of the two-cell stage is destroyed, or in which the two blastomeres are separated from each other are clearly described and discussed. The significance of, and the difficulties inherent in the use of, such terms as mosaic and regulative eggs are stressed. Prof. Dalcq also explains what he means by "normogenesis" and "paragenesis"; normogenesis and regulation are at the two extremes, while paragenesis corresponds to the intermediary anomalies of development, including exogastrulation, morphogenetic induction in vertebrate eggs, vegetalization or animalization in those of the sea urchin, etc.

In Chapter 10 the author analyses the many aspects of induction and introduces the very useful concept of "morphogenetic potentials". This is followed (Chapter 11) by a very interesting study of mammalian development, including Prof. Dalcq's important studies on the cytochemistry of these eggs.

The scope becomes still broader in the next two chapters, which are devoted to the relationship between development, heredity, and evolution. Finally, in the last chapter, "Where do we stand?", Prof. Dalcq brings together many facts derived from studies of asexual reproduction, regeneration, and embryonic development. He finishes this attempt at synthesis with a few remarks that summarize his philosophy of life and the living.

One must heartily congratulate the translator, Mrs. Jean Medawar, on her expert job. Prof. Dalcq's style is elegant, elaborate, and precise. That all these qualities are found again in the English text deserves admiration. The presentation of the book is excellent and there are next to no typographical errors. Thanks to the quality of the paper, the reproduction of text figures (many of them original and slightly schematic) is much better than in the original French edition.

J. BRACHET

AGRICULTURE IN EAST AND WEST

Types of Rural Economy

Studies in World Agriculture. By Prof. René Dumont. Pp. xii+556. (London: Methuen and Co., Ltd., 1957.) 45*s*. net.

PROF. DUMONT is already well known for his studies of French agriculture: in this volume he ranges over a much wider field, including England, most of Europe, North and West Africa and northern Viet Nam, always, however, confining himself to places he has actually visited. The book is thus a series of vignettes, but the background is always broadly sketched in to keep a sense of proportion. In a disarmingly modest preface he describes the volume as a "preliminary exercise" by one who undertook these economic studies "too late in life to have acquired a really profound knowledge of them", but the apology is quite unnecessary: the most expert reader will gain a great deal from its pages.

The author's keen power of observation, and his ability to pick out and emphasize the essentials of the various systems described, give the book an exceptional value. He is equally interesting and informative whether he is dealing with the collective farms near Moscow and in Eastern Europe, the corridor system in the Belgian Congo designed to overcome the defects of the native shifting cultivation, or the skilful adaptation of agricultural systems to environment in the Alps.

He makes some shrewd and penetrating comparisons of British and French agriculture, one worked by tenant farmers, the other by peasants: characteristically he began his studies by working as a labourer on a small Shropshire farm. The English farmer, he found, operates on a larger scale, reduces manual labour to a minimum by heavy mechanization (the heaviest in the world, he states), prefers tenancy to ownership because he wants to use all his capital for working and development, devotes himself entirely to management, leaving the manual operations to the staff, and enjoys a social status such that "it would not be considered unusual for him to marry a woman qualified in law or medicine. In France," the author adds rather wistfully, "things are quite different." British agricultural policy he regards as the most enlightened in the world; it encourages high output and rural prosperity, and he specially notes that some of the farm workers had motor-cycles or even cars. But he foresees future troubles: we can produce only about half our food and must import the rest; our industrial supremacy has gone, and the terms of trade are moving steadily against importers of food.

Like others who know them, he praises highly the land reclamations in Holland, the most impressive in the world, though with the reservation that urban developments are throwing land out of cultivation more rapidly than new land is brought in: better urban planning could avoid this. Also he is doubtful about the ethics of British and Dutch nurserymen who between them burn a million tons of coal a year to grow early grapes and other fruits—purely luxury products: if the buyers would only wait a month or so they could obtain better flavoured fruits from the Mediterranean countries. Actually by far the chief products are tomatoes, cucumbers, lettuces, and other salads badly needed in our diet.

Italy deservedly receives considerable attention: no other country is experimenting with so great a variety of agricultural economic systems to deal with the problems of too many people multiplying too rapidly and trying to live on too few resources. The range is widened by the circumstances that the natural conditions are favourable in the north but become less and less so in travelling southwards. Individualist, communist, co-operative, metayage, mandatory labour, and other systems are under trial.

Having completed his wide survey ranging from primitive African to intensive Western European systems Prof. Dumont summarizes his conclusions. The greatest obstacle to agricultural progress lies in the smallness of the units in many countries. He is all in favour of the large, indeed the very large farm, and prefers the Russian collective or the Eastern European group-cooperative to the Western capitalist system, but only on the condition that membership be genuinely voluntary. He sees, however, the danger that it may foster the growth of a swollen and incompetent bureaucracy. Against the large capitalist farm are the facts that it is based on the profit motive, which he heartily dislikes, and that the workers lack the spur of personal interest—he does not discuss bonus payments. Whatever the system, however, capital must come in from outside to provide the necessary equipment: he gives striking examples showing the enormous benefit thus conferred. Prior to 1820, there was, perhaps, a ten-fold difference in efficiency between the various systems of agriculture in the different countries he has studied: the production of one cwt. of grain required about three-quarters to 7½ days of labour. The native African and Asian systems still require this. But in the highly developed countries the difference is enormously widened: it is no longer tenfold but more like forty- or fifty-fold; indeed, in the Corn Belt of the United States 5 hours' labour suffices to produce 24–48 cwt. of hybrid maize. The British reader will note that the period concerned corresponds exactly with that of industrial development, and will draw the conclusion that industrial and agricultural development must proceed *pari passu*, that agriculture advances best where workers can be taken off the land and put into factories to provide it with capital and to make the implements, the fertilizers, pest- and weed-control and other agents necessary for high output; when also a teaching organization has been developed to educate the farmers and farm workers, and a research organization to discover the principles governing the growth of plants and of animals so that new and better methods may constantly be devised and tested. Prof. Dumont prefers to insist on a fundamental re-orientation of national effort: the substitution of the present system of economy based on profit for one based on the fight against world hunger. This would necessitate a planned economy imposed on large-scale units operated on liberalized communist lines which he thought he saw emerging, and for which he pleads in an eloquent peroration. But this was written in 1953: in a postscript added in 1957 he sadly records the shattering of his hopes by the tragic events in Budapest.

The book is extremely interesting, written in the best French tradition of idealism tempered by a shrewd sense of the practical. Mr. Douglas Magnin, the translator, has done his work well, and his text reads as smoothly and persuasively as the original.

E. John Russell

THE CHEMISTRY AND BIOCHEMISTRY OF THE REDUCTONES

Chemie und Biochemie der Reduktone und Reduktonate

Von Prof. Dr. Hans von Euler und Prof. Dr. Bernd Eistert. Pp. xi+344. (Stuttgart: Ferdinand Enke Verlag, 1957.) 47.40 D.M.

The compounds designated reductones contain the grouping R—C(OH)=C(OH)—R'. As would be expected from their structure they display intense chemical reactivity, notably in their reducing power towards reagents such as dichlorophenol-indophenol (Tillmans reagent). The endiol grouping is found in a wide variety of organic substances, including both synthetic materials and substances of natural origin. One of the most important of these is L-ascorbic acid (vitamin C) and interest in the very novel problems encountered during the study of ascorbic acid and its analogues stimulated investigations into the general problems of reductone chemistry.

In the present volume three of the principal workers in the field, namely, H. von Euler, B. Eistert and H. Hasselquist, have collected together information from a wide range of publications and have presented it in a form which makes it readily available to other workers in this field. A brief glance at the lengthy list of names of authors and substances given in the index and at the very numerous references to original papers recorded page by page in footnotes will suffice to show that their task has been truly formidable. An astonishing variety of topics is discussed in the course of twelve chapters and a short appendix. Methods for the recognition and determination of reductones are given in detail in the first chapter, followed by a chapter on the endiol forms of the aliphatic and aromatic acyloins. This leads to a discussion of the complex forms of tautomerism displayed by the reductones. There are detailed accounts of the chemistry of the simplest member (triose reductone) and its derivatives, of reductones containing thiol or amino groups, aromatic and heterocyclic reductones, vinyl-homologues of reductones, and substances of the reductic acid type. Two of the main chapters are devoted to ascorbic acid and its derivatives, and to a consideration of the biochemistry of vitamin C and its analogues.

The book will be of great value to all whose work involves compounds containing the endiol system ($—C(OH)=C(OH)—$) or its dehydro form ($—CO—CO—$). Clear accounts are given of the theoretical background to the synthetic reductones, but in the important case of L-ascorbic acid one looks in vain for a connected statement of the evidence upon which the accepted structure is based. The necessary information is indeed recorded (although in ref. 7 on p. 196 the name of the journal is incorrect), but it is found in various places, and there is little indication of the many fundamental problems presented by the chemistry of ascorbic acid and its analogues.

In the chapter on biochemical aspects—where admittedly the number of possible references is legion —it is a pity that an omnibus reference to a review article (p. 305) should tend to obscure the very important part played by S. S. Zilva in the development of our knowledge of vitamin C. In view of the recent work by Calvin, it is doubtful whether many chemists would agree that glycolaldehyde (p. 298) or formaldehyde (p. 309) can be regarded seriously as precursors of the carbohydrates in photosynthesis. One feature is, however, well brought out in this section—namely, the extraordinary complexity of the problems involved in ascertaining the biological role taken by L-ascorbic acid and the little progress that has been made in this field despite all the efforts of the past few years.

It is clear that the reductone system still holds many important secrets both for the chemist and the biologist to uncover. E. L. HIRST

PHYSIOLOGICAL OPTICS

Light, Colour and Vision

By Prof. Yves Le Grand. Approved translation by Dr. R. W. G. Hunt, Dr. J. W. T. Walsh, and F. R. W. Hunt. Pp. xiii+512. (London: Chapman and Hall, Ltd., 1957.) 63s. net.

THIS book is a translation of Vol. 2 of Prof. Le Grand's "Optique Physiologique", and the first word must be one of congratulation to the team of translators. They have done a first-class job, as we might indeed expect they would, and they can derive much satisfaction from the fruit of their very considerable labours. There has evidently been close and cordial co-operation between author and translators, and the opportunity has been taken to report work of more recent date than 1948, when the French edition was first published.

The book is essentially a survey of researches on visual perception, with the main emphasis on colour vision. Comparison with Helmholtz's "Physiological Optics" is suggested on the jacket, but perhaps a more valid parallel would be with Parsons's "Colour Vision". Certainly, Sir John would have rejoiced, if he had lived a few weeks longer, to have seen the publication in Britain of this worthy successor to his own book, which was itself a landmark in the development of the subject.

The contents are divided into two Sections, with Section *A* headed "Experimental Facts", and Section *B* "Theories of Vision", but the merits of this division are not too clear. Thus, of the five chapters comprising Section *B*, three of them deal with the anatomy, the photochemistry and the electrophysiology of the retina respectively, and are primarily factual rather than theoretical. On the other hand, in the fifteen chapters comprising Section *A*, covering radiation, photometry, colorimetry, normal and anomalous colour vision, thresholds of various sorts, and spatial and temporal effects, a number of theoretical tit-bits have crept in.

One of the most effective of these is on p. 271, where the author discusses Fechner's integration of discrimination steps to produce a scale of sensation *S*. He concludes that "it may be questioned whether there is any reality in this quantity *S* which has lost all the attributes that are needed for a scale of constant intervals and that were assigned to it by Fechner in order to define it". In spite of this denunciation, the logarithmic relation between stimulus and sensation will no doubt continue to plague us for many years to come.

Le Grand's balanced account of colour vision theories does not conceal the fact that he himself is a Young–Helmholtz 'three-components' man and he regrets the disfavour into which Young's theory has undeservedly fallen among certain physiologists. Of the zone theories which are an elaboration of Young's theory, he recognizes that they may correspond with physiological facts, but that only experiment can confirm or deny this. He also reminds us that whatever the retinal basis for colour discrimination may be, the identification of the messages between retina and brain, and their decoding in the brain, have still to be explained.

Occasionally, Le Grand's judgment seems to falter, as when he suggests on p. 287 that all colour threshold problems can be solved from the discrimination ellipses in the chromaticity chart. Again, the manner in which on p. 302 he brushes aside after-images as an annoyance to the physicist, apparently unworthy of his study, is somewhat out of keeping with the general tenor of the book. Then his reference on p. 336 to the experiments by Horner and Purslow, in which the size of field was found to affect the red-green mixture required to match a yellow in the Nagel anomaloscope, does not explain that their observations were made with an unrestricted natural pupil and with the observer stationed at various distances from the anomaloscope field. The phenomenon is of very real interest, but it seems to be connected more with the pupil diameter than with the size of field, since the same effect is not observed with an instrument using an artificial pupil.

But these are minor criticisms of what is undoubtedly a very fine book. It is written by a physicist who has himself made notable original contributions, both theoretical and experimental, to the subject of vision, and who has taken a keen interest in its historical background. Above all, he brings out the mystery which still surrounds most visual problems and which adds so much to their attraction. For their complexity and inherent scientific interest, they compare favourably with the problem of launching a *sputnik*, their study is far less expensive and their solution is happily not a matter involving national military prestige. W. D. WRIGHT

Organic Reactions

Vol. 9. Edited by Roger Adams, A. H. Blatt, Arthur C. Cope, David Y. Curtin, Frank C. McGrew and Carl Niemann. Pp. viii+468. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 96*s*. net.

EVERY new volume in this series, which began in 1942, receives a warm welcome from research workers, teachers, and advanced students concerned with reactions capable of wide application in organic chemical synthesis. Many such reactions find repeated mention in text-books and laboratory manuals of organic chemistry; but usually such references are confined to a specific application, give no general survey of the scope of the process concerned, and fail to indicate its limitations, disturbing influences, and variations of practical technique. These omissions are fully met in "Organic Reactions", every volume of which contains a series of chapters each devoted to a single reaction, or sometimes to a definite phase of a reaction, of outstanding synthetic importance.

The seven chapters of the present volume, written, as usual, by workers actively engaged in the several fields, deal with the cleavage of non-enolizable ketones with sodium amide, the Gattermann synthesis of aldehydes, the Baeyer-Villiger oxidation of aldehydes and ketones, the alkylation of esters and nitriles, the reaction of halogens with silver salts of carboxylic acids, the synthesis of β-lactams, and the Pschorr synthesis and related diazonium ring-closure reactions. The account of the alkylation of esters and nitriles is by far the longest of these contributions: discussions of mechanism, scope, methods, and experimental conditions, are supplemented by twenty tabulated summaries giving the alkylating agent, product, yield, and base for an extensive variety of specific esters and nitriles. This chapter alone contains more than a thousand references to the original literature; and, in general, the work is admirably documented and indexed. JOHN READ

Mathematics and Statistics for use in Pharmacology, Biology and Chemistry

By L. Saunders and R. Fleming. Pp. x+257. (London: The Pharmaceutical Press, 1957. Published by direction of the Council of the Pharmaceutical Society of Great Britain.) 27*s*. 6*d*.

THE authors have attempted to provide a course adequate for honours students in pharmacy whose mathematical knowledge is slight. Early chapters summarize the elementary rules of indices and logarithms and principles of algebra and graphs. Differential and integral calculus, trigonometry, and differential equations are all covered within 110 pages. Apart from some carelessness of phrasing, such as describing a determinant as an operator, the text seems sound, though naturally without mathematical rigour. Whether it could in fact be understood by the students for whom it is intended is more doubtful; it seems more likely to be of service to graduates who have previously studied mathematics more thoroughly but who need a much-condensed revision course.

The second half of the book is concerned with probability and statistics, and is less satisfactory. The text is marred by a number of wrong or misleading statements about populations and samples, expectation, degrees of freedom, and other fundamental ideas. It is difficult to imagine these chapters as adequate even for revision purposes, although the extent of the statistical methods that the authors regard as important for pharmacists is encouraging. The final chapter on quality control and acceptance sampling of pharmaceutical products and errors of dispensing is by far the most interesting in the book; this certainly deserves careful study, and could usefully be developed more fully. D. J. FINNEY

The Support of Medical Research

Edited by Sir Harold Himsworth and J. F. Delafresnaye. (A Symposium organized by the Council for International Organizations of Medical Sciences.) Pp. xi+170. (Oxford: Blackwell Scientific Publications, 1956.) 17*s*. 6*d*. net.

THIS book is a report of a conference which the Council for International Organizations of Medical Sciences held in London late in 1954 under the joint auspices of Unesco and the World Health Organization. The meeting was well attended, and provided the participants with an opportunity for informing each other how research councils and similar institutions operate in their respective countries. It also made possible the statement of views on the desirability of medical research in universities being financed both directly out of university funds and out of subventions from outside bodies, such as the Medical Research Council in Great Britain. The several ways by which central research organizations can support medical research were also discussed, as was the training and recruitment of medical research workers. Appendixes to the book provide brief accounts of the arrangements for medical research which exist in the countries represented at the conference.

Buried Treasure

By Paul Johnstone. Pp. iii+67 plates. (London: Phoenix House, Ltd., 1957.) 16*s*. net.

WITHOUT doubt the television programmes on archæology, organized by Paul Johnstone, have much increased the general interest in the subject. His advisory panel has consisted of experts in the various aspects of the study with the result that viewers have had of the best and not merely second-hand material. The book under review is an account by Johnstone of the various programmes he organized. Piltdown was long supposed to be the earliest human skull found; the exposure created a stir which spread well beyond purely scientific circles. It was right that the story of Piltdown and its true significance should be given in the first chapter. But though Piltdown has had to go, there still remains *Australopithecus* in South Africa, and it is logical that a study of this early creature should follow. The earliest appearance of art and how the artists worked continues the story into late Pleistocene times. Accounts of Jericho, the neolithic stone temples in Malta, Stone Age house building, and the great West Kennet Long Barrow come next; and this leads on to a description of the recent work done at our greatest stone monument of all, Stonehenge. Finally, there are chapters on the Etruscans, on the Gaulish finds at Châtillon-sur-Seine, on Maiden Castle near Dorchester, and on the discoveries made in the Tollund peat bog in Denmark of the well-preserved body of a prehistoric (Iron Age) man. The book is richly illustrated, and there is a short bibliography.

M. C. BURKITT

DR. IRVING LANGMUIR'S CONTRIBUTIONS TO PHYSICS

By DR. ALBERT W. HULL
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SIR ERIC RIDEAL'S excellent tribute to Dr. Irving Langmuir (*Nature*, **180**, 581; 1957) emphasizes, very properly, his contributions to chemistry. To those of us who had the privilege of working with him, Dr. Langmuir was unsurpassed also as a physicist; and could equally well have received the Nobel Prize for his contributions in physics.

Sir Eric has mentioned Langmuir's study of the loss of heat from electrically heated wires in gases. This had been the subject of his Göttingen Ph.D. thesis—a very unexciting subject, but see what it led to in his hands! On coming to the General Electric Research Laboratory, he was quick to grasp the opportunity afforded by Coolidge's development of drawn tungsten wire, and spent the first three or four years carrying heat-loss studies to higher temperatures. At one point Dr. Whitney, director of the Laboratory, had to defend Langmuir before the board of directors, who thought he was wasting his time. "You leave Langmuir alone," Dr. Whitney said; "he is doing good work." The results proved it.

One of these results was his equation for heat loss, which he represented as conduction in a stationary film around the wire, with convection outside this film. In discussing this equation with him soon after its publication, I commented that the mechanism seemed artificial. He made the excellent reply: "What difference does it make, provided it gives the right result?"

Shortly thereafter he justified this theory by calculating, and then demonstrating experimentally, that the loss of heat from a lamp filament in nitrogen at atmospheric pressure could be made even less than in vacuum by coiling the wire in a tight helix, thus effectively increasing its diameter and hence the thickness of the 'stationary' film.

It was inevitable that Langmuir should observe a deviation from this equation in the case of hydrogen, namely, a large increase of heat loss above 2,200° C. This he explained correctly as due to the dissociation of the hydrogen into atoms. It was several years later when, in response to a letter from R. W. Wood, asking why a platinum wire in a remote part of a tube carrying a glow discharge in hydrogen should become white hot, Langmuir answered at once, "Association of hydrogen atoms to molecules at the wire". Thinking of this, Langmuir reasoned that if the dissociated hydrogen from an arc discharge were blown against a metal a great deal of heat could be delivered to it—the hydrogen welding torch.

Langmuir's interest in tungsten filaments led him, in 1912, into electronics, the field that was to prove so fruitful in his hands. Several years previously, O. W. Richardson had published his famous equation of electron emission. Langmuir noted that this equation predicted for tungsten, near its melting point, an electron emission of several hundred amperes per square centimetre. He tried it, and found not amperes, but only milliamperes. The emission followed Richardson's equation only up to a certain temperature, above which it became saturated and depended only on voltage. I happened to be visiting Langmuir when he made this discovery—I was teaching at the time. He described fully his experiments, with none of the secrecy that was not uncommon at some places at the time, and said: "It should be possible to apply Poisson's equation to this". He did, and the result was his famous law of electron space-charge, which became the basis for the great electronic tube developments that followed. He devoted considerable time to the calculation of accurate space-charge formulæ for cylindrical and spherical electrodes, and the voltage gradient in electron tubes, including the important voltage minimum resulting from the initial velocities of the electrons.

Early in his electron-emission studies Langmuir noted an enormous increase in electron emission when he used, instead of pure tungsten wires, the 'thoriated tungsten' lamp wire, to which ½ per cent of thorium oxide had been added to prevent large crystal growth and 'off-setting'. The observation itself was a tribute to his careful vacuum technique, in this case the immersion of the entire tube in liquid air to avoid contamination by water vapour from the glass. But his explanation of it is a marvellous example of his insight into physical phenomena. He visualized, and proved, that the thorium oxide is partially dissociated by the tungsten, releasing thorium atoms which diffuse to the surface and form a strongly adherent monatomic film, of lower work function than tungsten metal. These thoriated tungsten filaments are standard components of to-day's medium-power tubes.

A key feature of Langmuir's early research was good vacuum. The pumps available were clumsy and slow. In 1915, W. Gaede published an article on his 'diffusion pump'. Langmuir at once concluded that the action of this pump was not diffusion, but mechanical transport of the gas by mercury vapour atoms. He proceeded to design a high-speed 'condensation pump', in which a large blast of mercury vapour sweeps the gas before it, and then condenses on a water-cooled wall and runs back to the boiler. All high-speed high-vacuum pumps used in electronics and nuclear physics to-day embody this principle.

In 1922 Langmuir turned his attention to low-pressure gas discharges. He predicted and proved experimentally that a negatively charged electrode in a gas discharge is surrounded by a 'positive ion sheath', containing positive ions but no electrons; and that an insulated electrode must charge itself negatively, sufficiently to repel all but a small fraction of the electrons moving toward it; the amount for mercury vapour being 7–16 V., depending on the pressure. This showed that all previous measurements with probe electrodes had been in error by amounts of this magnitude. He then demonstrated, in a series of brilliant experimental studies, two correct methods of measuring potential in a discharge, one using a heated electrode, the potential of which is adjusted until the electrons emitted by it are just able to escape; and the other a 'kink' in the semi-logarithmic plot of the volt-ampere characteristic of a cold probe. These methods have become standard procedures.

His quantitative theory of the positive-ion sheath showed why a negative voltage on the grid of a thyratron cannot interrupt the discharge, since each grid wire is surrounded by a thin positive-ion sheath that insulates it from the discharge.

He explained correctly the increase of pressure toward the anode end of a tube as the reaction of the oppositely directed momentum delivered to the glass walls by the positive ions.

Langmuir's classic studies of the adsorption of cæsium on tungsten, begun in 1923 and carried on intermittently for fifteen years, are a beautiful example of the combination of physics and chemistry in a pioneer investigation. The experimental part was physics, an extended series of measurements, first with K. H. Kingdon and later with J. B. Taylor, of the electron and positive-ion emission from tungsten wires in cæsium vapour. He predicted and verified experimentally that at high temperatures, where the work function of the clean wire (4·6 V.) is greater than the ionizing potential (3·9 V.) of the vapour, every cæsium atom that struck the filament left it as a positive ion; but that below 1,100° K. no positive ions were formed, because the fraction of the surface of the wire that was covered with cæsium reduced its work function below 3·9 V. Also that there was no positive-ion emission from a thorium-coated thoriated tungsten wire, the work function of which is 3·1 V.

The chemical part of the investigation included the use of a suitably modified form of the Saha equation for thermal ionization of a gas; and an adaptation of Gibbs's equation of state to two dimensions. With this powerful approach he predicted accurately not only the emission of electrons, ions and atoms as a function of temperature and density of adsorbed atoms, but also the spreading force of these 'adatoms', their heat of evaporation and the contact potential of the partially coated filament.

One more example of Langmuir's powerful, yet simple, application of physical laws was his calculation of the light-scattering power of 'white' smoke as a screening agent. Having previously developed, in his icing studies, a method of measuring particle size, he calculated from Rayleigh's law of scattering the optimum size of particle; and then, with V. J. Schaefer, produced particles of this size, with a screening power per gallon of oil many thousands of times greater than the black smoke then in use.

A final contribution, completed shortly before his death, was an exhaustive mathematical study of the probability of induced rainfall produced by periodic seeding of clouds with silver iodide.

I cannot conclude without an affectionate personal tribute to Irving Langmuir, as a loyal friend and stimulating colleague—inadequate words—to whose inspiring influence I owe a very great deal.

THE GEOLOGICAL SOCIETY OF LONDON

By Dr. W. CAMPBELL SMITH, C.B.E.

EARLY in 1807 a small group of men actively interested in mineralogy had been brought together by Dr. William Babington for meetings at his house. Several of these men had been members of the British Mineralogical Society (1799), which in 1806 had been incorporated with the still earlier Askesian Society.

This little group, with others, making thirteen in all, primarily interested in mineralogy but recognizing the need to learn about the wider fields of the then new science of geology, became the founders of the Geological Society of London. The meeting at which the Society was founded was held at the Freemasons' Tavern in Great Queen Street on November 13, 1807.

At the second meeting the Hon. C. F. Greville was invited to become patron, Greenough was elected president, and honorary members were elected from distinguished men of science in the British Isles. The honorary members numbered forty-two, of whom five were foreigners. Foreign members as such were not instituted until 1814. Among the first of these, elected in 1815, were Leopold von Buch, Cuvier, Haüy and Werner. Baron Humboldt was elected in 1817.

Six of the thirteen founders were Fellows of the Royal Society. These were Babington and Bournon, William Allen, founder of the firm of Allen and Hanbury, Humphry Davy, then secretary of the Royal Society, G. B. Greenough, a pupil of the celebrated Werner at Freiberg, and W. H. Pepys.

The new Society grew rapidly, and the lists of members elected in the early years are full of names now famous in science: W. H. Wollaston joined the Society in 1812, William Buckland in 1813, Sedgwick in 1818, Lyell in the following year, and Murchison and Faraday in 1824. Charles Darwin, persuaded thereto by Lyell, was secretary during 1838–41 and, coming to rather later days, T. H. Huxley during 1859–63.

A royal charter had been applied for in 1824 and was granted on April 23, 1825. There were then 372 elected members, of whom 260 were resident in or within twenty miles of London. The class of honorary members ceased with the charter. Except for a decline around 1857, after the Crimean War, there was a steady rise in the fellowship to 1,361 in 1881, after which numbers fell a little, reaching their lowest in 1942 (1,067). Thereafter there has been a steady rise to the present figure of 2,326 in 1957. This considerable increase may be attributable partly to the increased interest taken in geology in all the universities and its increasing application in some industries; it is also a result of efforts of the Council to make the Society more useful to geologists, prompted thereto by the suggestions made by three of its recent presidents.

There have been few changes in the rules for Fellows and Foreign Members. A new class of Foreign Correspondents, from which Foreign Members were elected, was made in 1863, but discontinued in 1946. Women Fellows were not admitted until 1919, although proposals to this end had been made in 1889, and again in 1907 and 1909, and this in spite of the fact that many women geologists had made important contributions to the science, as indeed the Society had publicly recognized by various awards since 1893. A new class of Junior Associates was instituted in 1944 for men and women students of geology not less than eighteen and not more than twenty-three years of age.

The Society was very active from the start. Committees were set up to arrange the collection of minerals, to arrange for a uniform nomenclature, to prepare and collect mineralogical maps, models and sections of mines, and to approve communications previous to their being read before the Society.

The collection of minerals, rocks and 'extraneous fossils' grew rapidly and was of great use to the members. Its use particularly as regards British fossils was later superseded by the collection in the Museum of the Geological Survey, founded in 1835. Much work had been expended on arranging and cataloguing the Geological Society's collection by a succession of able and enthusiastic curators. A list of all the type-specimens was prepared by C. Davies Sherborn between 1891 and 1899, and a catalogue based on this list and edited by J. F. Blake was published in 1902. By this time the Library, which is one of the best in its field, was needing more space and in 1911, to make room for the books, the Society's collections were presented to the British Museum (Natural History) and the Geological Survey.

The Committee of Maps, appointed in 1809, does not seem to have been very active; but G. B. Greenough, first president of the Society, had started work on a geological map of England as early as 1808. This he presented in 1812; and it was published by the Society in 1820. The cost of drawing and engraving alone was £1,300.

It seems strange that the Society embarked on the preparation of this map, as it must have been known that William Smith had a geological map in hand. He was neither a member nor an honorary member of the Society, and he seems to have been almost ignored. However, the Society did something later to make amends for its early neglect of the 'father of English geology'.

W. H. Wollaston, who died in 1828, left the Society £1,000 to create a donation fund to aid or reward the researches of any individual or individuals of every country. The first use made of this fund was to strike a medal and to present the first Wollaston Medal to William Smith, together with the proceeds of the donation fund. Much later still, an annual William Smith Lecture was instituted. The first of these was given by W. W. Watts in 1945.

Other medals were founded much later: the Murchison (1871), Lyell (1875), Bigsby (1876), and at a still later period, the Prestwich Medal (1896). A fund was founded in 1876 by H. C. Barlow in honour of Prof. Robert Jameson, of Edinburgh. Many other bequests have been made for the encouragement of research in geology or for assistance in travel or with publications. They bear the names of the benefactors: Blanford, Daniel Pidgeon, Fearnsides, Garwood, Gloyne, Greenly, J. B. Tyrrell, Henry Woods and R. H. Worth; the last fund is especially for the encouragement of amateur geologists.

In 1945, the Anglo-Iranian and Burmah Oil Companies agreed jointly to place at the disposal of the Society a sum of money to be used to promote each year a geological tour for university students. The first of these tours was undertaken in 1946.

Apart from this, the Geological Society has not undertaken the organization of geological excursions. To the great benefit of all geologists this work was taken thoroughly in hand by the Geologists' Association, founded in London in 1858.

Quite early in its history the Society began publication of selected papers in the *Transactions*, 1811–56. These were in quarto and were profusely illustrated. There were long delays in printing the *Transactions*, and, in order to achieve a speedier reporting of papers read and of other geological news, *Proceedings* were published. These were first issued in 1826, but were discontinued in 1846 in favour of the *Quarterly Journal*, commenced in 1845 and now in its 113th volume. The present "Abstract of Proceedings", issued after each meeting, is a slightly modified form of the Abstracts first circulated to Fellows in 1857. The Society is now about to start a new publication of *Memoirs*. This new venture has been made possible by a generous bequest under the will of the late Henry Woods.

Meetings at which the results of geological research have been communicated and discussed have been, and still are, the most important activity of the Society. The earliest meetings of the Society were held at the Freemasons' Tavern, the members dining together before the meeting. Rooms were rented successively in Garden Court, Temple, and Lincoln's Inn Fields; but it was not until 1816, when rooms were taken at 20 Bedford Street, that a suitable meeting room became available. In 1828, apartments at Somerset House were granted to the Society, and there the Society remained until the move to its present rooms in Burlington House in 1874.

The practice of members dining together before the meeting continued for some years, and in 1824 the Geological Society Club was formed as a dining club limited to forty members. This Club still continues, but the hour of the Society's meeting was changed in 1915 from 8 to 5 o'clock; so the Club now dines after the meeting instead of before.

The centenary of the Society in 1907 was celebrated with great ceremony, and its proceedings are recorded in the centenary volume published in 1909. In preparation for the centenary, a history of the Society was written by Horace B. Woodward. There the real history of the first hundred years of the Society is told, and in it is recorded how the meetings of the Society have witnessed the gradual growth of the whole of geology from its beginnings. It is difficult in a few words to give any adequate account of the contributions Fellows of the Society have made to their science in the past fifty years, and what follows is the merest sketch.

One can recall now classic papers on the structure of the Highlands, cauldron subsidences and ring intrusions with their accompanying cone-sheets and dyke-swarms; great papers on the Lake District, and on glaciation; the geology of almost the whole of Wales worked out by perhaps a dozen different authors. In palæontology one recalls the papers on ammonites and the detailed zoning of the Jurassic; non-marine lamellibranchs and zoning of the Coal Measures; the flora of the Kent Coalfield; the analysis of the Pliocene flora based on the study of fossil seeds, and the later technique of pollen analysis.

Memorable papers dealing with metamorphic and volcanic rocks have greatly advanced our knowledge of these branches of petrography; and discussions on differentiation, assimilation and the more recently advanced theories on the formation of granite may have been almost as animated as some of the early discussions of the previous century.

Wegener's theory of continental drift was the subject of a discussion in 1935; rostro-carinate flints and eoliths was another subject discussed before a large audience; and, one must admit it, the most crowded of all the meetings were those in 1912 and 1913 when fragments of the Piltdown skull and the broken lower mandible and canine tooth were described.

New techniques have been introduced to the Society both as papers and as exhibits. The use of cellulose films in the study of plant remains, applicable also to graptolites and corals, in 1923 and again in 1928; the use of polarized light for the study of the minute structure of foraminifera was demonstrated in 1920; and still earlier (1917–18) the use of X-rays for a similar purpose. Another war-time paper read in February 1915 was on radioactive methods of determining geological time, and a great meeting in 1923 was Joly's lecture on the bearing of some recent advances in physical science on geology; a development from his much earlier published book, "Radioactivity and Geology".

In the early days of the Society the main interest of its members was in minerals and mines, but they soon turned their attention to the wider fields of geology and to stratigraphy. The charge that the Society has too much neglected the economic applications of geology has perhaps been justified, but there is ample evidence now of its active interest in the practical problems of the day. A lecture and papers on oil in Britain, and a discussion in 1933 on the falling water-level in the Chalk under London, attracted crowded audiences. Many papers have dealt with the constitution of coal and the structure and zoning of the coal measures, and recent methods of geophysical survey and results that have been deduced from them have been the subject of several papers in the past ten years.

There are plenty of papers and material for interesting lectures, and the lecture room at Burlington House is often crowded to capacity. The problem that faces the Society is certainly not a lack of new fields of inquiry but rather perhaps how to extend its scope and bring to the Fellows more papers on the geology of other lands. The more material needs are: space for its audience, shelves for its books, and money for its printing. Reluctantly it has at last had to raise the annual subscription to meet the rising costs. Financing printing is, however, only half the solution; the remaining problem is the ever-present one of how to persuade authors not to write until their work is as complete as they can make it, and, when they write, to aim at brevity as well as clearness in expression and condensed presentation of essential details. This was the plea of three successive presidents in the 'eighties. It is still the plea of the Society to-day.

The 150th anniversary of the foundation of the Society was celebrated on November 13, 1957, and was marked by an afternoon meeting at which the president, Dr. Leonard Hawkes, gave a brief address, followed by the thirteenth William Smith Lecture, given by Prof. C. E. Tilley. A conversazione was held in the evening in the rooms of the Royal Society and in the Geological Society's apartments. Exhibits arranged by Fellows, many university geology departments, oil companies, the Geological Survey of Great Britain, and the overseas Geological Surveys, illustrated recent progress in geology.

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NUTRITIVE VALUE OF PROTEINS

The 112th meeting of the Nutrition Society was held on October 12 at the Royal Free Hospital School of Medicine, London, and took the form of a symposium on "The Nutritive Value of Proteins", with Dr. D. P. Cuthbertson, director of the Rowett Research Institute, Aberdeenshire, in the chair.

In his opening remarks, the chairman first pointed out that the quality and quantity of our protein needs are ever present in our daily speculations of what we shall eat and wherewithal we shall be clothed, and these in turn are largely governed by the kind of food our farm animals eat. The quality of the protein in the concentrated part of the diet or ration can in some cases be enhanced by proper processing, but it is sometimes damaged. Britain's annual imports of animal protein feeding stuffs amount to 1,048,000 tons and cost £38,129,000 a year, and a considerable saving on this could be effected by avoiding damage to the nutritive value not only of these imports but also of home-produced concentrates during processing and storage, and by their proper use to balance the ration.

The problems of protein quality and quantity for animals, including man, are of importance not only to the United Kingdom as one of the world's largest importers, but also to such bodies as the Food and Agriculture and World Health Organizations. For these need to know the nature and amount of the protein-rich supplements—milk, fish, soya-bean, groundnut preparations and so on—which should be added to a basic cereal or starchy diets in order to prevent protein malnutrition and to achieve some minimum standard of adequacy.

Dr. Kathleen Henry (National Institute for Research in Dairying), in a joint paper with Dr. S. K. Kon on "The Nutritive Value of Proteins: General Considerations", pointed out that earlier concepts of nutrition divided proteins into those of first- and those of second-class quality, the former being of animal and the latter of vegetable origin. With increasing knowledge it became evident that the differences between foods as protein sources reflect differences in amino-acid composition and also that the superiority of 'first class' protein is often partly due to accompanying vitamins. We know that the distinction between animal and vegetable proteins is neither rigid nor always justified.

The value of a food as a source of protein is determined by the concentration of protein in it, the digestibility of the protein, the availability of its amino-acids for the synthesis of tissue protein, and its amino-acid pattern, particularly the content and proportions of the essential amino-acids. Digestibility and amino-acid pattern in turn determine the value of the food protein to the animal. There exist now many biological methods of assessing a protein on this basis, most of which compound these variables into one numerical expression. All are designed for, and capable of, assigning to a protein a relative order of nutritional merit and thus all can be considered as measuring its biological value.

Normally, proteins are considered in relation to their ability to promote growth or repair of body tissues or both. A protein that may be adequate for repair and maintenance in an adult animal may be less satisfactory for the combined functions of growth and repair in the young. Furthermore, the value of a protein for certain functions, such as replacement and building of specific plasma proteins, hæmoglobin and enzymes, may be quite different from that for the repair of body tissues as a whole.

Dr. Henry then dealt with the amino-acids essential for different species and at different ages, and the need both to secure that the amino-acids are present in the correct proportion, and to satisfy the energy requirements for maximum utilization of protein. She also dealt with mixed diets, the supplementary effect of proteins and the timing of their administration. It was stressed that the assessment of quality from amino-acid composition requires confirmation from feeding experiments. The effects of heat treatment were considered briefly in relation to culinary needs, elimination of toxic effects and preservation.

"Biological Methods of evaluating Protein Quality" was the topic of a paper by Dr. A. E. Bender (Bovril, Ltd.). He stressed the need to realize the nature of the conventional tests for protein quality and to appreciate the significance of the results derived from them. He dealt first with the methods of assay: the screening tests to give approximate grading, the protein efficiency ratio for growth, the net protein retention, the rat-repletion method and the microbiological technique. Next, Dr. Bender dealt with quantitative measurements, the Thomas–Mitchell method which measures the percentage of the absorbed nitrogen retained in the body and is termed the 'biological value', the 'nitrogen-balance index' introduced partly to avoid measuring endogenous excretion required in the preceding method, the carcase-nitrogen method which may involve only a simple water determination, the 'egg-replacement value' used mainly in human experiments, and growth and nitrogen balance methods. Various indirect methods were also outlined.

What is often required, however, is an experimental version of a field test, and here the gross protein value test has proved very useful. The diet is based on the normal practical diet of cereal, fed at 8 per cent protein-level, supplemented with 3 per cent test protein. The diet thus simulates husbandry conditions in which a knowledge of the nutritive value of the combination is required rather than the biological value of the concentrate alone. The gross protein value is the extra growth produced (beyond that on the control ration) divided by the supplementary protein eaten in a two-week experiment.

All measures of protein quality are essentially a function of the limiting amino-acid: the tests yield no information about the other amino-acids. The 'biological value' or the 'protein efficiency ratio' are not complete descriptions of a protein, since it is possible to find two proteins with the same biological value but with differing amounts of the non-limiting essential amino-acids.

Dr. K. J. Carpenter (School of Agriculture, Cambridge) then dealt with "Chemical Methods of evaluating Protein Quality". He stressed the impossibility of devising a single test (chemical or biological) that will give the answer for all circumstances. Analysis for amino-acids takes too much time and gives no information about digestibility or availability. A number of quick laboratory tests have been developed for foods to answer the needs of specific industries.

Of the cereals, only maize has been shown to be of variable protein quality, and that appears to be inversely related to the nitrogen content. Baking has little effect on quality, but the processing of breakfast foods may be deleterious.

Taking soya-bean oil meal as the principal example of the oil-seed meals, Dr. Carpenter pointed out that it requires some heating to destroy a trypsin inhibitor and so attain maximum value. The destruction runs parallel to, and may be followed by, the fall in urease activity. Heating beyond this maximum damages protein quality. Solubility tests carried out directly on the meal will give a measure of this damage; they are not effective with enzymic digests prepared from the meal. The enzymic release of specific amino-acids (estimated microbiologically) points to the 'locking-up' of lysine in overheated samples. Formol-titration similarly reflects damage by following the reduction of free ε-NH_2 groups, particularly that of lysine. In cotton-seed meal, quality control is complicated by the toxicity of the gossypol present and its apparent interaction with protein quality.

Animal products used in animal nutrition—fish and meat meals—present special difficulties because, in addition to changes induced by varying processing, the amino-acid composition of the raw material may vary considerably.

Animal products are rated highly because of their high concentration of nutritionally available lysine. As for the oil-seed meals, heat damage reduces the availability of the lysine. On the hypothesis that lysine is nutritionally available only when its terminal NH_2-group is free, a recently developed method measures 'available lysine' as the dinitrofluorobenzene derivative. The results obtained with a series of fish, whale and meat products have shown a close correlation with corresponding results from chick-feeding tests under conditions that emphasize the lysine contribution of the test materials.

The sulphur amino-acids are possible alternatives to lysine as the limiting amino-acids. Dr. Carpenter hoped that processing damage to lysine and cystine (more susceptible than methionine) might be roughly parallel, though the presence or absence of oxygen may upset this.

Dried milk, the product of a very even raw material, is exceptionally subject to processing damage; the dinitrofluorobenzene method and microbiological assay of an enzymic digest gave parallel rating of quality. For the evaluation of mixed diets this latter method was thought to be the most effective.

"The Importance of Protein Quality in Animal Feeding" was described by Dr. Gabrielle Ellinger (Rowett Research Institute). Economy in the use of protein may be exercised by the correct allocation of concentrates to practical rations, and by the conservation of quality during the production of concentrates.

Currently, practical rations for non-ruminants are compounded to contain protein in excess of requirement to compensate for the fluctuations in the quantity and quality of protein in available feeding stuffs.

To have practical significance, the evaluation of concentrates must be for their capacity as supplementary protein. The cereals, used principally as sources of energy for fowls, contribute 40–65 per cent of the total protein in some practical rations according to the classes of poultry concerned. Similarly, in pig rations 50–70 per cent of the protein is derived from cereals according to the proportion of millers' offals and bran included. Related to the chick's and pig's requirements for the essential amino-acids, the proteins of wheat, barley, oats and maize are deficient mainly in lysine and rather less deficient in the sulphur amino-acids. Maize is also deficient in tryptophan. No processing damage is involved, although feeding quality of maize is known to vary with variety and fertilizer treatment.

Beyond the quantitative supplementation of the cereal proteins, therefore, concentrates must compensate for the failure of cereal proteins to contribute their share of the essential amino-acids. The concentrates that are offered as feeding stuffs may be derived from a wide range of raw materials and differ greatly in their amino-acid composition. Processing damage introduces further variations in the protein quality of any given concentrate. Lysine and the sulphur amino-acids are not only the acids most subject to damage but also, being the limiting amino-acids in the cereals, their concentration largely determines the supplementary value of the concentrates.

The critical level of protein in the test rations must be considered in relation to the energy content. The highest critical level of protein at which additions bring no improvements and reductions a fall in production is in itself a measure of protein quality, and has been used for grading certain concentrates as supplements in pig rations. Alternatively, in the gross protein value experiments, concentrates fed at a constant and very low level of protein contribution and compared with standard protein have been effectively graded according to the heat damage sustained. A concentrate fed for its contribution of a particular amino-acid may be evaluated in terms of the availability of that acid.

Prof. B. S. Platt and Mr. D. S. Miller (Human Nutrition Unit, Medical Research Council), in their paper on "The Quantity and Quality of Protein for Human Nutrition", reviewed some of the findings of earlier workers in this field which are too frequently neglected. They also directed attention to the more recent Princeton Conference on Human Protein Requirements and their Fulfilment in Practice and to Terroine's emphasis on the distinction between physiological requirement—the minimum amount of protein required to maintain nitrogen balance—and the hygienic requirement—the amount needed under the stresses of everyday life.

Many of the difficulties of prescribing a diet for the human subject are concerned with (*a*) the complexity of the mixtures eaten by man; (*b*) the nature and timing of snacks and meals; (*c*) the effect on food values of a wide variety of methods of processing, including cooking; (*d*) the level in the diet, not only of protein but also of other sources of energy—fats and carbohydrates—and of various vitamins and minerals; and (*e*) the balance between the proteins and several other dietary factors. In some human dietaries, better protein utilization might be achieved by providing additional amounts of either fat or carbohydrate or both, thereby not only preventing wasteful burning of protein but also inducing a protein-sparing action. We do not know whether the pattern of amino-acid requirements is the same for maintenance as for growth of the young or, therefore, whether there are additional needs of the mother during pregnancy and lactation. However, the validity of the methods for the determination of the physiological requirement of an individual for a specified protein or for the essential amino-acids is fairly well established, although it is still not understood, for example, (*a*) why in Rose's experiments it was necessary to have such a high calorie intake; (*b*) why the ratio of infant to adult requirements per kilogram of body weight is so much higher when expressed in terms of essential amino-acids (about 10 : 1 for most amino-acids) as compared with the ratio in terms of reference protein (about 5 : 1); (*c*) what the composition and amount in a diet of nitrogenous matter other than the essential amino-acid nitrogen should be; and (*d*) what determines the variations in physiological minima for nitrogen for different individuals. The importance of zymotic factors in the production of protein malnutrition has not yet been fully appreciated.

Possibly for maize and most certainly for cassava pap, the volume of the infant stomach must be a limiting factor in adequate protein nutrition of the young child. The necessity in these circumstances of providing food rich in protein is clear; this may be most conveniently and desirably provided as human milk, but where the diet is low in protein the problem of extra supplies of good protein is simply shifted to the mother who can, however, utilize cruder sources of supply than can the young child.

The final paper of the session was on "Nitrogen Balance following Injuries" by Dr. J. P. Bull (Medical Research Council, Industrial Injuries and Burns Research Unit, Birmingham). Dr. Bull pointed out that the circumstances, nature and timing of injury and the corrective procedures are sufficiently different to make one cautious in accepting an operation as a very close analogy to accidental trauma. In the latter Dr. Bull considered that the overall nitrogen balance is not entirely informative when one considers losses of whole protein, as in exudate or hæmorrhage and transfusions of similar materials on the same basis as oral feeding and urinary and fæcal losses. There is no possibility of an initial stabilizing period in accident cases, and the previous nutritional status cannot be known with precision. In the more severe injuries, therapy must necessarily be varied to meet individual requirements; nutrition is only one of these, and must be changed to permit other procedures.

It has been shown that intravenous plasma protein is only slowly metabolized, and if nitrogen is so given in excess it will be excreted in the urine only after several days. Correspondingly, after transfusion of red cells, excretion of excess nitrogen is even longer delayed. Furthermore, if there has been loss of plasma, as from a burn, or loss of blood from other injuries, intravenous replacement may be virtually direct, so that neither the loss nor the transfusion should appear in the nitrogen balance on the same basis as oral and urinary exchange. Even the quantities accepted for calculation are suspect; digestion and absorption of orally fed protein may well be disturbed in the severely injured patient, and renal excretion of nitrogen is frequently depressed. When one considers the details of the balance sheet within the body, the situation is clearly more complex again. Whatever the overall balance may be, the internal economy of nitrogen is grossly deranged, as shown by changes in plasma proteins.

There appears to be a general increase of catabolism, possibly combined with a diminished anabolism of protein in which adrenocorticotrophin and adrenal cortical hormones may well be playing a part. Prior depletion of protein prevents the increased excretion of nitrogen after injury. It thus seems likely that the more labile protein stores are first used, and when these are exhausted further tissue protein is not raided.

Dr. Bull reported a comparison of nitrogen input with renal nitrogen output in patients who had been adequately treated by transfusion, and found little difficulty in obtaining 'apparent positive' nitrogen balances. Though this clearly does not represent the whole story, it should be remembered that comparison of intake with renal output is the main ground for claims that the 'catabolic phase' makes negative balances obligatory. From this point of view exudate losses should not necessarily be included, since they do not represent catabolism but rather loss of part of an organ equivalent perhaps to an amputation or plasmaphoresis.

Dr. Bull considered that, in the present state of knowledge, the following principles seem rational: (1) Where there are known losses of blood proteins, these should be replaced by transfusion. Plasma and blood are the rational replacement fluids for burns, and blood transfusion for other injuries. Recent studies show that these losses are greater than has previously been assumed, and we are probably only now beginning to obtain adequate correction. (2) Generous protein and calorie supplies should be available for the injured patient in his diet. Many ordinary hospital diets are inadequate in this respect. (3) There is no practical limit to the amount of nitrogen which can be given, either intravenously as hydrolysate or amino-acid mixtures or as oral high-protein tube feeds. It is rational to minimize the loss of nitrogen and to anticipate the subsequent strongly anabolic phase of healing by supplements to ordinary feeding. Inputs of the order of 0·5–1 gm. of nitrogen/kgm. per day and 40–60 Cal./kgm. can be given to the more severely injured patients. (4) In the severely injured patient a multitude of complex processes are at work, and it is presumptuous to expect them to be explained under any single simple theory.

In winding up the symposium, the chairman said that there had been brought to light the need for a clearer definition of terms and a more thorough appreciation of the older literature, which is liable to be forgotten or ignored; that chemical analyses, though useful guides, are not enough by themselves and that the product must, in general, always be tested biologically in the way it will be used; and that there are problems of quality in protein nutrition of man in health, when injured or diseased, that warrant much further study.

D. P. CUTHBERTSON

RETINAL SUMMATION AND HUMAN VISUAL THRESHOLDS

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ONE of the mainstays of the duplicity theory of vision is the observation that the centre of the human fovea, which contains only cones, is much less sensitive to light than the extra-foveal regions, dominated by rods. Even at the present time, numerous workers tacitly infer from this finding that, receptor for receptor, rods are very much more sensitive than cones. Observations on dark-adaptation have suggested that the ratio of the two sensitivities may amount to several hundred or even one thousand, and the photo-chemists' apparent inability to extract and characterize cone-pigments goes hand in hand with the view that the low cone-sensitivity is due to the low *in vivo* concentration of these pigments. The plausibility of such an explanation is probably responsible for the fact that experimental evidence not in support of the above views has failed to find acceptance. It may, therefore, be of interest to try to harmonize the two sets of observations and to establish a formal connexion between them.

Lythgoe[1], Stiles and Crawford[2], Craik and Vernon[3], Baumgardt[4] and others have suggested that the large value of the ratio extra-foveal sensitivity/foveal sensitivity may well be due to the good summating properties of the peripheral retinal regions. These would be revealed particularly when experiments are carried out with medium-sized or large test-fields. But as the fovea shows relatively poor summation, visual threshold tests with small fields both in foveal and extra-foveal regions would provide more comparable data than when the fields are large. There is no doubt that this expectation is strikingly fulfilled by experiment. Fig. 1 represents a plot of the logarithm of R_I, the ratio of foveal to extra-foveal thresholds, against the logarithm of A, the size of the test-field, measured in square minutes of arc. Corrections were applied to the measured values for light absorption by the macular pigment, and, where thresholds had been measured with white light, for the non-equality of the energy distribution of the stimulus. The former factor reduces cone thresholds for white-light by approximately 0·1 log unit, the latter increases them by about 0·38 log unit. The resultant correction is small but tends to reduce the scatter of the results. The values of R_I were also calculated so as to refer to the maximum of the spectral sensitivities of dark-adapted foveal and extra-foveal regions, respectively. The letters refer to the authors, and are listed separately in the references. There is an approximately linear relation between R_I and A': extrapolation near the origin

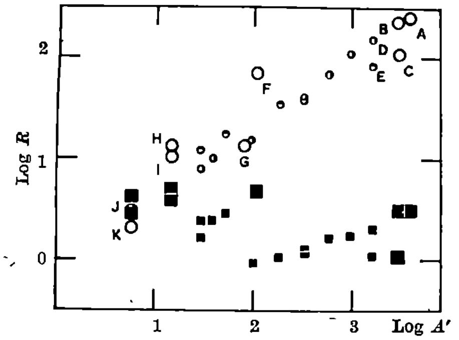

Fig. 1. Log ratio of foveal to extra-foveal thresholds in the dark-adapted human eye as a function of the test-area in log square minutes of arc. Circles: ratios expressed in terms of intensities. Squares: the corresponding values expressed in terms of the 'effective stimuli'. (The letters refer to authors listed in the references)

suggests that, for stimulus areas commensurate with the cross-sectional areas of the receptors involved, R_I approaches unity. This is to say that, when the summating properties of the retina have been eliminated, the sensitivities of rods and cones are approximately equal. Baumgardt[4] reached this conclusion readily from his own results. However, his approximate treatment of the values of R_I as observed with large values of A took no cognizance of retinal summation.

The Effective Stimulus

The concept of the effective quantity of light is of some help in this respect. It has previously been shown[5] to lead to a useful generalization of the Ferry–Porter law, and involves the rejection of light intensity as the almost exclusive factor in stimulus variation. The effective quantity Q is defined as

$$Q = I(AN)^{p} \cdot t^{q} \qquad (1)$$

where A is the retinal area stimulated by light of intensity I and for a duration t; N is the relevant receptor density in the region stimulated, and p and q are the coefficients of spatial and temporal summation, respectively. In the following discussion t^q will be assumed to be constant. The importance of the concept of Q becomes apparent as soon as one considers an orthodox dark-adaptation curve: when a non-fixating human eye is exposed to light, and then left to dark-adapt, its threshold, as measured with, say, a 1°-field, drops rapidly at first, reaches a plateau after some 2–3 min., starts dropping quickly after another 5–7 min., and approaches its final threshold after another 20 min. The first plateau represents the threshold of the cones, the second that of the rods. Yet a consideration of the effective light stimulus Q shows that the two portions of the curve are not strictly comparable, because both N and p are different for rods and cones, respectively. The intensity I can provide a measure of the effective stimulus Q only when N and p are constant. The fact that p can change with time even when N is constant[3,6,7] renders exclusively photo-chemical interpretations of dark-adaptation untenable. Indeed, for a test-field of 1° angular diameter a temporal change in p of 0·5 (cf. ref. 6) accounts for a full two log units of dark-adaptation.

The idea of the effective stimulus is readily applied to the experimental results plotted in Fig. 1. It is then seen that:

$$\log R_Q = \log \frac{Q_c}{Q_r} = \log R_I + (p_c - p_r) \log A + p_c \log N_c - p_r \log N_r \qquad (2)$$

where the suffixes r and c refer to rods and cones, respectively. The data for N_c and N_r (at eccentricities ranging from 0 to 20°) were obtained from Østerberg's[8] counts. Baumgardt[9] has determined the variation of p_c with A; these findings were confirmed and supplemented by Brindley[10]. Baumgardt also showed that, at an eccentricity of 15°, p_r is 1 for A less than 1·3°. As it was not permissible to assume that this would be true also at smaller eccentricities (and, in a relevant experiment, Wolf and Zigler[11] had altered retinal eccentricity while altering the size of the test field), additional measurements were made with a Crookes adaptometer. The region examined was 8° above the right fovea, where Wald[12] carried out his peripheral measurements. The observer, R. A. W., was dark-adapted for 35 min., without having previously been exposed to bright light. Five test-fields, ranging in angular diameter from 0·60° to 1·45°, were presented in a random manner in three different sessions. The stimulus, modified by an Ilford 624 (green) 'Bright Spectrum' filter, was exposed for 1/25 sec., and the threshold criterion was two 'seen' out of three exposures, presented in rapid succession. The results are shown in Fig. 2: the lines, reproduced from Baumgardt[9], are consistent with these results. It would appear that even with a 1° test-field, applied relatively closely to the fovea, rod summation is found to differ from that observed for cones. The values R_Q, calculated from equation 2, are shown as black squares in Fig. 1 and correspond to the values R_I plotted as white or small semi-white circles, from which they have been derived.

Two features are outstanding: first, R_Q is approximately independent of A, the size of the test-field, and secondly, it is of the order of unity. This suggests that, when allowance is made for regional differences in receptor density and for the different summating properties of the dark-adapted fovea and periphery, respectively, rod and cone thresholds are approximately equal. This is true even when they are measured with a test-field so large as to cover the whole of the rod-free area.

The above calculation has involved two simplifying assumptions, both of which tend to make the calculated values R_Q too large. The cone density N_c

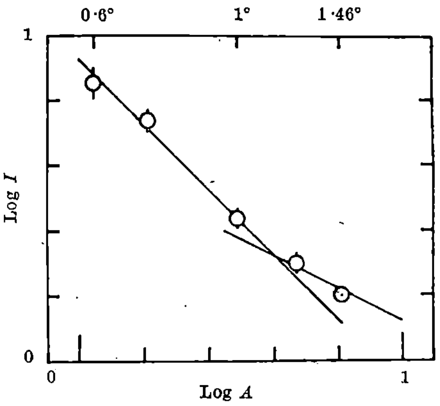

Fig. 2. Log threshold intensity (arbitrary units) as a function of the log test-field (arbitrary units). The angular diameters of the test-fields are shown at the top. Standard errors of the mean are indicated. The lines are reproduced from Baumgardt's data (ref. 9). For details see text

was taken to refer to all cones. If it is assumed tentatively that the number of 'green sensitive' cones forms only half to a third of the total, the log R_Q values corresponding to small values of A will be reduced by 0·3–0·5 and those referring to larger test-fields by not more than about 0·2. Again, the value of N_c was assumed to be constant throughout the rod-free area of the fovea. The removal of this assumption would reduce the log R_Q values for log A greater than 2·6 by less than 0·2. Owing to some uncertainty regarding the exact variation of foveal summation with area for very small areas, the R_Q values for larger test-fields are certainly the more reliable of the two. The additional corrections lead, therefore, to log R_Q values equal to, or less than, zero.

There is no need to labour the point, beyond stating that a single cone may well be as sensitive as a single rod, if not more so. It would be a bold man, indeed, who would introduce into the argument morphological differences between the two types of receptor. Cones are sometimes said to have special light-funnelling properties; human foveal cones, however, have a more rod-like appearance than the rods themselves, and one can scarcely even speculate on funnelling in a vessel the dimensions of which are comparable with the wave-length of light, and the optical properties of which are virtually unknown.

The analysis shown in Fig. 1 contains all the relevant results known to me with but three exceptions: first, Riezler, Esper and Meurers's[13], who failed to immobilize the observers' heads to an extent which is generally considered a minimum requirement (cf. also ref. 14); secondly, Craik and Vernon's[3], whose R_I value is shown in Fig. 1, but who do not seem to have specified the retinal eccentricity at which the rod portion of their results was obtained; and thirdly, Pirenne's[15], which raise a point of great interest. Using a blue test-field at 10′ angular diameter, he measured the absolute threshold in the fovea and at various eccentric locations up to 4°. Now Brindley[10] has shown that p_c equals 1 for blue test-fields as large as 13′ in diameter, whereas p_c equals 0·5 for smaller test-fields, red or green in colour. Clearly, an attempt to express a foveal threshold measured with a blue 10′-field in terms of the maximal foveal sensitivity (yellow-green) leads to an inadmissible situation, analogous to the one illustrated earlier by reference to the dark-adaption curve. As the relative number of 'blue' receptors in the fovea cannot be even guessed at, the only point which need be made is that Pirenne's observed value log $R_I \approx 2\cdot1$ reduces approximately to 1·1 when the corrections, previously mentioned, are applied. R_Q cannot be estimated.

A Photo-chemical Correlate

The approximate equality of rod and cone thresholds raises the question of the relative visual pigment concentrations in these receptors. Although there is no *a priori* reason why there should be direct proportionality between threshold and light-absorption (evidence is accumulating that such a relation need not obtain), one would not expect the concentrations to be greatly different. The first piece of photo-chemical evidence regarding this point comes from *in vivo* bleaching measurements on the squirrel's pure-cone retina[16]; it shows that the visual pigment density changes on bleaching by an amount commensurate with that found in experiments carried out on rod-retinæ. Brindley's sensory experiments[17] lead to the same conclusion.

Night Flying

The fact that, at small visual test-angles, the fovea and the periphery are approximately equally sensitive may have a practical sequel. At present, Service personnel due for nocturnal look-out or flying duties are kept in a state of near dark or red adaptation. In so far as the visual demands are only the detection of point sources of light, the sensitivity factor of not more than 5 or 6 which prolonged dark-adaptation bestows would scarcely seem to be worth the price possibly paid for it in terms of reduced morale. If the visual task involves the detection of 'dark shapes on the horizon', prolonged dark-adaptation is unavoidable. But when the object is the detection of point sources, dark-adaptation of a few minutes may well be adequate. Stars appear, after all, little brighter after 50 min. than after 5 min. spent in the dark.

Note added in proof. Since this paper was submitted for publication, Pinegin[18] has shown that, for very small test-fields, rod and cone thresholds are comparable in magnitude.

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OBITUARIES

Dr. O. G. S. Crawford, C.B.E., F.B.A.

O. G. S. CRAWFORD, who died on November 28, 1957, was one of the best-known British archæologists of his generation. Born in India in 1886, educated at Marlborough and Keble College, Oxford, where he turned from classics to geography, he soon began to make original contributions to archæology. He was impressed with the importance of studying the environment of early man, and the influence of geographical factors upon human affairs, ideas which found expression in his first book, "Man and his Past" (1921). His interests led him to undertake an archæological survey of an area near his home, which was published in 1922 as "The Andover District", and is still well worth reading. In 1913 he joined the Wellcome expedition to the Sudan, but this opportunity was cut short by the outbreak of the First World War. After a period in the infantry, he joined the Royal Flying Corps as an observer, being shot down and taken prisoner in 1918. There were few at that time who foresaw the special contributions that aerial survey could make to archæological studies, but Crawford's field-work on the chalk downs had shown him the use of shadows in studying complicated earthworks, and his war-time flying experience impressed upon him the value of the aerial view for the understanding of archæological sites.

At the time of the First World War archæological posts were few and offered little prospect of a career, but Crawford's appointment in 1920, as the first archæology officer at the Ordnance Survey, provided just the opening he needed. Until the time of his appointment, the archæological information embodied in Ordnance maps was largely in the hands of the field staff, who might have little knowledge of archæology, no matter how competent they were at surveying. The task confronting Crawford was immense; however, he found time not only for routine revision of archæological detail on the Ordnance maps, but also for the preparation of a series of 'period' maps, of which that of Roman Britain was the first and best known. The value of this work at the Ordnance Survey, undertaken with a minimum of assistance, may be seen in the official large-scale maps of the United Kingdom, which attain a standard in archæological cartography scarcely approached elsewhere. The results of Crawford's field surveys were published as individual papers or larger works, such as "The Long Barrows of the Cotswolds" (1925), an important account of a selected class of monuments.

It is probably as the pioneer of archæological air photography and as the founder-editor of the quarterly journal *Antiquity* that Crawford will best be remembered. His achievement in the first sphere culminated in the publication, with Alexander Keiller, of "Wessex from the Air" (1928), a splendidly illustrated account of an archæological air reconnaissance of Salisbury Plain and adjacent areas, which sets a new standard in archæological research. In 1928, Crawford visited the Middle East, in an attempt to secure the preservation of air photographs taken by the Royal Air Force, and to direct attention to the unique possibilities open to air photography for research in that region. He was ever keen to foster the development of the subject in Britain, either publishing discoveries himself or making known the work of others in the same field. Much of his later work appeared in *Antiquity*, over which he took great pains, making several special journeys to Europe and North Africa. If the first dozen years of that journal represent its best period, it has always provided a forum for review and criticism and for exchange of ideas on all branches of archæology.

As an archæologist Crawford had a flair for field survey, which served him well when studying earthworks, either on the ground or from the air. He was a marked individualist, gifted with considerable powers of expression, to which the pages of *Antiquity* bear witness. For such a person, relations in an official department cannot always have been easy, but he had a great capacity for friendship, and was able to awake in others something of his own immense enthusiasm for his chosen subject. He was created C.B.E. in 1950, elected Fellow of the British Academy in 1949 and awarded honorary degrees by the Universities of Cambridge and Southampton.

J. K. S. St. Joseph

Prof. W. J. Jongmans

The sudden death of Prof. Jongmans, at Heerlen on October 13, robs the world of one of its most active palæobotanists. Willem Josephus Jongmans was born on August 13, 1878, at Leyden, where he received his early education. A student of the University of Leyden and later of the University of Munich, he was awarded a D.Phil. of the latter University in 1906. In the same year he was charged with palæobotanical research in one of the Dutch Government Services concerned with fuel resources, and the following year, 1907, was appointed a curator at the Rijksherbarium in Leyden. In 1919 he was released from the post at the Herbarium to become head of one of the departments in the Government Geological Service. While holding this position Jongmans was nominated head of the office at Heerlen, which led directly to his appointment as director of the Geological Bureau of the Netherlands Mining District at Heerlen, a post which he held from 1924 until his retirement in 1946. In addition to being director of the Bureau he was, from 1932 onwards, extraordinary professor of palæophytology in the University of Groningen.

Throughout his career, Jongmans's interest was directed towards the study of the flora of the Carboniferous period, and his extensive knowledge led to the publication of many authoritative papers on the plants from such widely distant places as Limburg and Sumatra, North America and Anatolia, Peru and Egypt, Spain and the U.S.S.R. But perhaps he is best remembered in Britain for the excellent "Monograph of the Calamites of Western Europe", written in collaboration with Kidston (1915–17), and the monumental "Fossilium Catalogus", published in twenty-two parts between 1913 and 1937. Jongmans's interest was not, however, confined purely to the plants, but extended over the floral assemblages of which they had been members. Early in his life he made a specialist study of the stratigraphic relations of the Carboniferous floras and he was responsible for many publications on this aspect of palæobotany. We should remember also his very important opinions on the nomenclature of fossil plants.

Though he officially retired in 1946, Jongmans carried on active research until the very last, and he was often to be seen in the Geological Bureau, which was only a short distance from his home at Heerlen. Time was always found to welcome and encourage a visiting palæobotanist who had come to see the magnificent collections and discuss problems with the master who had done so much for the furtherance of his subject. In recognition of his services to his country and science, Jongmans had been elected an Officer in the Order of Orange-Nassau and a Knight of the Order of the Netherlands Lion.

Alan Wesley

Mr. C. T. Gimingham, O.B.E.

Through the death of Conrad Theodore Gimingham on November 16, agricultural entomologists and plant pathologists have lost one of their pioneers and dearest friends.

Gimingham joined the staff of the Ministry of Agriculture's Plant Pathology Laboratory at Harpenden, as entomologist in 1928, at a most important time in the development of agricultural entomology. The specialist biological advisory services in agriculture had started some years earlier when several young and enthusiastic biologists were stationed at universities and agricultural colleges to investigate local problems and give advice to farmers. The Plant Pathology Laboratory acted as their co-ordinating link, and Gimingham came into very close touch with all the advisory entomologists. In 1944 he succeeded the late Sir John Fryer as director of the Laboratory and as chairman of the Conference of Advisory Entomologists, with which he had been closely associated since his appointment. It was one of his great delights, and although he relinquished his chairmanship shortly after his retirement, he remained a member until his death. The modern developments in the insecticide field, with which Gimingham had much to do, started in the 1920's, and he proved to be an ideal person to guide the biologists who had become available, to see that the best use was made of the new materials provided by research and industry.

In the late 1930's it became evident that there was a real need to institute some form of approval scheme for crop-protection chemicals. It was largely through Gimingham's ability for painstaking negotiation and the deep respect in which he was held by both sides that in 1942 the Ministry and the Association of British Insecticide Manufacturers instituted the voluntary Crop Protection Products Approval Scheme. The success of this venture bears testimony to his achievement.

He was deeply occupied in phytosanitary work at home and in Europe, for example, with the Colorado beetle, and he must be given a good deal of the credit for preventing this pest from becoming established in Great Britain after the Second World War.

Perhaps Gimingham's greatest influence lay in his keen interest in the development of the younger entomologists. His quiet modesty, kindliness and sincerity made him the ideal guide, philosopher and friend. We were happy and privileged to place our trust in him, and many of us are thankful for his help.

Gimingham was closely associated with the Royal Entomological Society and the Association of Applied Biologists, of which he was president during 1938–40.

He married, in 1912, Muriel Blake, who survives him together with two sons and a daughter.

F. H. Jacob

NEWS and VIEWS

Rothamsted Experimental Station : Sir William Ogg

The retirement of Sir William G. Ogg from the directorship of the Rothamsted Experimental Station is announced to take place next September. He succeeded Sir John Russell in 1943, having previously been director of the Macaulay Institute for Soil Research, near Aberdeen. At Rothamsted he continued the expansion begun in the inter-war period, and successfully organized the inclusion of the Soil Survey of England and Wales previously directed by the late Prof. G. W. Robinson, of Bangor, bringing Dr. A. Muir from Aberdeen as the new head. As the owner and manager of a well-known farm in Aberdeenshire, Sir William has had exceptional opportunities of appreciating the new, and often difficult, agricultural problems of the post-war period and the ways in which modern science could contribute to their solution. His genial approachability has given him considerable popularity in agricultural circles, and on a variety of occasions he has been asked to undertake official visits overseas to advise on problems where his knowledge and shrewd judgment proved very helpful. His friendly relations with the Rothamsted staff enabled the expansion of the various departments to proceed smoothly, and when the Station finally obtained vacant possession of the attractive old manor house, which had been acquired with the estate in 1934, he had it converted into a hostel, thereby providing living quarters for some of the staff, as well as additional accommodation for conferences and other gatherings. His useful term as president of the Society of Chemical Industry will long be remembered. It is understood that he will retire to his farm, where all his friends and former colleagues will wish him and Lady Ogg many happy years of useful activity.

Mr. F. C. Bawden, F.R.S.

Mr. F. C. Bawden, head of the Plant Pathology Department of the Rothamsted Experimental Station, has been appointed director of the Station in succession to Sir William Ogg. Mr. Bawden, who is forty-nine, is well known for his brilliant researches on the virus diseases of plants, for which he was elected a Fellow of the Royal Society in 1949. His appointment shows the growing importance of plant pathology in Great Britain: the directorship has hitherto been from the side of soil and plant nutrition, the original, and for long the main, subject of the Rothamsted investigations. After a distinguished career at Cambridge, he went to Rothamsted in 1936 as physiologist to the Virus Disease Unit and soon attracted attention by identifying, in conjunction with his biochemical colleague, N. W. Pirie, a number of plant viruses and virus strains as nucleoproteins. They isolated in crystalline form the tomato bushy stunt virus, the first ever to be so obtained. With another colleague, A. Kleczkowski, much valuable work has been done on the serology of the viruses. New methods have been discovered of inactivating viruses without destroying their antigenicity. Mr. Bawden has also organized much valuable field work to discover the factors affecting the rate of spread of virus diseases, in the hope of finding measures of control. He has shown that he not only possesses high scientific ability and power of organization, but also that he can appreciate scientific merit in others. Under his direction, Rothamsted may confidently be expected to maintain the high position it has hitherto held among the world's institutes for the development of agricultural science.

Ministry of Agriculture, Fisheries and Food ; Fishery Research : Mr. G. M. Graham, C.M.G., O.B.E.

The Ministry of Agriculture, Fisheries and Food has announced the retirement on February 21 of Mr. G. M. Graham, director of Fishery Research. Mr. Graham has served on the Ministry's staff for thirty-eight years, having joined the staff of the Lowestoft laboratory in 1920. In his earlier years, Mr. Graham was especially concerned with research on the cod, and his work laid the foundations for our knowledge of that species in the North Sea. In 1927 he was loaned to the Government of Kenya to survey the fisheries of Lake Victoria; and in 1931 he was loaned to the Biological Board of Canada to study the herring in Passamaquoddy Bay. He was Buckland professor for 1939. Mr. Graham served with the Royal Navy during the First World War, and during the Second World War he was with the Ministry of Aircraft Production in operational research and served with the honorary rank of wing commander in the European operations with the Royal Air Force. He was made O.B.E. (Mil.) in 1946.

On his appointment as director of fishery research in 1948, Mr. Graham turned himself enthusiastically to problems arising out of the War and to the development of modern fisheries investigation. He will be especially remembered for the encouragement and direction that he has given to the mathematical treatment of the study of fish populations. During his directorship the fisheries research staff has increased greatly in size, and the number of research ships was increased to include the *Ernest Holt*, which has carried the English investigations far into the north-east Arctic. A new laboratory for shell-fish investigations was also started at Burnham-on-Crouch under the leadership of Dr. H. A. Cole. In 1954 Mr. Graham was made C.M.G.

Mr. R. S. Wimpenny, O.B.E.

Mr. R. S. Wimpenny, who has been deputy director of fishery research at Lowestoft since 1948, has been appointed director of fishery research in succession to Mr. Graham. Mr. Wimpenny joined the staff at the Lowestoft laboratory in 1925 and was chiefly engaged on plankton research, in which he advanced our knowledge of the fat content of copepods, and the biology of diatoms. In 1927 he left the Ministry's staff to become director of fishery research to the Egyptian Government. While in Egypt he established a successful fishery for grey mullet in Lake Quaroun, the mullet fry being transported by air 100 miles inland from the sea. Mr. Wimpenny rejoined the Lowestoft staff in 1932 and resumed work on plankton. He has also done research on the plaice, which was the subject of his lectures as Buckland professor in 1949.

During the First World War Mr. Wimpenny served as a pilot in the Royal Flying Corps and, later, in the Royal Air Force. During the Second World War he was district inspector of fisheries for the eastern part of the south-east district of England and was Port Fishery Captain of Rye. Since the War he has been especially responsible for leading the work of the Lowestoft laboratory in research in the near fishing waters. He has also given much time to the work of the International Council for the Exploration of the Sea, and has been chairman of its Consultative Committee since 1951. Mr. Wimpenny was made O.B.E. in 1957.

Geological Society: Awards for 1958

The Council of the Geological Society of London has made the following awards for 1958: *Wollaston Medal:* to Prof. Pentti Eskola, doyen of Finnish geologists, distinguished for his contributions to metamorphic geology, especially in regard to the redistribution of material during metamorphism, the origin of granitic magmas and the conditions during the earliest geological time; *Murchison Medal:* to Dr. R. G. S. Hudson, for outstanding researches on the Carboniferous rocks of the north of England, in particular on their stratigraphy and palæontology; in recent years his work has been connected with the search for oil in the Middle East; *Lyell Medal:* to Dr. Helen Muir-Wood for her fundamental contributions to knowledge of the Brachiopoda; *Wollaston Fund:* jointly to Mr. R. J. A. Eckford for his work on the Geological Survey in connexion with the igneous rocks of Scotland and in particular his investigations of the geology of the Southern Uplands, and to Mr. W. Manson for his work on the Geological Survey in connexion with the stratigraphy and palæontology of the Scottish Carboniferous rocks; *Murchison Fund:* to Dr. Geoffrey Bond in recognition of his researches into the Carboniferous stratigraphy and palæontology of Britain, and the Karroo system and later deposits of southern Africa; a moiety of the *Lyell Fund* to Mr. H. R. Warman for his stratigraphic and tectonic work in Sicily and South Iran, and his contribution to oil and gas exploration in the United Kingdom; another moiety of the *Lyell Fund* to Dr. Eileen Lind-Hendriks, in recognition of her researches on the geology of the Cornish peninsula.

Extension of Imperial Chemical Industries' Research Fellowship Scheme

Important changes have been made in the scheme of post-doctorate fellowships for research in chemistry, physics, engineering and related sciences offered by Imperial Chemical Industries, Ltd. Since the start of the scheme in 1944, Imperial Chemical Industries Fellowships have been tenable in a considerable number of British universities, but not in all. In future, the scheme will apply to all universities in the United Kingdom, to the University College of North Staffordshire and to Trinity College and University College, Dublin. The number of fellowships will be increased from 92 to 103. Individual fellowships will now range in value between £700 and £1,000 per annum, and the scheme is guaranteed for five years. As in the past, the universities and colleges will themselves make the appointments and draw up the regulations governing the holding of the fellowships. Imperial Chemical Industries exercises no control over the conduct of the research work. It is hoped that the scheme will help in promoting vigorous schools of research in British universities, and so contribute to the advancement of scientific knowledge upon which industrial progress ultimately depends. The enlarged scheme will cost approximately £93,000 per annum—a sum which, when added to other financial assistance given by Imperial Chemical Industries to universities and learned societies, raises the Company's total contribution to scientific education and research in Great Britain to more than £300,000 per annum.

Team-work and Discovery in Science

In his Perkin Medal Address, entitled "The Metallurgy of the Unusual", delivered before the American Section of the Society of Chemical Industry in New York on January 10, Dr. W. S. Kroll took issue with those who claim that 'the days of 'sealing wax–baling wire' science are over.' The fight of the individual against the collectivity in which he lives is as old as humanity and it will never cease to exist. While Dr. Kroll granted that the team could not be avoided in development work, he challenged its justification in research. He questioned whether leadership can be created in such a system: when teams are put to work to make important discoveries or inventions, they either fail dismally or are far too costly. He maintained that many laboratories in the United States are over-fond of gadgets and complicated equipment which often take more time to repair than to use. These instruments remove the investigator from his experiment; automatic research tools can thus be a great handicap to invention and progress. We have to offer the recalcitrant lone-wolf research worker some asylum since he is now menaced with extinction. His help is indispensable in the early stages of any new development and he acts like a scout, prospecting new territory before it is exploited by the crowd. The inventor or scientist needs self-expression and the affirmation of his personality: to try to depersonalize him in a team is psychologically a great mistake. Very great discoveries, in Dr. Kroll's opinion, are still so close to the surface that they can be unearthed with little expense by nonconformists with an inquisitive mind, with knowledge, the urge to create and who are prepared to accept sacrifice as a way of life.

Acta Meteorologica Sinica

THREE issues of the periodical *Acta Meteorologica Sinica* have been received from the Institute of Geophysics and Meteorology of the Academia Sinica, Peking. Each contains six or seven papers. The papers themselves are in Chinese but each has a summary in either English or Russian, with roughly equal numbers of summaries in each of these languages. In the issues received, all the papers are on dynamical and synoptic meteorology with the exception of one on hygrometry. Frequent references are made to recent European and North American meteorological literature. Typical titles are "A Test for 24 and 48 hr. Numerical Forecasting with a Quasi-geostrophic Two-parameter Model" and "Statistical Investigation on the Blocking Situations over Asia". It does not seem that numerical forecasting with electronic computers is yet under examination in China, but Fjørtoft's graphical method is in use. Study of the papers would be easier if titles in English or Russian were given to figures and tables and perhaps even isopleths might be labelled, and columns and rows headed in one or other of those languages. It would also be very helpful if personal names of authors could be given in Latin script as well as in the Cyrillic form.

Cleveland Museum of Natural History, Ohio

UNDER the title of "A Reason for Pride" (Cleveland, Ohio: Cleveland Museum of Natural History, 1957) an attractive booklet describes how the site of the well-known Cleveland Museum of Natural History is required for a development plan of the city and the progress that the Trustees have made with a new building. At the outset, mention is made of the great assets of this Museum, and a brief résumé is given of the chief collections assembled during the past thirty-seven years. The new site is in Wade Park and covers eleven acres. Building is already in progress, and when completed will include a Hall of Nature, a Gallery of Man, a Hall of Science, and a Planetarium. In addition, the grounds surrounding the Museum will be made into a Nature garden containing outdoor exhibits of flowers, shrubs and trees native to the Cleveland district. All exhibits, both inside and out, will be planned in sequence to cover systematically the subjects of Nature and science in all their phases.

Agricultural Research

"FUNDS for Research in Agricultural Experiment Stations, 1953–54" is No. 8 in the series "Reviews of Data on Research and Development" issued by the U.S. National Science Foundation. Expenditures for research by agricultural experiment stations in the United States increased tenfold from 7 million dollars in 1920 to more than 74 million in 1953–54; 17 million for basic research and 57 million for applied research. Research funds for these stations came, for the most part, from the State governments and supplemented the core of support provided by the Federal Government. The States accounted for 45 million dollars; the Federal Government for 13·5 million, and other sources, such as sales and royalties, for 16 million. The 53 stations, practically all administered by the land-grant colleges and universities, are the fountainhead of agricultural research in the United States. The largest amounts were devoted to animal production and field crops; the smallest, to genetics and farm forestry. Copies of the report can be obtained from the National Science Foundation, Washington 25, D.C.

Tetrahydrothiophen

TETRAHYDROTHIOPHEN (called tetrahydrothiophene in the trade) is a colourless liquid with a fairly high boiling-point (above 120°) but low flashpoint (64° F.) which is now in production in England by Robinson Bros. Ltd., Ryders Green, West Bromwich. The substance has a strong odour of coal-gas and is used in odorizing colliery methane and natural gas (see *Nature*, **180**, 1444; 1957) and also re-formed petroleum gases before they are used in town gas supplies. These gases are otherwise practically odourless and in that condition would not betray their presence in case of leakage. The odorized gases, on the contrary, have the characteristic smell of ordinary coal-gas. Details are available from the manufacturers on request.

Shelter Belts and Microclimate

A LINE of work in the Forest Products Laboratory with a probable future for research is connected with shelter belts. In the past century, in the south of Scotland and the north of England, shelter belts were planted by landowners for the protection of stock and crops. In order to save land, they were usually much too narrow and often consisted of Norway spruce. When the trees had attained a certain height and weight in the crowns a winter gale would either blow them down or more usually make a hole at one end from which successive gales would sweep away the plantation. The Forestry Commission has recently published its Bulletin No. 29 on "Shelter Belts and Microclimate" (London and Edinburgh: H.M. Stationery Office, 1957), by Dr. J. M. Caborn, of the Department of Forestry, University of Edinburgh, to whom it gave a grant and assistance in carrying out the research work. The investigation included wind, temperature, atmospheric humidity, evaporation and transpiration, soil moisture, precipitation and snow distribution, the economic significance of the influences of shelter belts and general conclusions on shelter-belt types, lay-out and structure. Help was received from the Department of Meteorology, Imperial College of Science and Technology, London, from the Danish Heath Society, from the Swiss Forest Research Institute, Zurich, from the Meteorological Office and from colleagues on the forestry staff at Edinburgh. The results, if put into force, should provide a different type of shelter belt in Britain both in density and quality of timber. The Bulletin should prove of use in Colonial countries where shelter belts on a larger scale are very much needed for the improvement of agricultural crops and stock.

Biochemistry and the International Union of Biological Sciences

A COMMITTEE of the Section of Biochemistry of the International Union of Biological Sciences has recently been formed. It is essentially a co-ordinating committee between the International Union of Biological Sciences and the International Union of Biochemistry. It is assumed that this committee will be specifically concerned with chemical biology within the framework of the Unions federated in the Council of Scientific Unions. An important function of the committee will be to make proposals for international symposia to both Unions. It is hoped that a full committee meeting will shortly be held, perhaps during the fourth International Congress of Biochemistry in Vienna in September 1958. The committee as at present constituted consists of M. Florkin (Liège, *president*), O. Lindberg (Stockholm), R. Brunel (Toulouse), F. Lynen (Munich), P. Boyer (Minneapolis) and T. W. Goodwin (Department of Biochemistry, University of Liverpool, *secretary*).

Conference on Salt Marshes

THE Marine Institute of the University of Georgia has organized a Conference on Salt Marshes, to be held at Sapelo Island during March 25–28, 1958. The Conference is being sponsored jointly by the National Science Foundation and the Marine Institute. It will be international in character. Its purpose is to bring together scientists who are working on, or interested in, salt marshes, for discussion of research on this particular environment. An invited group of about twenty-five people will participate in the Conference; invitations will be extended on request to a limited additional number of persons who wish to attend at their own expense. The Conference is under the direction of Dr. Alfred C. Redfield, of Woods Hole, Massachusetts. Further information can be obtained from Dr. Robert A. Ragotzkie, University of Georgia Marine Institute, Sapelo Island, Georgia.

Low-Temperature Physics Conferences

THE sixth international conference on low-temperature physics will be held in Leyden during June 23–28, 1958, in connexion with the fiftieth anniversary of the first liquefaction of helium by Kamerlingh Onnes. Further information can be obtained from Dr. J. van den Handel, Kamerlingh Onnes Laboratory, Leyden, The Netherlands. A conference of the First Commission of the International Institute of Refrigeration will be held in Delft during June 17–20, 1958. At this meeting technical aspects of low temperatures will be discussed as well as scientific subjects. The secretary of the Delft conference is Prof. B. S. Blaisse, Mijnbouwplein 11, Delft, The Netherlands.

Announcements

MR. R. F. HAYMAN, industrial gas officer of the Gas Council, has been appointed chairman of the Industrial Gas Development Committee of the Council in succession to Mr. W. H. Tarn, whose term of office as chairman of the Committee expired on December 31.

DR. H. O. J. COLLIER has been appointed director of pharmacological research at Parke, Davis and Co., Ltd., Hounslow, Middlesex, from February 1. For the past twelve years, Dr. Collier has been head of the pharmacology department at Allen and Hanburys, Ltd., Ware, Herts.

RECOMMENDATIONS for the Meldola Medal, which will be awarded to the chemist who, being a British subject and less than thirty years of age on December 31, 1957, shows the most promise, as indicated by his or her published chemical work; and for Beilby Memorial Awards, given to young British investigators in science to mark appreciation of records of distinguished work, should be made by February 28. Further information can be obtained from the Royal Institute of Chemistry, 30 Russell Square, London, W.C.1.

THE Society of Protozoologists is to publish "A Catalog of Laboratory Strains of Free-living and Parasitic Protozoa", with sources from which they may be obtained and directions for their maintenance. This will appear as an integral part of the February issue of the *Journal of Protozoology* (5, No. 1). Reprints, which will be sold at a nominal cost, can be ordered from Dr. D. M. Lilly, Society of Protozoologists, St. John's University, Department of Biology, Jamaica 32, New York.

May and Baker, Ltd., state that from time to time they still receive empty Winchester quart bottles containing small amounts of sodium wire. Although all bottles that have been used for ether are examined before washing, it is difficult to detect such small pieces of sodium. This practice has resulted in several incidents, potentially serious, in the bottle-washing plant. In the interests of safety, any residual sodium metal used to dry the ether should be carefully and completely decomposed with a low-boiling alcohol before return to the supplier. Drying in this way is not necessary with the very dry grade of ether now available when required.

THE tenth British Mathematical Colloquium will be held in Reading during March 26–28. Further information can be obtained from J. E. Reeve, Department of Mathematics, The University, Reading.

THE Anniversary Meeting of the Chemical Society will be held in Bristol during March 31–April 2. There will be symposia on "Developments in Aromatic Chemistry", "Applications of Electron and Nuclear Resonance in Chemistry" and "Recent Work on the Inorganic Chemistry of Sulphur". Further information can be obtained from the Secretary, The Chemical Society, Burlington House, London, W.1.

IN *Nature* of December 28, 1957, p. 1448, reference was made in the article entitled "Lubrication and Wear" to an international discussion on the subject twenty years ago under the chairmanship of "the late Dr. H. J. Gough". We are glad to learn that a mistake was made and that Dr. Gough is still alive.

A WAGES POLICY

THE most pressing problem in the British economy is the race between the growth of personal incomes and the rise in industrial output. It was fitting, therefore, that, during the annual conference of the Institute of Personnel Management which was held at Harrogate during October 4–6, the 800 members attending were invited by Sir Richard Snedden, director of the Shipping Federation and chairman of the Industrial Relations Standing Committee of the British Employers' Confederation, to consider the means of dealing with this apparently intractable problem. Sir Richard made it very clear that there was no universal prescription for good industrial relations. These depended upon individuals; they had to be established gradually, patiently and even laboriously. The first essential is that each side must be confident of the good faith and integrity of the other. The next is leadership, but it must be responsible leadership including courage on both sides to take the unpopular decisions that responsibility sometimes entailed. The best way to build up confidence and to create effective leadership was for employers' and employees' representatives to meet frequently, preferably to discuss less-controversial matters, rather than meeting only at long intervals over such questions as hours of work and wages. The third essential is to avoid bringing in third parties except as a very last resort.

The classic approach to wages is that each industry should give the best wages that it could afford in order to get the best labour. The determining factor in wages-levels is the ability to pay, but there is no simple universal formula linking wages to production. There are seven reasons which seemed to make the discovery of a uniform magical slide-rule rather improbable.

First, it would be necessary for the Trades Union Congress and the British Employers' Confederation to reach an agreement and to bind their members. The Trades Union Congress is a powerful body, but it has never claimed to supervise, much less regulate, the wage claims of its component parts. The British Employers' Confederation is in the same position.

Secondly, the measuring rod usually suggested is the general index of industrial production. That index is not and cannot be comprehensive, and, at the outside, covers only half the employed population.

Thirdly, there are inherent weaknesses in any index of production. The proportion of products which are capable of unambiguous measurement and comparison at different dates is relatively small.

Fourthly, even if one took not the general index, but the component indices for individual industries or groups, labour is not the only claimant—although a most important one—to a share in the benefits of increased production. The consumer has a claim for lower prices. Capital also has a claim.

Fifthly, the actual increase in production would inevitably vary from industry to industry, from firm to firm, from department to department and even with individuals. It would not be easy to convince those acquainted only with their own personal increased efforts to share the benefits with others.

Sixthly, in considering wages, what are called 'fringe' benefits must not be left out of account. Reduced hours, increased pensions, and increased holidays can be just as inflationary as a direct increase in wages. They may even be more inflationary because they are likely to be more permanent.

Lastly, a scarcity of anything leads to higher prices and even a 'black market'. Why should labour be any exception ?

It is shortage of labour which makes employers yield increases of wages against their better judgment, and it might even be that shortage of labour sometimes compels some trades union leaders to put forward wage claims which they are not really convinced are in the best long-term interests of their own members.

The formidable difficulties are not all equally applicable to all industries. The course which Sir Richard thought must be pursued is first to create a climate of public opinion favourable to effective action to ensure that wage increases operate only where they are earned. The actual solution must be worked out by industries for themselves and to suit their individual circumstances.

The way in which wages policies in industry have developed was examined by Prof. D. T. Jack, of King's College, Newcastle on Tyne, chairman of the Courts of Inquiry into the engineering and shipbuilding disputes in 1957.

The traditional system of wage negotiation has some advantages. It provides a certain flexibility in the whole structure of wages. It has fostered a sense of responsibility on the part of the two negotiating parties in each trade and industry affected by this process.

There is, however, a frequently voiced demand for a strong type of unified, compactly designed or consciously planned wages policy to replace the traditional policy which has operated for so long. There are three main sources for this desire. The first is the recognition in many quarters that, in a period of inflation, the wage-price spiral is frustrating to all wage earners and most injurious to some.

The second is bound up with the effect of full, or, sometimes, over-full employment. Here we have a situation in which bargaining strength is heavily weighted on the side of the unions. Provided the monetary system is accommodating, it would be very surprising if wages were not pushed up by more than the overall increase in the productivity of labour, with the consequent increase in labour costs.

Then there are the economic planners, some of whom recognize that their calculations and guesses may be reduced to nothing if the wages section of the economy is allowed to follow its own course while the remainder of the economy is tied to a rigid plan.

If a unified wages policy is held to be desirable, the means of promoting it must be considered. Experience in other countries has not been encouraging. There have been experiments in the United States of America and certain countries of Western Europe which have not been strikingly successful in preventing inflationary tendencies. In Britain the trades unions have a strong dislike of any radical departure from the traditional sectional wage-bargaining procedure. Despite this, there has been some evidence in recent years that wage claims, apparently put forward independently, tend to conform to a certain pattern. Some years ago, nearly every wage claim was expressed in terms of an application for x shillings a week increase. The following year, nearly every wage claim was formulated in terms of an application for a percentage increase of y, and the following year it took a different form. The energy which might conceivably be devoted to the working out of a wages policy between, say, the Trades Union Congress and the British Employers Confederation, was concentrated on the type of suitable tactical procedures. In the old days, the usual practice was for wage claims to be presented, in the first instance at least, to the most prosperous industries. In recent years, there is some evidence that a rather different procedure has been followed. Wage claims have been presented, not to the most prosperous industries, but to other industries which, for some reason or other, are regarded as of public importance and which are either not profitable at all or barely profitable. Having succeeded there, the next step is to present a greater demand upon the prosperous industries with the simple argument that, if the non-prosperous industry can afford a wage increase of x shillings, then the more prosperous industries must obviously be able to afford x plus A shillings.

Some people believe that a wages policy could only be formulated by means of national negotiation at the very highest level. Representatives of the Trades Union Council would meet representatives of the British Employers' Confederation, and, between them, they would hammer out any wage increases for the following year. Such an experiment would meet with no success.

A wages policy cannot be considered in a vacuum, and must be related to the larger issues of economic, financial and monetary policy.

In the whole of the post-war period, successive Governments in Britain have failed to deal with those inflationary forces which lie within their own orbit of control; this complicates the question of what function any body charged with the formulation of a wages policy could usefully perform. Full employment with inflation requires the co-operation of the main economic groups within the community. How can that co-operation be most effectively secured ?

Do the existing procedures for arbitration in Britain encourage inflationary tendencies ? There would be considerable danger if any arbitrator were to obtrude into his decision his own personal judgment of the wider consequences of his award, if the wider consequences were not dealt with in evidence before him by people who were competent to present that evidence. If one or other of the parties appearing before an arbitrator were to present a statement on the wider issues for the economy as a whole, he would probably be told by the other party that it was a matter not within his competence.

The suggestion that arbitration should be made compulsory does not make for a more satisfactory solution. That being so, does the court of inquiry procedure provide a more elastic means of coping with the problem than the arbitration procedure ? To some extent it does, because the terms of reference of most courts of inquiry enable these courts to inquire into the causes and circumstances of the dispute. There is the further point that the reports of courts of inquiry are generally reasoned statements and not merely decisions, as in the case of awards of arbitration.

On the other hand, reports of courts of inquiry do not provide a complete answer because their terms of reference again generally limit inquiries to the particular dispute which has arisen between the parties, and it is not usual for these courts to seek evidence on the wider issues which may be involved in a particular claim.

One of the main gaps in the present system of industrial relations in Britain is that, in the past, there has been no body which would speak with authority on the wider issues which are raised by major wage claims on the economy as a whole. Now, however, there is the Council on Prices, Productivity and Incomes. What good can such a body do ? Parties to a dispute represent sectional interests, and their submissions are very properly dominated by those sectional interests. If we cannot go to the parties for enlightenment, where can we go ? One cannot look to Government because of the persistent record of Government failure to deal with those inflationary forces which lie within the power of the Government to control. Governments which have failed in their responsibility are scarcely entitled to admonish or exhort the public, or sections of the public, for their apparent misdeeds. Moreover, a Government which intervenes in industrial disputes in a manner which is intended to influence a result could scarcely be said to be performing its traditional function of 'keeping the ring'. At the lower, administration-level, only two departments are concerned: the Treasury and the Ministry of Labour. Neither is quite fitted to perform the function which is now required. The Treasury is too far removed from the world of industrial relations and too academic in its approach to command the attention of the public or the interested parties by its bulletins or by its announcements. The Ministry of Labour probably has its ear too close to the ground and is too preoccupied with individual disputes to go far beyond its appropriate brief.

Those concerned with the conjoint problem of inflation and full employment must be prepared to do some fresh thinking about the traditional arrangements for dealing with wages generally. Up to the present, the record is mainly one of failure. Governments have failed, and the two sides of industry have equally failed, to show any imaginative approach to the issues which have now become real.

The attitude of the trades unionist to scientific development and human relations in industry was put by Lewis Wright, general secretary of the Amalgamated Weavers' Association and chairman of the Trades Union Congress Scientific Advisory Committee (see *Nature*, **180**, 1013 ; 1957). No trades union, said Mr. Wright, opposes the development of automation, but none will approve the development of the machine at the expense of human dignity. The trades unionist wishes to see the machine exploited and not the worker ; the latter should receive some of the benefits accruing from the exploitation of the machine.

Besides the plenary sessions, a series of sectional meetings was held to consider the role of the shop steward in industry, industrial conciliation and arbitration, education for management, job analysis for managers and other staff, and ergonomics and industrial management. Reports of all these meetings have been published in the *Journal of the Institute of Personnel Management* (34, No. 342 ; Dec. 1957).

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sity College of

THE HOME UNIVERSITIES CONFERENCE

THERE can be no doubt that the Home Universities Conference, held in mid-December each year, is achieving increasing importance. The topics chosen for discussion are always live, as the fact that the Conference is sponsored by the Committee of Vice-Chancellors and Principals should guarantee. In addition to four or so delegates from each university, there are always representative guests present—members of the University Grants Committee, of the Ministry of Education, headmasters and headmistresses of schools and distinguished visitors from Britain and abroad.

Last December, the first subject for discussion was "The Place of Residence in the University To-day"—chosen because of the recent publication of the report of the sub-committee of the University Grants Committee on halls of residence. The Conference was clearly a strong believer in the educational value of halls of residence, but doubted whether they are being provided quickly enough. "Every new generation is a new invasion of savages", and if it behoves universities to play their part in civilizing their students, halls of residence are demonstrably among the most efficient means for doing this. As Prof. W. R. Niblett said, they should not be merely fringe enterprises in a university: they are closely related to its very *raison d'être*. But though professors may almost all be converts to the cause of halls of residence, they are sometimes apt to regress rapidly when asked to make a contribution at a financial cost to the development of their own departments. Prof. Seaborne Davies penetratingly remarked that it is chiefly upon the support of the disinterested that halls of residence have to rely.

During the Conference someone might have pointed out that halls of residence are among the best assets to a modern university in capturing good students for any department. It is not in the quality of their research or their teaching that modern universities are most open to criticism. These often, indeed, are first-rate. But too many students who might in favourable circumstances have emerged as leaders, with a wide interest in life and able to make human contacts with ease, remain over-specialized and insufficiently awakened; and with increasing numbers of 'first generation' students in our universities this is increasingly true. Industry to-day realizes more and more that a period in a good hall of residence is an immense asset to a student, and especially perhaps to a scientist. For many scientists in their maturity are not going to be primarily scientists but managers—and therefore makers—of men.

The introductory speeches, and also the contributions to the discussion on halls of residence, acute though some of them were, scarcely brought out sufficiently fully the differences between the older and newer universities in the living conditions they provide. It was suggested, for example, that really large halls in modern universities might still have something of the same civilizing effect on their inhabitants as Trinity College, Cambridge—for few declared that to be too large. In actual fact, many do, of course, regard Trinity College as far too big; but it is at least doubtful whether a hall of residence in a modern university will be so potent in its influence unless size is limited to a reasonable number of students under each warden (possibly not more than one hundred), each student having a private room of his own in which to work and live a private life. Of course, this is not to deny for a moment, any more than the Niblett Report does, that groups of halls of residence on one site have many possibilities.

At the second session of the Conference, on "Procedure for the Selection of Undergraduate Students", the different points of view on this subject of people from universities and schools showed up sharply. Sir James Mountford, commenting on the report published a few months ago under the auspices of the Committee of Vice-Chancellors on "Applications for Admission to Universities", emphasized that the basic problem was the number of applications compared with the number of vacancies. In his view, there was deplorable chaos in the procedure for the selection of students. He did not believe that a clearing-house system was a practicable solution to the problem, though universities might well be less secretive about the number of vacancies they had. It seemed to him, however, that the chief remedies must be supplied by the schools themselves. They should refuse to let their weak candidates apply for university entrance at all. They should support a movement for transferring the parts of the examination for the General Certificate of Education on which selection is based, from July to some time in the spring term.

As representatives of the schools hinted, these proposals really left the universities with very little of the burden of the problem: it was evidently the schools, not the universities, who were required to make the difficult adaptations. It is not easy to refuse candidates a chance of getting into a university if parents and boys themselves are keen on such a chance being allowed. As for change of date for the General Certificate (Advanced Level) examinations: it must be remembered that sickness in schools is at its maximum in the spring term, and that the effect of such a change might be to cut to five terms the total sixth-form course of a number of boys and girls—both those hoping for a university career and those with no such intention—who needed at least six if they are to be given an adequate sixth-form training. In a sincere and practical address, Miss M. J. Bishop, herself a very experienced headmistress, protested against the continuing onerous weight of faculty requirements. These were a threat to all unexamined sixth-form work. The rampant individualism of universities was the despair of the schools.

Dr. C. L. Pratt, of Christ's College, Cambridge, supported the idea that a vigorous pruning of faculty requirements should be made. The Imperial Chemical Industries' bursary scheme suggested that some schoolboys at least can be orientated, after they have entered a university, to a scheme of specialized study—for example, in science—when their sixth-form course had been almost entirely concentrated on the arts. He emphasized that what matters most in choosing candidates rightly for university entry is the shape of the curve of the candidates' progress up to the time of selection: Was a particular boy or girl likely to develop a great deal, or was he already near his peak ? He suggested that the selector must not be professionally and whole-time on the job: he should be made to live with the people he chooses. Selectors should suffer the consequences of their own decisions.

In the discussions on this key subject of selection for university entrance, it is to be noted that the headmistresses were able to speak knowledgeably of the problems of entry to both older and newer universities. No headmaster from a grammar school made a contribution, and the heads of public schools who spoke could only speak about selection for Oxford and Cambridge. One fancies that within the next few years, with the intense pressure on university entry and little chance of any significant increase in the number of students taken at Oxford and Cambridge, the public schools will have to make themselves much more aware of conditions at modern universities. Incidentally, it was pointed out that in Scotland the examinations which determine entrance qualifications to universities start in mid-March each year. But England rarely learns from Scotland in such matters.

The final session of the Conference tackled the problem of academic mobility. The investigation undertaken by the Association of University Teachers in 1956 suggested that too many members of university staffs stayed too long in one place. 22 per cent even of professors have never taught in a university other than that in which they hold their chair. Prof. A. G. N. Flew, of the University College of North Staffordshire, pointed out that a period of university teaching overseas could be of immense value in broadening the mind—in indicating, for example, that the English division of the curriculum into arts and sciences was not part of an inevitable ordering of things. Dr. R. S. Aitken, vice-chancellor of the University of Birmingham, considered that mobility among science staff was about right but that among arts staff it was insufficient.

Discussion in the Conference indicated that there was a widespread feeling that at present there was too great a degree of academic immobility. In particular, it was held that universities ought to advertize senior lectureships wherever possible, whereas the almost universal present practice is to promote from within the institution. Strong pleas were entered for further exchanges within the Commonwealth: a number of Commonwealth countries are at a critical stage in their university development, and it would be of the greatest value to them that some of the best people should have a period of university service in them. But pleas were also entered for exchanges within the United Kingdom itself: even one term of teaching in a different university might be a great stimulus.

With the rapid increase in numbers of university staff during the past few years, there is to-day an altogether disproportionate number of university lecturers in the 30–40 age group. Some speakers saw a good deal of discontent ahead when many of these people were still lecturers and yet in the 50–60 age group. They suggested that this was an argument for providing more senior posts—more new universities even—for then there would be more chairs for which to compete.

There appear to be great differences between university departments of applied science in the closeness of their contacts with industry. In some, it is standard practice for lecturers in, say, engineering to be taken from industry and to return to industry after a period of teaching and research. In other universities this is rare. But the Conference did not clearly show what its mind was in this matter.

In fact, the Home Universities Conference is much better as an assembly to which thoughtful and challenging contributions can be made either from platform or floor than as a place in which there is a keen to-and-fro discussion. Perhaps this is inevitable when there is a large and representative collection of university dons assembled with their vice-chancellors in the comfortable and dignified—if apparently underground—William Beveridge Hall of the University of London. Be that as it may, British universities in general are in great debt to the University of London for its kindly and hospitable welcome to a Conference which is bringing together, as no other conference does, people from the staffs of all British universities at a time of year when they are prepared to be thoughtful in a creative way.

AUTOMATIC MEASUREMENT OF QUALITY IN PROCESS PLANTS

AUTOMATIC control has been utilized by the process industries for many years; indeed, many commercial processes in use to-day could not function efficiently without its aid. Over the past decade, however, the basic philosophy of automatic control has undergone a marked change as a consequence of the introduction of powerful new instrumental techniques. The function of automatic controllers has hitherto been that of regulating certain basic parameters of a process, in the hope that adherence to fixed values of such parameters—temperature, flow or pressure—would result in an end-product of unvarying quality. The analysis of the end-product has, of necessity, been carried out in laboratories remote from the plant, with the consequent introduction of long delays between the detection of variations in the end-product quality and the initiation of the appropriate remedial action on the plant itself. The economic benefits which could be obtained by carrying out such analyses directly on the process stream have stimulated the development of a wide variety of instruments for the purpose, many of which have passed the experimental stage and are now accepted as sufficiently reliable for plant use.

The Society of Instrument Technology is to be congratulated on its choice of "The Automatic Measurement of Quality in Process Plant" as the subject of the 1957 Conference, which had as its aim the bringing together of research workers, instrument engineers and other workers in this field to discuss these developments and their common problems.

Membership of the Conference, which was held at University College, Swansea, during September 23–26, was restricted in order to promote informal discussion; it is noteworthy that a number of the Conference members were drawn from the United States, Germany, Holland, Norway and the U.S.S.R., so that the open discussions provided an international forum for the exchange of ideas.

The seven formal sessions of the Conference fell into two complementary groups; a number of papers were devoted to a review of the experience which has been gained with established instruments, while the second group explored the possible plant application of analytical techniques at present utilized only in the laboratory. In addition to the formal technical papers—which will be published with their associated discussions by Butterworths Scientific Press—the Conference heard two informal talks which related its main topic to fundamental issues. Prof. D. P. Eckman considered the basic problem of the optimization of control by on-line computation, while another guest speaker, Dr. W. P. Colquhoun, drew an illuminating comparison between the human senses and automatic instrumentation.

The opening session of the Conference was concerned with the adaptation of laboratory techniques to plant measurement. Laboratory analytical techniques are, for the most part, well established and well understood; it is natural to suppose that an automatic analysis can be carried through by the mechanization of the laboratory method, although such methods are often based on a sequence of discrete measurements and so are not readily adaptable to truly continuous operation. This point was stressed in E. Hodgson's paper, which described an instrument for the determination of the crystallizing point of batch samples. It is clearly advantageous to know the composition of a plant stream throughout the course of a reaction, rather than to know its composition at intervals, and it is therefore an obvious, if difficult, step to make the analysis continuous.

Three papers, which were presented in the following session, described the manner in which this further step had been accomplished for calorimetric measurements on town's gas—a measurement of considerable importance to the gas industry, which is bound by law to maintain certain standards of calorific value and purity in the gas supplied to consumers.

Considerable discussion was aroused by another of the papers presented in this session, in which the authors underlined the difficulty of securing representative samples of gaseous streams—a problem which, it is often said, is more difficult than the analysis itself. It is significant that this theme recurred frequently in papers devoted to a wide range of analytical techniques.

The need for continuous control has resulted in the extensive use of physical methods of analysis; this trend was reflected in the eleven papers, presented on the second day of the Conference, which reviewed the use of such diverse methods as mass spectrometry, vapour phase chromatography and refractometry.

Three of the papers were devoted to existing instruments working in the visible and infra-red region of the electromagnetic spectrum. Infra-red analysis is now well established as a process technique, in spite of the fact that it is often difficult to find completely characteristic absorptions, and considerable overlapping of the spectra is common. In practice, of course, such imperfections are overcome by corrective procedures, but it is clear that the fundamental power of the method would be greater if it were possible to obtain narrower absorptions and higher resolution. These features are characteristic of microwave spectra, which are also very sensitive to molecular structure. The potentialities of microwave spectroscopy in process control analysis were considered in a paper by Dr. J. Sheridan; a second paper, read by Dr. R. E. Richards, described yet another relatively new branch of chemical spectroscopy—nuclear magnetic resonance, which may well be applied to process stream analysis, although little published information is available on its industrial applications. To the plant engineer, perhaps, these techniques may appear to be too difficult and complex for eventual adaptation to plant use. He would, however, do well to ponder on the implications of the final paper of the day, read by Dr. E. T. Hall. Dr. Hall is well known to the archæological world for his work on the dating of antiquities by the analysis of their chemical composition. In the course of his research (which has included, among other achievements, the detection of the Piltdown skull forgery) Dr. Hall developed an X-ray fluorescent analysis instrument, which is to be manufactured commercially for process use.

The last session of the Conference was devoted to a review of the uses of radioactive isotopes in quality measurement and a stimulating paper by Prof. W. Fishwick, which provoked considerable discussion, on the possibilities of analysis by physical measurements of an out-of-the-ordinary character. The session ended with an open discussion on the engineering design of instrumentation.

The catholic nature of the papers given at this Conference was in itself an indication of the rapidity with which technologists adapt to their own problems the tools provided for them by research workers in other fields; it is obvious, nevertheless, that the transition from research tool to plant instrument is difficult and expensive. It is essential that an instrument for plant use should function reliably for long periods without attention, and that maintenance should be reduced as far as possible to standard procedures, so that it may be carried out by relatively unskilled personnel.

The development of such instruments must at the same time be accompanied by the development of the associated sampling systems, since both are essential to the successful operation of the analyser on the plant. It is evident that a great deal of effort is at present expended on the design of sampling systems to meet the needs of various sectors of the process industries, each of which must therefore devote in isolation technical man-power to problems which must, in many cases, share many points of similarity. The consequent inefficient use of skilled technologists might well be remedied by the adoption of some coherent plan of attack which would co-ordinate the efforts of both users and manufacturers, both of whom were represented at the Conference; it is to be hoped that the Society of Instrument Technology will act on the suggestion, so well received by the Conference, that the time is ripe for it to establish a working team to codify existing knowledge on sampling techniques and to correlate development work in this field.

SCIENCE IN UNITED STATES UNIVERSITIES

A SURVEY of scientific research activities at colleges and universities in the United States, published by the National Science Foundation as No. 6 of "The Reviews of Data on Research and Development", gives the number of scientists and engineers employed in the natural and social sciences during the academic year 1953–54 as 70,000.

Detailed information was obtained from 180 out of 190 institutions constituting almost all the schools granting advanced degrees in science, and more limited information was obtained from 807 out of the remaining 930 schools. The returns covered 62,251 or 90 per cent of the total, and of these 31,435 were engaged in research, 8,262 being full-time, the total full-time equivalent being estimated as 16,534. Of these latter, 5,481 were engaged in research (2,281 in engineering sciences, 1,077 in chemistry, 837 in physics), 3,508 in biological sciences, 2,171 in chemical sciences, 3,658 in agricultural sciences, 389 in psychology, and 1,327 in social sciences.

The 180 larger institutions reported 24,000 supporting personnel, corresponding to a full-time equivalent of 15,060, giving a ratio of approximately 1 : 1. Of the 46,500 faculty members in the natural and social sciences at the 180 larger institutions, about 37,500 were employed full-time, and two-thirds of all the faculties spent some time on research, representing two-fifths of the total faculty-time, whereas in 807 small institutions less than 2 per cent of faculty-time was devoted to research, less than 10 per cent, or 16,000, employed being engaged in research.

Nearly 1,500 professional schools were reported by the 987 institutions, of which 764 were in arts and sciences, 131 engineering, 106 health, 71 agriculture, 217 research organizations (mainly responsible for a particular field of research) and 263 other professional schools. Two-thirds of the institutions were private and the remaining public-controlled institutions employed 56 per cent of the total engaged in the natural and social sciences, 61 per cent of which were engaged in research.

STARLING ROOSTS

A FASCINATING account of the way in which starlings roost and the sites they choose has been given by H. A. S. Key in the *Bedfordshire Naturalist* (11 ; 1957). Starlings are abundant in Bedfordshire, and the many resident birds are considerably augmented during the winter months by many thousands of others which arrive chiefly from Scandinavia. At night the birds congregate in communal roosts which are usually sited in thorny copses and spinneys. In general, once a roost has reached an optimum condition of growth and non-disturbance, it is used for many seasons. At each roost the pattern of assembly is much the same. The birds fly at first in leisurely stages towards the roost, but as the daylight fades and they get nearer to the point of assembly, their flights are more direct and flocks tend to converge and amalgamate.

The point of assembly is close to the roosts and often on the ground, where the birds form a dark carpet and the noise of their whistling and chattering is considerable. Then, suddenly, they get up, often indulging in some preliminary aerobatics, first in extended and then in close formation, before the entire party moves in a steady stream into the roost proper. Here with a great deal of commotion they wheel around and settle on the trees. For a short period there may be changes of perching areas within the roosting wood, but finally, when it is almost dark, the whole mass of birds is assembled in the regularly used part and then as each stem becomes packed with the jostling mass the din reaches its crescendo. From this tight grouping they are then not easily disturbed and sharp noises such as hand-clapping usually only suffice to cause the nearest group to move a few yards away.

In north Bedfordshire it would appear that the majority of the birds frequent one or other of two very large roosts, the populations of which would be hard to determine. These are Horn Wood, near Bozeat, Northants, just outside the west boundary of the county, and another site near Everton in the east. There was some years ago a smaller roost in Keysoe Park Wood, but this seems to have been abandoned.

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THE NATIONAL TRUST

ANNUAL REPORT, 1956–57

THE sixty-second annual report of the National Trust, for 1956–57, makes slight reference to the threats offered to its primary duty of ensuring the safety of fine open country or fine buildings which arise from Government departments or other public authorities. Some evidence is recorded of increasing public appreciation : in 1956 nearly 900,000 visitors paid for admission to those properties where an entrance fee is charged, an increase of more than 200,000 on 1955, and membership increased by more than 5,500 to 61,713, with a further increase of 3,740 during the first seven months of 1957.

Nevertheless, the Council's hope that the 100,000-mark will be reached in 1959 seems modest indeed and far too low, either to relieve the Council of continuing financial anxiety (in spite of a small surplus in 1956, when membership income increased by £17,000) or to ensure the widespread public understanding and support necessary to avert the increasing destruction and vulgarization of the countryside, country towns and villages. While the position of the country house to-day seems slightly less gloomy and in archaeology a considerable sum has been spent in the past eighteen months on the preservation of the Cerne Giant in Dorset, repairs have been commenced to the Roman ruins at Ribchester, and satisfactory progress is reported in repairs to the Roman wall at Hotbanks, the report expresses the opinion that the face of England is rapidly changing for the worse.

Cafés, petrol stations, advertisements, neon lights, concrete lamp-standards, ill-sited and ill-designed, are everywhere, and persistent irresponsibility is shown in siting high-power cables, nuclear power stations and radar installations. The Trust has protested more than once during the past year against such ill-considered siting, but although this desecration is viewed with anxiety and regret the Council believes that a change of faith in official quarters and the establishment of a new canon of taste could, even now, save the situation and repair much damage already done. The Council appeals to members for active support in its practical proposals for dealing with the development of the English landscape, and in particular the report urges the importance of reducing signposts to the essential minimum and for far more thought in their design and siting.

GROWTH AND REPRODUCTION IN WORM-FREE SHEEP AT PASTURE

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NEMATODES parasitic in the alimentary tract have been shown to cause a depression of the growth-rate of lambs maintained indoors[1,2] even when the level of infestation has been sub-clinical. This has been confirmed for lambs at pasture[3], and it has been found possible to raise lambs free from stomach and intestinal worms (with the exception of *Strongyloides papillosus*) by rapid folding over clean pasture[4].

Thirteen Suffolk × half-bred ewe lambs reared with their infected ewes in this way in the spring of 1956 were weaned on to 6 acres of worm-free pasture (that is, one not grazed by ruminants for at least two years) in June of that year. They remained on this area, for the most part set-stocked, until April 1957, with the exception of three weeks (Oct. 29–Nov. 23, 1956) when they were brought indoors to be tupped. This procedure was necessitated by the absence of a worm-free ram. At the same time, 15 of the best remaining ewe lambs from the farm flock were selected for comparison. The previous live-weight history of these two groups is shown in Fig. 1. The decline in live-weight gain of the infected ewe lambs (Group *I*) during the autumn was characteristic of sheep of that age on the farm and occurred in spite of grazing a better pasture than that available to the worm-free lambs (Group *F*). Thus, at tupping time, Group *F* lambs were, on average, 17 lb. per head heavier than those in Group *I*. The latter were maintained throughout the tupping period on a nearby field, and the same ram was employed for both groups, spending the day in the field and being brought in to Group *F* at night.

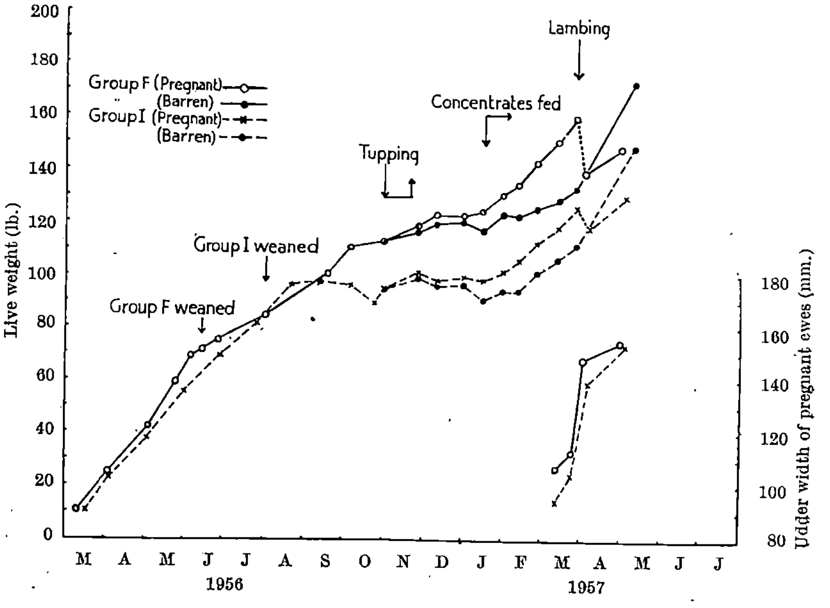

Fig. 1. Mean live weights and udder measurements of Groups *I* and *F*

On November 23 Group *F* was returned to its field, and Group *I* was grazed on a comparable, and at no time inferior, sward. Fig. 1 shows the subsequent mean live-weight changes for both groups of sheep. From January 16, 1957, concentrates (80 per cent cereal, 15 per cent dried lucerne meal, 5 per cent linseed cake) were fed to both groups at the rate of ¼ lb./head/day, rising gradually to 1 lb./head/day on February 25 and continuing at that rate until April 24. A mineral mixture rich in magnesium was included to prevent hypomagnesæmia.

The egg counts for each group are shown in Fig. 2. The egg-count curve for Group *I* was typical of sheep of that age at that time, but rather low. Group *F* fæces were negative for parasite eggs until the sheep were brought inside for tupping, when a mean count of 2 eggs per gm. was recorded. This declined to

Table 1. DATA FOR EWES AND LAMBS AS MEANS FOR EACH GROUP

Group	Live-wt. gain of ewes (lb.)		Udder width of ewes at lambing (mm.)	No. of barren ewes	No. of lambs born dead or died within 12 hr. of birth	Length of gestation period (days)	Birth-wt. of lambs (lb.)		Live-wt. gain from birth to 28 days Singles (lb.)
	Barren. 29.10.56–26.3.57	Pregnant*. Tupping to post-lambing					Singles	Twins	
F	20·9 (4)†	25·9 (6)	148 (9)	4	0	143	11·3 (7)	7·2 (4)	25·5 (6)
I	15·9 (6)	25·8 (6)	139 (8)	6	2	143	8·4 (7)	6·7 (2)	23·9 (6)
Difference	5·0	0·1	9	—	—	0	2·9	0·5	1·6
Per cent difference	31·4	—	6·5	—	—	0	34·5	7·5	6·8

* Based on weight gains of ewes with single lambs only.
† Numbers of animals are given in brackets.

zero and remained so until lambing time, when eggs again occurred. This shows that Group *F* carried a few worms which, at times of stress leading to a temporary lowering of resistance, produced measurable numbers of eggs. The parasitological consequences of this to ewes and lambs will be dealt with elsewhere.

Since it is not possible to prove that any group of living sheep has no worms at all, it has been suggested[5] that a 'worm-free' sheep be defined as one that normally shows no evidence of infestation even when set-stocked on pasture with every opportunity for re-infection. In this sense Group *F* were worm-free over the year considered here. The live-weight gain of the ewes from tupping to lambing included any differential growth of fœtus and maternal tissue: the mean difference in live-weight just before lambing on March 26, 1957, was 32 lb./head in favour of Group *F*. The ewes were weighed within 24 hr. of lambing, however, and the gain in body-weight has been calculated for the period from tupping to this post-lambing weight (Table 1). At intervals during late pregnancy and lactation, udder-widths were measured on all the ewes, the width being the distance across the teats measured externally at the base of the teat. Group *F* udder-widths exceeded those of Group *I* by 6·5 per cent at lambing time (Fig. 1).

The birth data for the lambs produced by both groups are given in Table 1. Group *F* produced significantly heavier single lambs ($P < 0 \cdot 01$) than Group *I*; there were fewer barren ewes and lower mortality. Two lambs in Group *F* suffered from mis-mothering and had to be removed; one of them died later. There was no difference in the length of the gestation periods. There were too few twins to make a meaningful comparison of their weights or growth.

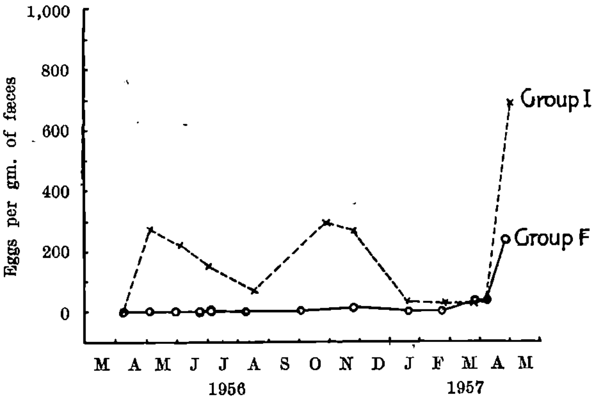

Fig. 2. Mean egg-counts of Groups *I* and *F*

The arrangements for tupping were of necessity restrictive and preclude a valid comparison of lambing percentages. The differences observed in the birth-weights of the lambs may be attributed either to the presence and absence of worms over the whole life of the ewe or merely during pregnancy. Worm-infestation before pregnancy resulted in a mean difference of 17 lb. per head in November. There was, however, no correlation between the weights of the ewes at tupping time and the birth-weight of their lambs in either Group *I* (with a range of 17 lb. in ewe weights) or Group *F* (with a range of 30 lb.). Moreover, infected ewes produced considerably lighter lambs than worm-free ewes of comparable weight at tupping time. Thus it seems unlikely that the lower lamb weights can be attributed to the fact that the infected ewes were lighter when mated. The number of twins was small, but the ewes that bore twins were among the heaviest in each group.

The infection carried by Group *I* ewes during pregnancy, although light in terms of fæcal egg counts, was clearly the major factor. The non-pregnant ewes of Group *F* gained 31·4 per cent more weight during the winter period (October 29, 1956–March 26, 1957) than those of Group *I*; numbers were small, however, and this difference was not statistically significant. The growth of the in-lamb ewes of each group from tupping to lambing (based on immediate post-lambing weights) was the same. The effect of worm-infestation was therefore just over 30 per cent in both non-pregnant and pregnant ewes but in the latter it affected only the fœtus and the associated maternal tissues. In Group *F* the pregnant ewes carrying singles gained slightly more body-weight than the non-pregnant animals; in Group *I* the difference was much greater, though not statistically significant. Thus the effect of worm-infestation appeared to be greater on barren than on in-lamb ewes and did not affect the growth of the latter, except in a reproductive sense. The growth of the pregnant ewes of Group *I*, in fact, was equal to that of Group *F* and appears to have taken complete priority over the growth of the fœtus.

The udder-width measurements differed by 6·5 per cent, which might indicate a lower capacity to produce milk. This suggestion was supported by the growth of lambs from birth to 28 days old: single lambs in Group *F* gained 6·8 per cent more weight during this period. These differences were not statistically significant; but it should be noted that the majority of Group *F* single lambs were female (6 out of 7) while the majority of Group *I* lambs were male (5 out of 7). There was no correlation of birth-weight with growth to 28 days in either group.

Twenty-eight days after the birth of the lambs, therefore, Group *F* single lambs were 11·3 per cent heavier than those of Group *I*; the barren ewes were 16 per cent heavier and the ewes suckling single lambs were 13·8 per cent heavier in Group *F*.

This suggests that the effect of a moderate degree of worm infestation on the growth of ewes is similar to that found for other sheep[3] but that in pregnant ewe lambs the effect may be suffered entirely by the developing fœtus and the associated maternal tissues.

We wish to thank Dr. William Davies for facilities granted, Mr. C. D. Kemp for the statistical treatment of the results, and Mr. J. E. Betts for technical assistance.

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LOCALIZED ELECTRONS IN BODY-CENTRED CUBIC METALS

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IN this article we gather together experimental evidence supporting a recent idea about the electronic structure of body-centred cubic transition metals proposed by one of us[1] and developed by the other[2]. A closely related theory has been given independently by Stevens[3]. We suggest, essentially, that the valence orbitals on a given metal atom can be divided into two classes, the orbitals of one of which bond strongly with the rest of the lattice, and those of the other only weakly.

In a body-centred cubic metal each atom is surrounded by eight others at the corners of a cube, so that the site symmetry is cubic. We discuss at first the metals of the first transition series as most of the experimental data refer to them, although a qualitatively similar discussion would apply to the other two series. The $3d$-, $4s$- and $4p$-orbitals are then the important valence orbitals, the $4f$- and other orbitals probably making only a minor contribution to the cohesive energy. Under the cubic group these orbitals form bases for representations the irreducible components of which are shown in Table 1 (in the usual notation, see ref. 4). The main bonding interaction is presumably the σ-interaction between nearest neighbours. Table 1 shows that the s-, p- and $d(t_{2g})$-orbitals can take part in this, but that the $d(e_g)$-orbital cannot. (The $f(a_{2u})$ and $f(t_{1u})$ but not the $f(t_{2u})$-orbitals can also take part in σ-bonding but we shall not consider f-orbitals here.)

If we take rectangular Cartesian axes centred at a site and parallel to the cube edges, then the nearest neighbour nuclei lie along the directions of the eight vectors (±1, ±1, ±1). The two d-orbitals of the e_g representation are then d_{z^2} and $d_{x^2-y^2}$ and each has zero amplitude along all the nearest-neighbour directions. This shows in a more immediate way that they cannot σ-bond along any of them. A consideration of the angular variation of s, p and the three t_{2g}-orbitals (d_{xy}, d_{yx}, d_{zx}) shows readily that the σ-interaction allowed by group theory should really be large provided that the radial functions allow sufficient overlap. Hence, to the approximation of considering only σ-interaction with nearest neighbours, the seven valence orbitals $4s$, $4p_x$, $4p_y$, $4p_z$, $3d_{xy}$, $3d_{yz}$, $3d_{zx}$ bond and are able to hold the metal together, while the two orbitals d_{z^2} and $d_{x^2-y^2}$ are entirely non-bonding. We call the former class 'bonding orbitals' and the latter class 'localized orbitals'.

Table 1. REPRESENTATIONS SPANNED BY ATOMIC ORBITALS AT A SITE AND NEAREST NEIGHBOUR AND NEXT-NEAREST NEIGHBOUR σ- AND π-ORBITALS IN A BODY-CENTRED CUBIC LATTICE

Atom	Orbital	Representations
Site atom	s	a_{1g}
	p	t_{1u}
	d	$e_g + t_{2g}$
	f	$a_{2u} + t_{1u} + t_{2u}$
Nearest neighbour	σ	$a_{1g} + a_{2u} + t_{1u} + t_{2g}$
	π	$e_g + e_u + t_{1g} + t_{1u} + t_{2g} + t_{2u}$
Next-nearest neighbour	σ	$a_{1g} + e_g + t_{1u}$
	π	$t_{1g} + t_{1u} + t_{2g} + t_{2u}$

It may clarify matters to relate our treatment to those postulating hybrid σ-bonds directed towards the corners of a cube (that is, towards the nearest neighbours). Van Vleck[5] showed that it is possible to construct eight equivalent hybrids from $sp^3d^3f^1$. Here the f-orbital is f_{xyz} (or a_{2u}) and the remaining seven are our bonding orbitals. The two d-orbitals which cannot be used in these hybrids are our two localized d-orbitals. Thus in Pauling's resonating-bond model[6] for a body-centred cubic metal the resonating bonds are formed only from our bonding atomic orbitals and never from localized ones.

If we include π-bonding and next-nearest neighbour interaction in our theory the distinction between the two classes of atomic orbitals is no longer complete. The e_g-orbitals can π-bond with the nearest neighbours and σ-bond with the next-nearest neighbours (this latter circumstance is to be related to the possibility of constructing octahedral sp^3d^2 σ-hybrids). The other orbitals also have extra bonding possibilities, as one sees from Table 1 (in an earlier paper (ref. 1, Table 2) the nearest neighbour π-interaction of the $d(t_{2g})$ orbitals was incorrectly omitted). However, the general conclusion that the seven 'bonding' orbitals are relatively strongly bonding while the two 'localized' orbitals are only weakly so should still hold.

The discussion we have given so far suggests that one should regard the two localized orbitals in the same way as one regards inner shell orbitals, or $4f$-orbitals in rare-earth metals. In other words one should assign a definite integral number of electrons (the same for each site in the metal) to the set of localized orbitals at each site. Denoting a bonding atomic orbital by b and a localized one by l, this means that we assign a definite configuration $b^m l^n$ to each body-centred cubic metal, with $(m+n)$ the number of valence electrons and m and n yet to be determined. Here n cannot be greater than four, by the Pauli exclusion principle.

For $b^m l^1$ or $b^m l^3$ we have the localized electrons at any site forming a component of a ^2E_g state; for $b^m l^2$ the pair of localized electrons could belong to

Table 2. CONFIGURATION ASSIGNMENTS FOR BODY-CENTRED CUBIC FIRST TRANSITION-SERIES METALS
Hypothetical body-centred cubic metals in brackets

Metal	K	(Ca)	(Sc)	Ti	V	Cr	Mn	Fe	(Co)
Configuration	b^1l^0	b^2l^0	b^3l^0	b^4l^0	b^5l^0	$b^{5-6}l^{1-0}$	b^6l^1	b^6l^2	$b^{6-7}l^{3-2}$

$^3A_{2g}$, $^1A_{1g}$ or ^1E_g states. Using Racah's notation[7], the $^3A_{2g}$ state lies lowest in energy, with the ^1E_g state lying $(8B+2C)$ above and the $^1A_{1g}$ state the same amount higher still. The symbol b^m refers to a situation which cannot be described in any simple fashion. If there are N metal atoms, the mN bonding electrons could, of course, be assigned to bands formed from bonding orbitals. This would, however, involve an approximation introduced only for ease of calculation, but which is not implicit in our model. Our assignment of the configuration symbol b^ml^n merely implies that in the metal mN electrons are in bonding atomic orbitals (we allow polar structures for b^m but not for the localized electrons) and that on each site n electrons are in localized atomic orbitals.

In principle, to describe a metal with two localized electrons one should take the best linear combinations of functions each of which is a product involving $^3A_{2g}$, $^1A_{1g}$ or ^1E_g states at each site. One could not then say that l^2 at a given site and for a given total electronic function is a definite one of the possible site states $^3A_{2g}$, $^1A_{1g}$ or ^1E_g. However, one would naturally expect the lowest eigenfunctions based on configurations b^ml^2 to correspond to states which are almost entirely $^3A_{2g}$ at each site, and this is an assumption of our theory.

The next problem is to decide what the individual values of m and n are. At the beginning of a period, one expects the electrons to go into the bonding orbitals. Thus body-centred cubic potassium would be b^1l^0. It would be difficult to decide from *a priori* considerations when the electrons start going into the l-orbitals. If one accepts our model, however, the experimental data for the first long period strongly suggest that the first six electrons go into b-orbitals and then the l-orbitals start filling up at least until two electrons are in them. The configurations we propose for body-centred cubic metals, then, are shown in Table 2.

In a more complete discussion we would consider interconfigurational interactions. To have a complete set of basic configurations we would include structures having different numbers of localized electrons on different sites. Our proposal is, however, that we may usually restrict attention to one of the special configurations b^ml^n without great inaccuracy. We shall find that the magnetic evidence may indicate a mixture of configurations for chromium, and then, of course, the majority of low-lying states will be linear combinations of functions corresponding neither to b^6l^0 nor to b^5l^1, but of functions corresponding to $n=0$ on some sites and $n=1$ on others.

We now pass on to show how the experimental data accord with our model and the above assumption about the individual values of m and n.

Magnetic Properties

Neutron diffraction experiments[8] on vanadium do not indicate any magnetic moment. This we interpret to mean that vanadium has the configuration b^5l^0. Chromium[8], however, appears to have a small moment per atom, although the experimental position is not quite clear. This perhaps justifies the symbol $b^{5-6}l^{1-0}$ in Table 2. We regard the low-lying states of chromium as being formed from structures with no localized electron on most sites and perhaps with one on others.

Body-centred cubic iron is ferromagnetic with a saturation magnetization of 2·22 μ_B per site. Neutron diffraction confirms this figure[8]. It has been interpreted by supposing there are two electrons with parallel spins on each atom which then align ferromagnetically by an indirect interaction through a conduction band[9]. This interpretation, according to our point of view[1], means that iron is predominantly b^6l^2. The two localized electrons on a given site have their spins parallel because the lowest state of l^2 is $^3A_{2g}$. The 'conduction band' is roughly equivalent to b^6 in our model.

In view of the analogy between our localized d-orbitals and inner-shell $4f$ rare-earth orbitals, this model of ferromagnetism in iron is precisely analogous to the model for ferromagnetic gadolinium with the configuration b^34f^7 in which the localized $4f$-electrons carry the magnetic moment.

Electron Distribution

The spatial distribution of electrons in transition metals has been studied by Weiss and co-workers[10] using X-ray methods. They find that for face-centred cubic nickel and copper the electron density corresponds to an inert gas core together with the anticipated number of d-electrons (ten in copper and about nine in nickel) each having a radial distribution similar to that given by Hartree–Fock calculations. However, in body-centred cubic chromium there is no evidence at all for d-electrons with a normal radial distribution, while for body-centred cubic iron the electron density corresponds to the core and just two normal d-electrons.

The absence of any density corresponding to d-orbitals in chromium is very puzzling. Presumably the radial functions for the electrons used in bonding are very different from those in the free atom and so escape detection by the X-ray method. However, the presence of just two radially localized electrons in iron is nicely consistent with the suggestion that there are two non-bonding electrons present in the e_g orbitals[1], since a non-bonding electron would be expected to have a radial distribution not too different from that in the free atom.

The low-temperature phases of both chromium and iron are body-centred cubic, but while there is a body-centred cubic form of manganese at high temperatures the low-temperature manganese structures are very complicated. It has been suggested[2] that this is because in the configuration b^6l^1 anticipated for body-centred cubic manganese the localized electron in the doubly degenerate e_g-orbital would lead to a Jahn–Teller distortion of the lattice. Considered alone, this evidence would, of course, be very indirect.

X-ray Spectra

Finally we discuss the soft X-ray spectra of body-centred metals. Our theory would lead us to anticipate that the allowed transitions from the $2p$- and

$3p$-orbitals to the $3d$- and $4s$-orbitals would show one remarkable feature, namely, the presence of relatively narrow bands corresponding to transitions to the $3d(e_g)$-orbitals[2]. Furthermore, in chromium, since the e_g-level is just about to fill up, we should expect the narrow band to lie at the absorption edge. In iron, on the other hand, two electrons are already in the e_g-orbitals so that a third would be forced to go in with antiparallel spin. It follows that the most stable empty orbitals are bonding orbitals, so that the narrow absorption band should be preceded by some absorption involving transitions to the conduction band. Both these anticipated features have been reported in the M_{II} and M_{III} spectra of chromium and iron[11], but no explanation of them has previously been given.

It is perhaps necessary to remark that the X-ray spectra give the relative positions of different unoccupied orbitals only in a qualitative sense. The excitation of an inner electron increases the effective charge on the nucleus and so perturbs the energy-level scheme of the metal. If different orbitals are perturbed to different extents, the relative positions of these orbitals may be modified. In particular, a localized orbital will be more affected than an orbital which is part of a broad band, so the stability of the e_g-orbital will be exaggerated somewhat in the X-ray spectrum. The difference between chromium and iron, however, is unambiguous.

Additional Data

There is not much to say about the later transition series. Neutron diffraction indicates no atomic magnetic moments for niobium, molybdenum or tungsten, suggesting the configurations b^5l^0, b^6l^0 and b^6l^0 respectively.

In the second and third series the last element to have the body-centred cubic structure is that in group VI[12]. In the first period, however, iron has both this structure and a close-packed structure[12]. Now body-centred cubic iron has a stabilization of about 9 kcal./mole due to the exchange energy between the two l-orbitals[1], there being no such exchange energy in close-packed iron. Since the two structures are almost equi-energetic[13] one must suppose that there is a compensating gain of bonding energy in the close-packed structure. Accepting this empirical balance, one then expects the body-centred cubic structure to be less stable relative to close-packed structures for ruthenium and osmium because one knows that the exchange integrals (from atomic spectral data) are smaller, and the overall cohesive energies (and hence presumably bonding energies in the limited sense) are larger. Although ruthenium and osmium are hexagonal close-packed, whereas iron is face-centred cubic, one may still suggest that the fact that only iron of the group VIII metals forms a body-centred cubic structure is due to the two reasons given.

In neither the hexagonal nor the cubic close-packed metal lattices is it possible to find any s-, p- or d-orbitals which do not interact in a σ-fashion with nearest neighbours. Hence our discussion does not apply directly to them. This means that the ferromagnetism of cobalt and nickel cannot be discussed in the same way as that of iron.

We are indebted to Prof. H. C. Longuet-Higgins and Prof. N. F. Mott for their interest in this work.

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ORIGIN OF TEKTITES

H. H. NININGER[1] has proposed that tektites be regarded as the ejecta from lunar craters produced by meteorite impact. He points to the work of L. J. Spencer[2,3] comparing the tektites with glassy matter from terrestrial meteorite craters. The wide distribution of tektites of a single type, such as australites, argues in favour of lunar rather than terrestrial craters.

This theory is especially attractive because there appears to be direct evidence that spherical glassy bodies have been ejected from some of the ray craters. The evidence is the fact that long bright streaks diverge from these craters ; and that these streaks appear to return light in the direction from which it came in the manner of a beaded-glass screen[4]. (Prof. M. Minnaert has informed me verbally that experiments at Utrecht on various surfaces have shown that the dependence of brightness on phase angle observed for the bright rays cannot be duplicated by plausible sorts of surfaces ; but can be duplicated by scattered glass beads.) Furthermore, in at least one case, namely, Tycho, the streaks extend almost half-way around the Moon, and hence correspond to velocities of the order of the velocity of escape from the Moon.

Nininger seeks to explain the distribution of tektite finds, chiefly within 40° of the equator, as a consequence of lunar origin, the tektites having followed, he believes, a direct line between the centres of the Moon and Earth, and arriving in the tropics because the Moon is overhead only in these latitudes. This explanation is not satisfactory, since it assumes implicitly that the orbital velocity of the Moon is perfectly cancelled by the explosion velocity. If the cancellation is imperfect, the orbital plane will be determined by the centre of the Earth and the resultant velocity vector, and will be oriented more or less at random.

This difficulty can be removed if we assume that the Earth possesses an outer atmosphere, extending 10 radii or more, and having a density of the order of 10^{-21} gm./cm.^{3}. (Dr. H.-K. Paetzold, of the Max-Planck-Institut, has verbally confirmed this order of magnitude of the density of the atmosphere at 10 Earth's radii.) In this case, many of the particles thrown from the Moon could be expected to encounter the extended atmosphere near perigee. The effect of the atmosphere will be to diminish the eccentricity and semi-major axis of the orbit of the particle around the Earth[5].

After a period of 10^7 years or the like, the orbit would become very nearly circular, and would approach the surface of the Earth. Owing to the attraction of the equatorial bulge of the Earth, the orbit would be more sharply curved where it crosses the equator. The equations of motion have been integrated for a closed, almost circular orbit which is symmetrical about the Earth's axis. It is found that the radius vector, r, can be expressed approximately as a function of the latitude φ for a meridional orbit by the relation:

$$r = r_0\left(1 + \frac{\alpha}{12}\cos 2\varphi\right)$$

where α represents the flattening of the Earth. On the other hand, the sea-level surface of the Earth can be described by the corresponding relation

$$r = r_0\left(1 + \frac{\alpha}{2}\cos 2\varphi\right)$$

It is seen that the orbital perturbations cancel only one-sixth of the effect of the Earth's ellipticity. It follows that such a satellite will be about 11 miles nearer the surface of the Earth at the equator than at the poles, and will be subjected to about fifteen times as much air resistance. It will thus nearly always come to Earth in latitudes near the equator, in accordance with the distribution found for tektites.

An example of a body describing such an orbit is provided by the meteor procession of February 9, 1913, described by C. A. Chant[6] and computed by the Rev. M. A. Davidson[7]. This group of bodies described a path 5,700 miles long from Saskatchewan to the South Atlantic at heights of the order of 40 miles. The orbit was clearly a nearly circular one about the centre of the Earth. W. J. Fisher[8] suggested that the bodies were intercepted by the equatorial bulge of the Earth.

It thus appears plausible that in the tektites we have portions of the lunar surface.

The kind assistance and advice of Mr. E. P. Henderson, of the U.S. National Museum, is gratefully acknowledged.

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ON the basis of observations accumulated by different authors over the past few decades, I consider that an extra-terrestrial origin of tektites is more compatible with their observed physical and chemical properties. The greatest difficulty encountered by any theory invoking an extra-terrestrial origin of tektites is to explain their peculiar distribution over the surface of the Earth. One would assume that, if tektites had arrived at the Earth in swarms, each swarm would have deposited them over one terrestrial hemisphere, unless the tektites were members of relatively small clouds. Since we observe the tektite deposits to be localized in small regions, we must conclude that the second alternative must be the correct one.

However, a cloud of such particles travelling through space would not retain any degree of compactness for more than a few hours, or perhaps days, and hence the cloud must have originated very near the Earth, possibly at the Moon. To test this hypothesis, I carried out a series of calculations which determined whether material ejected from the Moon by the impact of a meteorite on the lunar surface could arrive at the Earth in such a way as to reproduce the observed distribution of tektites on our planet. The initial conditions of ejection were chosen according to a model of meteoritic impact suggested by Whipple and Rinehart (unpublished work). The computations were carried out on the *IBM* 704 digital computer of the Massachusetts Institute of Technology. The distribution of tektites ejected from a lunar crater so computed agrees remarkably well with the observed distribution of australites (tektites found in Australia), thus making the Moon a very likely source for these peculiar objects.

Details of the calculations have been included in a paper submitted for publication in *Geochimica et Cosmochimica Acta*.

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THE glassy nature of tektites requires an explanation in terms of the processes of the impact explosions. The heating at a meteoritic impact is very intense, due to the great compression of the meteorite and a comparable quantity of the material of the ground. During the short duration of the event, however, not much heat can be communicated to the surrounding materials. Surfaces can be heated at most to their evaporation temperatures, and the depth to which heat conduction can then cause melting in a few seconds is limited to some millimetres in most substances. The mass ejected from craters is thought to be large compared with that of the meteorites causing them. The suggestion made by O'Keefe to account for the high reflecting power of the 'rays' around the younger lunar craters and also of their interior surfaces would require a large proportion of all this ejected material to be glassy; and so would the idea of the lunar origin of tektites.

A process that can distribute energy more rapidly than heat conduction through the interior of an opaque solid is required for the explanation, and a large pressure pulse appears to be the only possibility. An impact explosion will no doubt be responsible for a shock wave in the solid. It will, however, be mainly a single pressure cycle, and this can be expected to cause melting only in substances that possess much hysteresis in their compression characteristics. The material must end up as a liquid after the pressure pulse if it is to form beads. Sand or powder of hard rocks would qualify, as there the application and release of high pressure can greatly increase the final density above the initial one. The volume integral of pressure around the cycle representing the work absorbed in the material will then be large. Also the great decrease in the compressibility that will occur when all the empty spaces have been filled will allow pressure waves of a wide range of intensity to be propagated and to leave similar amounts of energy behind in heat in the material. Without such a sharply non-linear compression characteristic of the material, a shock wave intense enough to produce melting at one range from its focus would produce evaporation at a slightly smaller range, and again only little of the material would be left in liquid form.

On the Earth, the phenomenon of liquefaction by impacts of meteorites in sand has been recognized: the so-called impactites display terrestrial chemical composition, with somewhat similar glassy appearance to the real tektites. But these have occurred in a small fraction of the recognized impact events; where impacts occurred in originally compact materials, only the broken-up forms of these materials seem to have been ejected from the craters.

The present suggested identification of the tektites would allow, therefore, of a judgment concerning not only the chemical but also the physical condition of the lunar surface material. Experimentation with tektite material may allow one to specify more precisely in what state it must have been before the impact. Presumably these considerations go together with the idea that dust covers a large proportion of the lunar surface.

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A POSSIBLE BASIS FOR PHYTO-IMMUNITY

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IN studies on immunity in higher animals the most obvious analytical medium is blood. In plants, however, no such simple standard system is available; indeed, phyto-immunity is, in principle, difficult to formulate because plants have no blood. A variety of natural saps and juices have been suggested as agglutinating systems in previous literature (see, for example, Berridge[1]); the difficulty is to give *a priori* justification to any one system rather than another. What is required is a plant product continuously in contact with (bacterial) infection and demonstrating resistance to this infection over a reasonable portion of the life of the plant (say, 30 years, in the case of a tree). This article suggests that *Hevea* latex is such a system and records its agglutination reactions.

Early in 1956, a sterile box was constructed around a rubber tree (*Hevea brasiliensis*—an unselected seedling), and the latter tapped under aseptic conditions, the air space being irradiated by six ultra-violet germicidal sources (Fig. 1). (Details of this apparatus are to be published elsewhere.) It was found that sterile latex was not initially obtained; the latex vessels harboured bacteria to a depth of about 8 mm. This population could be removed by deep-sectioning. That this type of viable population exists in the vessels of many rubber trees has now been confirmed. It is possible to take latex from the interior of these vessels using a sterile hypodermic syringe and aseptic technique and obtain latex with a viable population of up to 10^5 bacteria/ml.

After each tapping, some 10^{10} viable bacteria develop on the tapping cut; at the following tapping, however, latex with about 10^6 viable bacteria/ml. is obtained, and of this figure some 90 per cent result from random external contamination by bacteria on the outside of the tree. The presence of the indigenous population of latex vessels and the

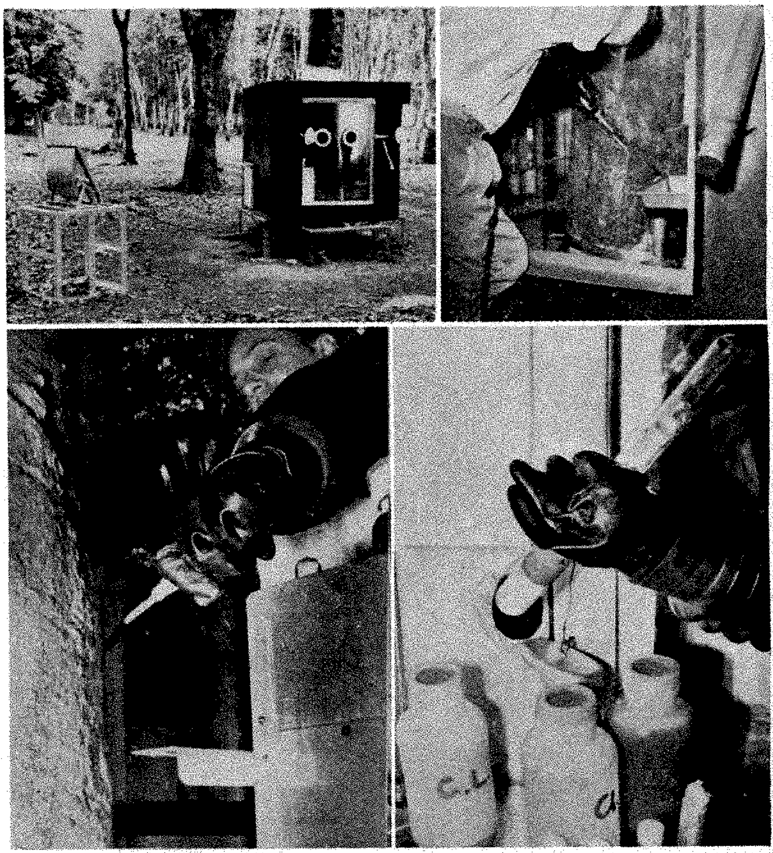

Fig. 1. Apparatus for tapping a seedling rubber tree under aseptic conditions; the sterile cabinet, the tapping operation and the removal of sterile latex in a sterile, sealed container through a dead-space are shown

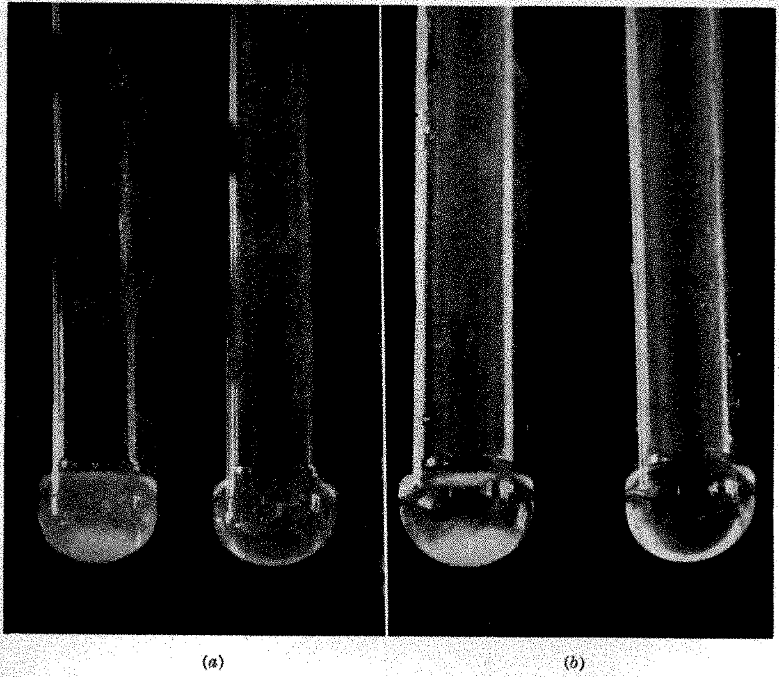

Fig. 2. Agglutination of bacterial suspensions by *Hevea* latex sera (53° C.). (*a*) Control suspension and agglutinated system for *Serratia marcescens* (Bizio). (*b*) Control suspension and agglutinated system for *Micrococcus* sp.

reduction in viable population achieved between tappings argue some powerful defence mechanism designed to limit bacterial attack. The most likely transport for this defence is latex itself (this does not exclude the possibility of a type of phagocytosis occurring elsewhere—say, in the plasma layer). Various types of antigen-antibody reaction could be suggested.

Fig. 2, *a* and *b*, shows agglutination of strains of *Serratia marcescens* (Bizio) and *Micrococcus* sp. both isolated from latex vessels; these are agglutinated by fresh *Hevea* latex sera from known (normal) infected trees, separated by high-speed centrifuging at 20,000 r.p.m. for 30 min. in rotor 40 of the 'Spinco Model *L*' ultracentrifuge (36,000 *g* maximum)[2]; the sera are filter-sterilized. Both somatic and flagellar agglutination are demonstrated by these sera. *H* agglutination takes about 40 min. at 53° C. and *O* agglutination some 8 hr. Despite the relative rapidity of these reactions, the titre is low, and almost neat serum is required for efficient agglutination.

Table 1. AGGLUTINATION REACTIONS IN BLOOD AND THEIR ANALOGUES IN *Hevea* LATEX

Designation	Blood system	*Hevea* latex analogue
Agglutination	Bacterial suspension in saline plus blood serum	Bacterial suspension in saline plus fresh latex serum (from centrifuge)
Hæmagglutination	Bacterial suspension in saline plus red blood cells	Bacterial suspension in saline plus *Hevea* latex hydrocarbon particles (resuspended)
Thomsen–Friedenreich panagglutination and bacteriogenic hæmagglutination	Agglutination of (bacterially) modified red blood cells by sera or other red blood cells (or the converse)	Agglutination of (bacterially) modified hydrocarbon particles by sera or other hydrocarbon particles from *Hevea* latex (or the converse)

In Table 1 are drawn up some normal agglutination reactions for blood, and these are compared to similar reactions obtained for *Hevea* latex.

Since the titre is low, non-specific agglutination might be invoked to explain the simpler reactions—by change of *p*H or by phosphate ion normally present in sera. This view is not favoured: fresh latex is almost neutral, mean *p*H 6·8, and the maximum difference between latices used in these experiments is 0·3 *p*H units; phosphate variations in seedlings are insufficient to explain observed variations in titre. Further, the analogue of bacteriogenic hæmagglutination is a particularly efficient reaction: hydrocarbon particles from virgin trees are rapidly agglutinated (and coagulated) by filter-sterilized infected sera; it therefore follows that some profound modification of these sera must have occurred as a result of previous infection. The difference in agglutination-rates between flagellates and non-flagellates is strong evidence in favour of a specific mechanism.

Of these reactions, those involving modified sera are well defined, there being no difficulty in detecting agglutination by eye; those involving hydrocarbon particles are weak when compared to hæmagglutination. Two factors contribute to this weakness: the first is the very small size of the hydrocarbon particle compared with the red blood cell (0·7μ as against some 8μ—a difference of about two thousand-fold in mass); the second is the low density of hydrocarbon. This means that agglutinated hydrocarbon particles with bacteria may either sediment or float in serum or saline, depending on whether a given clump is composed dominantly of bacteria or hydrocarbon; this does not facilitate macroscopic examination. It is believed that the Thomsen-Friedenreich and related phenomena may explain observations in which latex from newly opened (presumably uninfected) trees suddenly flocculates: contamination of this virgin latex with previously infected hydrocarbon or sera present in the tapping cup would initiate this process.

It is unfortunate that the gross contamination of trees in normal tapping results in these sera being polyvalent. Thus reaction to infection by single strains must be deduced from studies on previously unopened trees, with a resulting limitation in the number of experiments performed. Despite this difficulty, it is thought that these agglutination reactions of *Hevea* latex provide a general tool for the antigenic analysis of bacteria, particularly those pathogenic to plants.

This study forms part of a research programme on the microbiology of *Hevea* latex undertaken by the Board of the Rubber Research Institute of Malaya.

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LETTERS TO THE EDITORS

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Electron Spin Resonance of Coals: Saturation Effect

In an investigation into the electron spin resonance of coal, I found a saturation effect depending on the percentage of carbon contained in the coal. The samples, all of them vitrinites, were examined in air; the frequency at which the measurements were made was 9,000 Mc./s.

It was found that in those cases where the saturation could well be measured the saturation factor Z showed good agreement with the theoretical expectation given by

$$Z = (1 + \tfrac{1}{4}\gamma^2 H_1{}^2 T_1 T_2)^{-1}$$

In this formula γ is the gyromagnetic ratio, H_1 the amplitude of the alternating magnetic field, T_1 the spin–lattice relaxation time and T_2 the spin–spin relaxation time. As Z, H_1 and T_2 could be experimentally determined, T_1 could be calculated.

Instead of T_1 Fig. 1 gives the variation of $P(Z = 0{\cdot}5)$ as a function of the rank. We define $P(Z = 0{\cdot}5)$ as that amount of energy dissipated in one gram of coal, for which the saturation factor Z becomes equal to 0·5. In some cases, for example, when measuring the number of free radicals, this quantity may have a more direct significance to the experimental investigator than the value of T_1.

A variation similar to that in Fig. 1 may probably be expected if for some sugar chars $P(Z = 0{\cdot}5)$ is plotted as a function of the carbonization temperature[1].

From Fig. 1 it is seen that at carbon percentages less than 88 the value of $P(Z = 0{\cdot}5)$ is very low, so that in determining the number of free radicals in this range there is a risk of measuring them in a saturated state and hence of finding a number which is lower than the actual one.

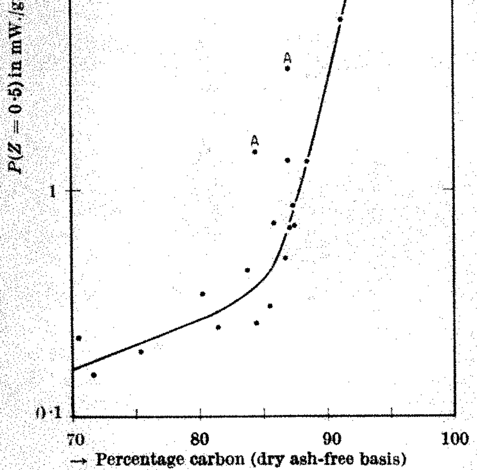

Fig. 1

At carbon percentages greater than 86 the value of $P(Z = 0{\cdot}5)$ shows a rapid increase. Lacking an energy source of sufficient power, I have not been able to measure the saturation effect beyond 94 per cent carbon. That the value of $P(Z = 0{\cdot}5)$ in this range must be very high is corroborated by the facts that a $P(Z = 0{\cdot}5)$-value of 1 mW./gm., for the coal under consideration corresponds to $T_1 \approx 4 \times 10^{-5}$ sec., and that Garif'yanov and Kozyrev[2] measured $T_1 = 12 \times 10^{-8}$ sec. for an anthracite.

I would also direct attention to the influence of ash content. In two cases measurements were made on samples of low and high ash contents (the latter samples are indicated by A in Fig. 1). It is seen that the presence of ash causes a rise of $P(Z = 0{\cdot}5)$. At the same time T_1 decreases, which suggests an increase in the exchange between the unpaired electrons and the surroundings. In both cases the samples of high ash-content proved to contain more free radicals than the practically ash-free samples, which seems to indicate that, at least in the two cases considered, the ash contains paramagnetic components.

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Dispersion Energies in Porous Sorbents

De Boer and Custers[1], by an integration process, approximated to the energy of interaction by dispersion forces between a molecule and several types of cavity. On a plane surface containing N atoms of substrate per cm.^{3} the interaction energy is near to

$$E_1 = -\frac{\pi N A}{6} \times \frac{1}{r^3} \qquad (1)$$

if the interaction energy between an isolated sorbate molecule and the nearest atom of sorbent is given by $-A/r^6$. A is a constant given approximately by the London theory of dispersion forces[2]. Then, in turn, in a hemispherical pocket, at the bottom of a very long cylindrical capillary with a hemispherical end, and in an isolated spherical cavity, all of radius r and just large enough to contain the molecules, the energies of interaction are respectively $E_2 = 4E_1$, $E_3 = 6{\cdot}36E_1$ and $E_4 = 8E_1$.

This calculation indicates that very large maximum enhancements of sorption energies could be expected in suitable capillaries. For two plane parallel surfaces r apart, $E_5 = 2E_1$. Thus, in slit-shaped cavities such as could occur with graphite, the ratio between initial and limiting heats of sorption may approach two. Such a ratio has indeed been observed, and the above explanation of it has been suggested[3]. However, with highly porous sorbents one may easily exaggerate the enhancement of dispersion forces due to environment, and I wish to subject the idea of this enhancement to a more critical examination.

In the first instance the perfect fit of a sorbate molecule into the pocket (energy $= E_2$), channel (energy = E_3) or cavity (energy = E_4) will not be encountered in practice. In the nearly spherical cavities in β-quinol, it is true that the free diameter is ∼3·9 A., accommodating one argon atom of diameter 3·83 A. neatly[4]. (By 'free' is meant not occupied even by the peripheries of the framework-forming atoms of the lattice.) However, in water clathrates of Type 1, the free diameter is 5·9 A. or 5·2 A.[5] (a 'loose' fit for one argon atom); in chabazite it is ∼7·3 A.[6] (three argon atoms just accommodated); in Linde sieve *A* it is ∼11·8–11·4. A.[6,7] (filled by thirteen argon atoms); while in faujasite it is ∼12–13 A.[6,8,9], filled by eighteen argon atoms. (In the last three sorbents the cavities are also linked by narrower windows into a network of channels, the diameter of which thus varies periodically along their lengths.) Also, and perhaps even more important for such intracrystalline sorptions, a molecule in a cavity is not interacting with a dense atomic distribution outside the cavity, but with a honeycomb-like structure having a rather small density of atoms per $cm.^3$ of sorbent.

One way to demonstrate this last situation is to give per $cm.^3$ of sorbent host-lattice the number *N* of the atoms of the host lattice. This is done in Table 1, which also gives isosteric heats of sorption at zero coverage and for finite coverage. In column 2 it is seen that *N* for the important oxygen and carbon atoms of the honeycomb-like sorbents (including β-quinol and the β-ice water lattice in gas hydrates) is only about a third to a quarter of its value in compact solid-sorbents such as rutile or graphite. Thus the value of *N* in equation 1 is an important factor in *reducing* the enhancement of dispersion forces in these intracrystalline environments. Indeed, E_4 could be reduced by this factor from $\sim 8E_1$ to $\sim 2E_1$. If now we compare the situation for argon inside carbon-rich β-quinol with that for argon adsorbed on a non-porous carbon such as the 'Spheron' or 'Graphon' of Table 1 we find ratios of sorption heats E_4/E_1 a little less than two, and very far from the maximum value of eight suggested by de Boer and Custers's treatment. This is despite the nearly perfect fit of argon into the β-quinol cavities. Moreover, when we compare the initial isosteric sorption heats of argon for finely porous 'Saran' carbons with those of non-porous 'Graphon' or 'Spheron' an enhancement is seen for the porous sorbents but only of ∼1·5 fold, again much less than the optimum value of eight.

Coming now to the porous oxygen-rich sorbents, chabazite and faujasite, and the dense rutile, it is seen from Table 1 that isosteric heats for argon for larger amounts sorbed are about the same on all three sorbents (polarization energy contributes to initial heats[12], especially for the calcium-rich chabazite crystals, so that the initial heats do not measure only dispersion energies). Evidently, then, the intracrystalline environment of argon in chabazite and faujasite is largely offset by the greater density of oxygen atoms for non-porous rutile, even though the argon is present only on external surfaces of rutile crystals.

Table 1. SOME HEATS OF ADSORPTION AND OF INTERCALATION (KCAL./MOL.)

Sorbent	*N* (atoms of sorbent per $cm.^3$) $\times 10^{-22}$	Sorbate	As $v \rightarrow 0$	Isosteric heat. For $v/vm = 0 \cdot 5$ (or for *v* ($cm.^3/gm.$) at S.T.P., given by figures in brackets)
β-Quinol (ref. 4)	2·27 (C) 0·76 (O) 2·27 (H)	A*	4·8	4·8
Gas hydrate (ref. 5)	2·66 (H_2O)	A*	∼3·0	∼3·0
		Kr*	∼5·3	∼5·3
		Xe*	∼8·0	∼8·0
Chabazite (ref. 10) (out-gassed at 480° C.)	3·0 (O)	A	∼6·0	3·0 (50)
		H_2	∼3·8	2·0 (40)
Chabazite (ref. 11) (out-gassed at 300° C.)		A	4·6	3·6
Faujasite	2·47 (O)	A	2·70	2·70 (25)
		O_2	2·80	2·80 (25)
Rutile (ref. 13)	10·6 (O)	A	3·50	2·50
		O_2	4·00	2·80
Carbon:	11·5 (C as graphite)			
'Spheron' pre-heated to 2,700° C. (refs. 14–16)		Kr	3·97	4·55
		A	2·70	2·80
		Ne	0·87	0·88
		He	0·37	0·34
'Graphon' (ref. 17)		A	2·60	2·75
'Saran' *S* 84 (ref. 14)		A	3·50	2·63
'Saran' *S*600*H* (ref. 14)		A	3·90	3·63

* Heats for intercalation in β-quinol and in gas hydrate should not depend on amount sorbed. In this case isosteric and integral sorption heats are identical.

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Flame Ionization Detector for Gas Chromatography

A NUMBER of gas chromatography detectors depending on ionization of the eluted gases have recently been reported[1]. Ionization has been effected either by β-rays from a radioactive source, or by a low-pressure glow discharge, or by electrons emitted in an ionization gauge.

A sensitive detector has been developed which depends on the ionization of the effluent in a hydrogen flame. A schematic diagram of the detector is shown in Fig. 1. The gases from the column in a suitable inert carrier are mixed with hydrogen, and burned in air at the tip of the glass jet. If hydrogen is used as the carrier gas, mixing is naturally unnecessary. The platinum electrodes are arranged to be in contact with the flame, the spacing being not very critical.

The electrical circuit used, Fig. 2, consists of a balanced cathode-follower impedance transformer. With a 0–1 m.amp. meter or recorder connected to the output terminals, full-scale deflexion was

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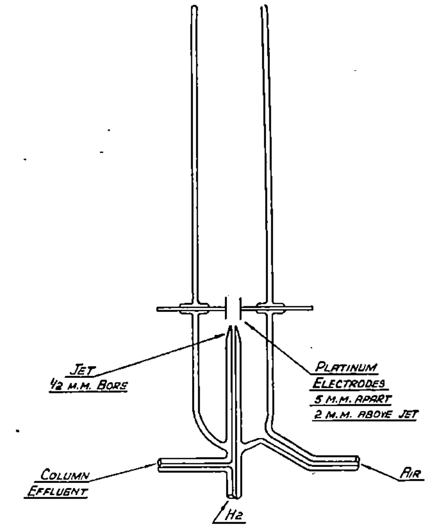

Fig. 1

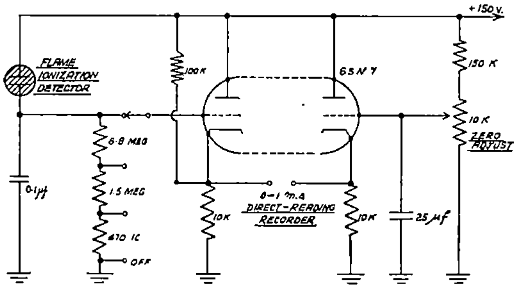

Fig. 2. Electrical circuit

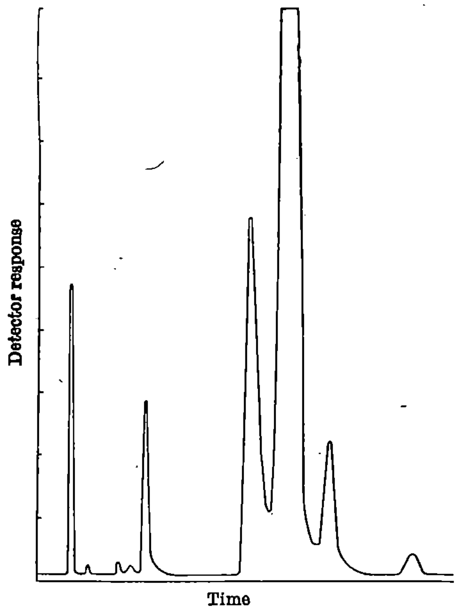

Fig. 3. Analysis of Japanese mint oil. Column packing: 'Celite' and di-nonyl-phthalate. Sample size, 5λ. Column temperature, 170° C.

produced with an injected sample of 1 µl., with a signal-to-noise ratio of better than 1,000 to 1, and no observable base-line drift over a wide range of operating conditions. The ultimate sensitivity of this detector has not yet been established.

A typical chromatogram using this detector is shown in Fig. 3. The electrical output appears to depend linearly on the sample size and was tested up to 10 µl., the reproducibility being at all times limited only by injection precision.

As the detector is constructed entirely of glass and metal, it is well suited to the detection of fractions from high-temperature columns.

A more detailed description of the detector will be published shortly.

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Electric Double Hysteresis in $(K_x\ Na_{1-x})NbO_3$ Single Crystals

Sodium niobate forms solid solutions of perovskite type structure with the niobates of potassium[1], cadmium[2] and lead[3]. At quite low concentrations of the latter in these compositions the room temperature orthorhombic antiferroelectric structure of pure sodium niobate ($NaNbO_3$) gives place to an orthorhombic ferroelectric form. The phase-change between these two structures has not, however, been observed in any of these systems. In the ceramic specimens which have been examined, the ferroelectric properties increase gradually over a range of compositions. Pure sodium niobate single crystals, on the other hand, show double hysteresis loops at high fields[4] suggesting a discontinuous change to a ferroelectric form.

Using the techniques previously developed for sodium niobate, I have now extended the single-crystal measurements to the system $(K_x\ Na_{1-x})NbO_3$, and find the following properties. The phase diagram, determined optically on a hot-stage polarizing microscope, is shown in Fig. 1. The behaviour of specimens in both regions *a* and *b* is characteristic of orthorhombic crystals of cubic habit, with twinned regions showing parallel and symmetric extinction, and there is no qualitative optical distinction between them. The refractive indices and birefringence are, however, different in *a* and *b*, so that the phase change in a single crystal may be readily distinguished. The lines 1, 2, represent extreme cases of the survival of phase *b* in *a*, and vice versa, and it is probable that the two phases co-exist over the whole region *ab*.

Crystals of pure sodium niobate show electric double hysteresis for fields greater than 90 kV./cm. perpendicular to the orthorhombic *c*-axis. With increasing potassium niobate content, the field required to initiate hysteresis in the mixed crystals is continuously reduced, and the halves of the double loop commence to overlap. As the composition approaches the boundary 1 on Fig. 1 (in the region of 0·6 mole per cent potassium niobate), the electrical properties become more complex and markedly

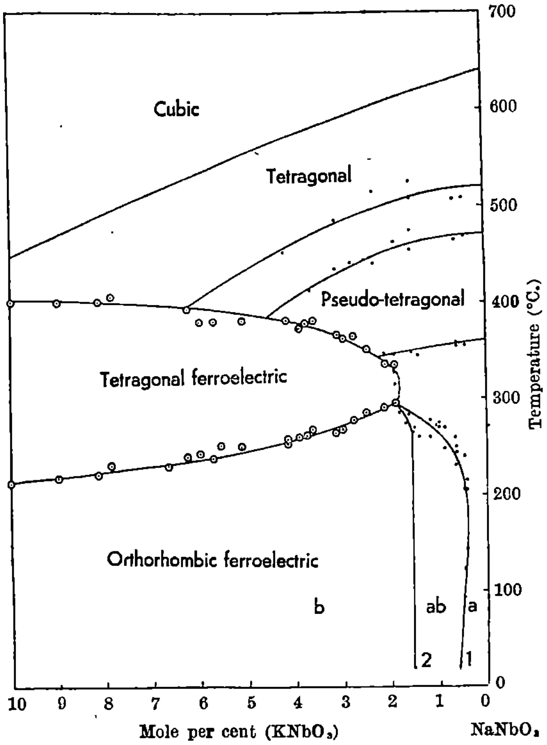

Fig. 1. Phase diagram for mixed $(K_xNa_{1-x})NbO_3$ crystals

dependent on pre-treatment. In virgin crystals, *PαE* is approximately linear up to a critical field-strength of the order of 20 kV./cm. at 50 c./s. Above this value, the initial cycles of the field produce double hysteresis loops, but subsequent cycling rapidly produces a ferroelectric loop (Fig. 2). Normal hysteresis persists below the previous critical field strength, and the performance of the virgin crystal is only regained after a sufficient period free from external fields. The time taken to recover varies widely between different specimens, but generally appears to increase as the composition approaches the phase boundary. With compositions containing more than 0·6 mole per cent potassium niobate, the mixed crystals give ferroelectric hysteresis loops.

These measurements confirm the discontinuous nature of the phase transition between antiferroelectric and ferroelectric orthorhombic structures in the $(K_x Na_{1-x})NbO_3$ system of solid solutions. The two structures, however, coexist over a considerably wider range of temperature than has been evident in any previously observed phase-change in a perovskite material.

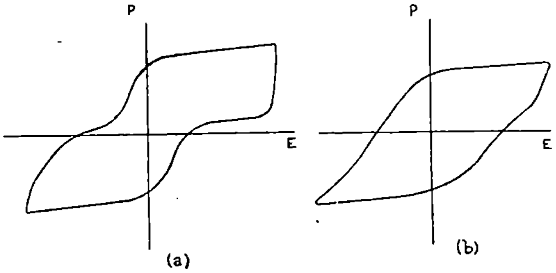

Fig. 2. Electric hysteresis in a single crystal of composition $(K_{0\cdot 0005}\ Na_{0\cdot 995})NbO_3$. (*a*) Initial application of 42 kV./cm. at 50 c./s. perpendicular to the orthorhombic *c*-axis; (*b*) 40 kV./cm. at 50 c./s. 1 hr. after cycling with 50 kV./cm. at 50 c./s.

There are a number of possible explanations for the absence of any discontinuity in the electrical properties of the equivalent ceramic materials. For compositions close to $NaNbO_3$ the single-crystal loops show that the field required to change the spontaneous polarization is high. There is also some evidence that the 'coercivity' increases with decreasing specimen thickness; thus with the distribution of orientations, and small crystallite size in the ceramics, it may not be possible to produce polarization re-orientation until the composition is markedly ferroelectric. It is probable also that there are larger composition inhomogeneities in the ceramics than in the single crystals, again tending to smear out the transition.

The very close proximity of the ferroelectric *b* phase to the pure sodium niobate makes it appear likely that similar phase-changes exist in the cadmium and lead systems. It is doubtful, however, whether the phase boundaries will be detected without a systematic investigation of single crystals of these materials.

A more complete account of this work, and the correlation with the thermodynamic treatment[5] of the properties of the solid solution sequence will be published elsewhere.

I am indebted to the Director of the British Electrical and Allied Industries Research Association for permission to publish this communication.

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Germanium and Gallium in Sea-Water

Germanium

No quantitative data have so far been published for the concentration of germanium in sea-water. The first observation of germanium in a specimen of marine origin was due to Cornec[1], who detected it spectrographically in the ash of *Laminaria* sp. Noddack and Noddack[2] found the element in nine widely differing marine organisms in amounts ranging from 0·07 to 2·2 p.p.m. They were unable to detect it in sea-water, and concluded that its concentration must be less than 0·1 μgm./l. Bardet *et al.*[3] attempted to co-precipitate a number of trace elements from 60-l. samples of sea-water from Roscoff (Brittany) using seven different carriers; spectrographic examination of the precipitates revealed the presence of germanium in three cases.

Buljan[4] and Ishibashi and Shigematsu[5] have attempted to predict the abundances of the elements in sea-water, and have arrived at the values of 73 and 0·2 μgm./l. respectively for the concentration of germanium. The former figure is obviously much too high, since it would give a silicon : germanium ratio in sea-water of about 20 : 1 as compared with a ratio of about 140,000 : 1 in the lithosphere (Riley, J. P., and Burton, J. D., unpublished work).

In order to get some quantitative information on the concentration of germanium in sea-water, 5-l. samples of sea-water were treated with ferric alum solution. The resultant precipitate of ferric hydroxide, which carried down more than 97 per cent of the germanium present in the sea-water, was dissolved in concentrated hydrochloric acid. Germanium was extracted from the acid solution with carbon tetrachloride, back-extracted with water and determined spectrophotometrically with phenylfluorone.

Surface samples of water from the Irish Sea (2), the English Channel (4) and the North Atlantic (2) were found to contain 0·06 ± 0·01 µgm. of germanium/kgm. (0·82 ± 0·13 µgm.-atom/ton). Samples taken at depths of 240–270 m. and 3,660–3,900 m. at lat. 47° 47′ N., long. 9° 18′ W., contained 0·06 and 0·07 µgm./kgm. (0·82 and 0·96 µgm.-atom/ton) respectively. The average germanium concentration found is of the same order as that predicted by Ishibashi and Shigematsu[5]. Germanium is concentrated in sea-water, relative to the closely related element silicon, having a silicon : germanium ratio of about 17,000 : 1 (assuming a silicon concentration of 1,000 µgm. silicon/l., which is probably considerably higher than average); compared with a ratio of about 140,000 : 1 in the lithosphere. The concentration of the element in sea-water is much more constant than that of silicon, which varies[6] over the range 10–2,500 µgm./kgm. This constancy is probably attributable to the fact that, unlike silicon, it is not utilized appreciably by plankton.

Further work is in progress on the marine geochemistry of germanium.

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Gallium

LITTLE is known of the occurrence of gallium in sea-water. Its presence was first detected by del Campo and Rodeja[1]. Bardet *et al.*[2] found it spectrographically, together with thirteen other trace elements, in water samples taken near Roscoff (Brittany). The only quantitative data so far published are due to Noddack and Noddack[3], who found 0·5 µgm. of gallium/l. in the water of Gullmars Fjord, Göteborg, Sweden; this analysis can scarcely be considered representative of ocean water, since the sample was taken from a fjord which is likely to be contaminated by drainage from the land. Ishibashi and Shigematsu[4] have predicted the abundance of gallium in sea-water to be 0·005 µgm./l.

The present communication records an attempt to obtain quantitative data on the occurrence of gallium in sea-water. The element was precipitated in 93 ± 5 per cent yield from 5-l. samples of filtered sea-water using ferric hydroxide as carrier. The ferric hydroxide precipitate was dissolved in hydrochloric acid, titanous chloride was added to reduce the iron to the ferrous state, and gallium was then extracted with di-*iso*-propyl ether. After evaporation of the ether, gallium was determined spectrophotometrically in the residue, using a modification[5] of the rhodamine *B* method of Onishi and Sandell[6].

Samples of the surface waters of the Irish Sea (4), the English Channel (1), and North Atlantic (2) contained 0·030 ± 0·007 µgm. gallium/kgm. (0·43 ± 0·10 µgm.-atom/ton). Two samples taken at depths of 240–270 m. and 3,660–3,900 m. at lat. 47° 47′ N., long. 9° 18′ W. contained 0·037 and 0·023 µgm. gallium/kgm. (0·53 and 0·33 µgm.-atom/ton) respectively. It is not considered that these variations are significant, since they are of the same order as the analytical error. The average gallium content of sea-water is thus about 0·03 µgm./kgm.—a value very much less than that found spectrographically by the Noddacks, but more in line with the relative abundance of the element in the lithosphere.

Further work on the occurrence of gallium in marine organisms and sediments is in progress.

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'Sub-Grains' and Etch Figures in Lead

IN the course of a recent investigation into the ageing characteristics of lead–antimony alloys[1], microscopical examinations of a range of aged specimens were carried out and recrystallized areas were observed in a number of the specimens which had been strained prior to ageing. The specimens had been prepared by the normal metallographic techniques of grinding and polishing and had been etched in Worner and Worner's reagent[2] to disclose the extent of precipitation. In a number of the specimens the precipitated antimony was cleared from the surface by a brief immersion in concentrated nitric acid (s.g. 1·42) and subsequent examinations showed the recrystallized areas to be covered with networks of fine lines producing an appearance of sub-grains, similar to that due to polygonization, which had been absent from the specimens prior to the nitric acid treatment.

Specimens of unalloyed lead which were given the same etching treatment were found to show this structure over their entire surfaces even in cast material, and modifications in straining and annealing procedure did not produce changes in sub-grain dimensions. Repeatedly re-etching the same area of a single specimen did not develop the same configuration of sub-grains, and it was concluded that the network of lines did not result from the structure of the lead but was an effect produced primarily by the action of the nitric acid.

The effects of etching treatments in a range of concentrations of nitric acid on prepared specimens of annealed, unalloyed lead were then observed and it was seen that the 'sub-grain' dimensions increased with the degree of dilution of the nitric acid (see Figs. 1 *a* and *b*). At 20 per cent dilution a mottling of the surface had started to spread from the 'sub-grain' boundaries and at 30 per cent dilution the entire surface was mottled and etch figures had started to form within the 'sub-grains' (see Fig. 1 *c*). These etch figures continued to develop to the extent shown in Fig. 1 *d* by treatment in nitric acid diluted 40 per cent.

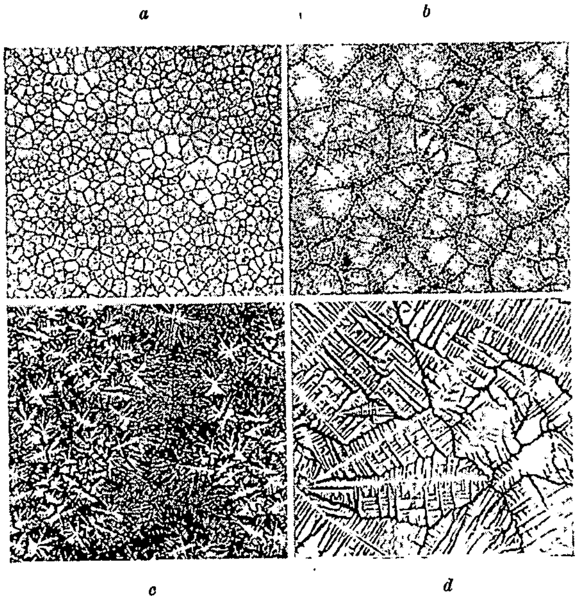

Fig. 1. *a*, Pure lead, treated in Worner and Worner's reagent and then in concentrated nitric acid, s.g. 1·42; *b*, as *a*, but finally treated in nitric acid, diluted 20 per cent; *c*, as *a*, but finally treated in nitric acid, diluted 30 per cent; *d*, as *a*, but finally treated in nitric acid, diluted 40 per cent. (All × 300)

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Anomalous Atmospheric Refraction at Sea

During the Atlantic crossing on Research Yacht *Princess Waimai* in 1954, to increase the accuracy of navigation astronomical sights were taken, as a rule, in series of observations: the noon sight series, extending usually for about an hour, with the Sun's culmination in its middle, 9 a.m. and 3 p.m. series, extending for about 20 min. Observations were taken about every minute. In all, 46 noon sight curves were obtained and 72 others, all in good weather conditions, within the tropics. The sextant used was a Henry Hughes instrument, with a recent class *A* National Physical Laboratory certificate. The height of the eye varied for different series of sights between 6 ft. and 10 ft.; estimated accuracy of observations within ±0·5 min. of arc.

Considering all the material, it appears that 24 per cent of sight points deviate by 2 min. of arc or more, and ½ per cent by 5 min. of arc or more, from interpolated curves.

Deviating points rarely appear at random, but rather in groups of three to five consecutive points, showing the same sign of deviation. But when a deviating group covers the culmination, there is often change of sign of deviation when the culmination is passed, that is, when the azimuth changes very quickly and the telescope sweeps over large stretches of the horizon between two consecutive sights. Groups of points deviating on either side of the curve are equally frequent. Morning sights show the lowest deviation frequency, namely, 15 per cent. There is little difference in frequency between noon and afternoon sights.

A plausible explanation of this phenomenon seems to be fluctuations of horizon height due to anomalous atmospheric refraction.

Some experiments have also been devoted to sextant optics. It was found that polarizing optics are superior to standard coloured glass 'shades', with which the sextant is normally equipped. Such optics often allow better horizon definition and also provide continuity in dimming incoming light. A 'Polaroid' disk, attached to one end of a sextant telescope so that it could be rotated, and another one, also with free rotation, in place of standard sun 'shades', was used. By rotation of the telescope 'Polaroid' one obtains the horizon contrast, and then the rotation of the sun 'Polaroid' provides the continuity in dimming the Sun. As any glare coming from the sea surface can be cut out completely by the telescope 'Polaroid', there is little need for additional horizon 'shades'; but, if desired, a third 'Polaroid', also with free rotation, can be attached in their place.

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Effect of the Metallic Ion on the Infra-Red Spectra of Salts of Carboxylic Acids

A full analysis of the infra-red spectra of salts of carboxylic acids requires an interpretation of the effect of the metallic ion. Although a theoretical study of the formate ion has been published, a fundamental investigation of the perturbation caused by the presence of the metal ion has not yet been attempted[1]. Therefore, at present it is necessary to rely on empirical correlations.

The strong absorption bands attributed to the unsymmetrical (ω_2 at 6·2–6·6μ) and symmetrical (ω_1 at 7·1–7·7μ) vibrations of the carboxylate ion (COO^-) have been the most thoroughly investigated[2].

Recently, Kagarise[3] reported that for mono- and di-valent metals there are linear relationships between electronegativity and wave number of the ω_2 band for eight metallic phenyl stearates. Theimer and Theimer[4] have claimed that there is a relationship between the ionic radius of the metal and the Raman ω_1 band for the salts of five fatty acids.

The relationships claimed by Kagarise must not be regarded as general. Preliminary results on eight

Table 1

Metal	Electro-negativity	Ionic charge	Radius (A.)	Wave-length of ω_2 band (μ)*
Li	1·0	+	0·78	6·348 (*S*); 6·442 (*M*)
Na	0·9	+	0·98	6·362 (*S*); 6·421 (*W*); 6·503 (*S*)
Mg	1·2	++	0·78	6·368–6·386 (*S*) broad band
K	0·8	+	1·33	6·415 (*S*)
Ca	1·0	++	1·06	6·362 (*S*); 6·510 (*S*)
Zn	*c*. 1·6	++	0·83	6·510 (*S*)
Ba	0·9	++	1·43	6·625 (*S*)
Pb	—	++	1·32	6·627 (*S*)

* The spectra were determined in 'Nujol' mulls with a Grubb Parsons double-beam infra-red spectrometer, with rock salt optics. Strength of band: *S*, strong; *M*, medium; *W*, weak.

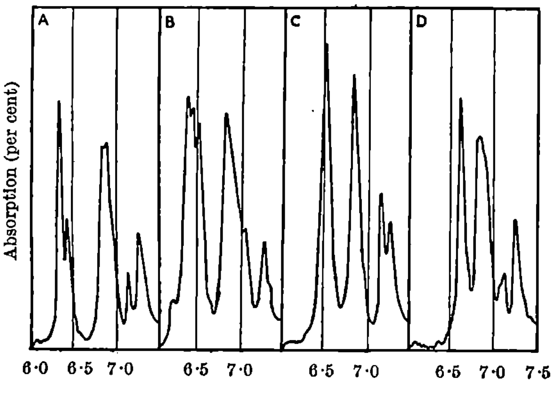

Fig. 1. Spectra of metal stearates (determined in 'Nujol' mulls). *A*, Lithium stearate; *B*, sodium stearate; *C*, zinc stearate; *D*, barium stearate

metallic stearates show that the effect of the metallic ion may be more complicated than a simple change in frequency of the ω_2 carboxylate band (see Table 1 and Fig. 1). The splitting of this band into a doublet (lithium and calcium) and a triplet (sodium) requires further investigation.

The influence of the metal ion may not be simply related to any one single factor. However, inspection of Table 1 shows that there is no relationship for these metallic stearates between the wave-length of the ω_2 band and either the electronegativity or the ionic radius of the metal.

For the eight metallic stearates investigated the dominant influence of the mass of the metal in determining the perturbation of the ω_2 carboxylate band is clearly illustrated in Fig. 2. However, because of the occurrence of doublets and triplets it is not possible to determine a single relationship between the wave-length of the ω_2 band and the mass of the metal ion.

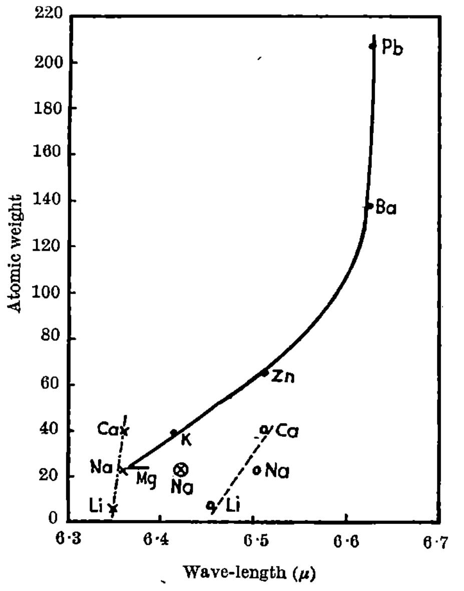

Fig. 2. Atomic weight versus wave-length of ω_2 carboxylate band for metallic stearates. ●, Single absorption band; × shorter wave-length of doublets; ○, longer wave-length of doublets; ⊗, intermediate weak peak (sodium stearate); —, broad band (magnesium stearate)

The dependence on mass noted here for metallic stearates is supported by the relationship between mass and frequency found in the spectra of carbonates[5] and metallic acetyl acetonates[6].

The award of a Research Fellowship to one of us (B. E.) by the Imperial Smelting Corporation, Limited, is gratefully acknowledged.

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A New Class of Antibiotic Salts of Reduced Toxicity

We have recently reported[1] the preparation and acute toxicity of a number of salts of basic antibiotics with acid vitamins. However, the good results obtained with the pantothenates in the reduction of the neurotoxicity of streptomycin[2,3] have not been as marked in the prevention of nephrotoxicity and other side effects produced by neomycin[4] and viomycin[4,5]. This prompted us to prepare other types of salts of antibiotics.

It was Short[6] who first reported that methionine and S-methyl-L-cysteine reduced the nephrotoxicity of polymyxin A. Kimmerle and Gösswald[7] showed that N-acetylmethionine reduced the toxicity of streptomycin and briefly mentioned that the leucinate of the same antibiotic had no advantage over the sulphate. We record here the preparation of amino-acid salts of basic antibiotics that may prove of interest not only in the general reduction of toxicity but also in the detoxication of specific organs.

The dihydrostreptomycin salts were prepared by neutralization of concentrated aqueous solutions of the base with three moles of the amino-acid or by double decomposition between solutions of dihydrostreptomycin sulphate and of an equivalent quantity of the proper barium amino-salt. The salts were then obtained by freeze-drying the solutions or concentrating them under reduced pressure at room temperature, dissolving the syrup in methyl alcohol and precipitating with a ten-fold excess of acetone. The tri-salts are stable in the solid state. They are very soluble in water giving solutions slightly alkaline except when the amino-group is acylated. The following salts were prepared: Glycinate (Anal. Calc. for $C_{27}H_{56}N_{10}O_{18}$: C, 40·09; H, 6·98; N, 17·32; Found: C, 39·99; H, 7·14; N, 17·15); DL-leucinate (Anal. Calc. for $C_{39}H_{80}N_{10}O_{18}$; C, 47·94; H, 8·25; N, 14·34. Found: C, 47·78; H, 8·45; N, 14·09); L-glutamate (Anal. Calc. for $C_{36}H_{68}N_{10}O_{24}$: C, 42·18; H, 6·69; N, 13·67. Found: C, 42·40; H, 6·97; N, 13·40); L-methioninate (Anal. Calc. for $C_{36}H_{74}N_{10}O_{18}S_3$: C, 41·93; H, 7·23; N, 13·58. Found: C, 42·16; H, 7·61; N, 13·47); N-acetyl-DL-methioninate (Anal. Calc. for $C_{42}H_{80}N_{10}O_{21}S_3$: C, 43·58; H, 6·97; N, 12·10. Found: C, 43·42; H, 6·94; N, 11·80) and S-ethyl-L-cysteinate (Anal.

Table 1. Acute Intravenous Toxicity of Salts of Dihydrostreptomycin

Salt	Potency γ base/mgm.	LD50 mgm. base/20 gm.
Glycinate	721	3·38
DL-Leucinate	597	3·94
L-Glutamate	569	3·74
L-Methioninate	566	4·12
N-Acetyl-DL-methioninate	504	3·32
S-Ethyl-L-cysteinate	566	3·17
Sulphate	799	3·18
Ascorbate (ref. 1)	524	4·55
Pantothenate	470	3·80
Glucuronate	500	3·24

Calc. for $C_{36}H_{74}N_{10}O_{18}S_3$: C, 41·93; H, 7·23; N, 13·58. Found: C, 41·28; H, 7·58; N, 13·50).

The acute intravenous toxicities determined in white mice are shown in Table 1, which includes for comparison the sulphate, pantothenate, ascorbate and glucuronate (prepared by a method similar to U.S. Patent 2,583,534, December 31, 1949).

The acute toxicities are, in most cases, lower than those of the sulphate or glucuronate except the S-ethyl-L-cysteinate in which, however, the anion also has tuberculostatic activity[8]. The leucinate and the methioninate are being studied further. These are less toxic than the pantothenate, and only the ascorbate is less toxic than they.

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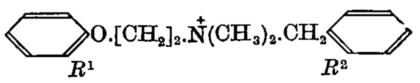
A New Series of Anthelmintics

We wish to report a new series of chemical compounds effective against nematodes parasitic in the gastro-intestinal tract of mammals. Certain of these compounds possess an unusually broad anthelmintic spectrum which includes appreciable activity against certain species causing infections of economic importance for which there is, at present, no satisfactory treatment.



(I)

These compounds (patent applications pending) have the general formula (I), where R^1 can be hydrogen, methyl or chlorine, while R^2 can be hydrogen, methyl, chlorine or fluorine. Lower activities are encountered when R^1 is a nitro-group, bromine or when R^2 is bromine. Numerous other variants are in course of examination.

The synthesis and initial biological assay of the series were carried out by two of us (F. C. C. and O. D. S.). *Nippostrongylus muris* was used as the test organism in this work. Afterwards, biological testing was extended to observe the effects of the more active compounds against trichostrongylid nematodes in sheep, *Uncinaria stenocephala* in dogs (J. S. and D. A. R.) and *Ancylostoma caninum* in dogs and cats (R. B. B.) as well as other species of nematodes cultured in small laboratory animals.

Certain members of the series possess anthelmintic activity against a wide range of species. It is of particular interest that these compounds appear to be more effective against the mucosa-dwelling species of parasitic nematode than against those living more freely in the lumen. Thus, considerable activity has been demonstrated against *N. muris* in the rat; *Nematospiroides dubius* in the mouse; *Nematodirus* sp., *Haemonchus contortus*, *Trichostrongylus axei*, *Cooperia curticei* and *Ostertagia* spp. in the sheep; *A. caninum* in the dog and cat. Lower activity has been demonstrated against *U. stenocephala*, *Aspiculuris tetraptera*, *Syphacea obvelata*, *Toxocara canis*, *T. cati*, *in vivo* and against *Ascaris lumbricoides* (from the pig), *in vitro*. The full range of activity has yet to be established. Field trials are in progress, and clinical trials are to be undertaken.

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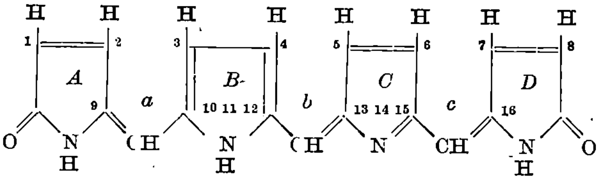
The IX-α Structure of the Common Bile Pigments

It is generally accepted that all the naturally occurring 'tetrapyrrolic' bile pigments must be of a IX-α structure, that is, that they are derived from the biliverdin which is produced biologically by rupture of the α-methene bridge carbon atom of protoporphyrin IX. Therefore, all bile pigments prepared from biological material should possess a 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2,8-divinyl (or diethyl), open-chain, 'tetrapyrrolic' structure (using the system of numbering shown in formula (I). Although some of the bile pigments have been synthesized by methods which exclude the formation of isomers other than IX-α, there is, at present, no analytical evidence of the absence of such isomers in the pigments obtained from biological sources. The presence of such isomers would be expected if biological fission of the protoporphyrin molecule did not occur exclusively at the α-methene linkage. Since stercobilin (and therefore also the less-hydrogenated bile pigments) is known to be produced by at least two distinct physiological mechanisms[1], such a possibility is not entirely speculative. The method of identification of pyrrole carboxylic acids described by one of us and used in investigations of the porphyrins[2] has now been applied to a study of the order of the β-side-chains of the bile pigments. In the bile pigments one α-position of each end ring bears an oxygen atom (usually formulated in a hydroxyl group[3]) instead of a carbon atom. It is therefore impossible for these rings, on degradation, to provide the αα′-pyrroledicarboxylic acids given under similar conditions by the corresponding porphyrins; any such acids can only originate from the middle rings of the pigment molecule.

The 'hydroxypyrroles' in general, and particularly those used in the syntheses of the bile pigments, are in fact pyrrolenones[4], and it is therefore probable that the bile pigments are also lactam compounds. The present systems of nomenclature[5] make no provision for this fact and do not allow easy derivation of the structures of the bile pigments. In this communication we have named the bile pigments as derivatives of the fully unsaturated structure I, to which we give the trivial name 'bilenone'.



(I)

The bile pigments are derived from I by appropriate substitution at positions 1–8 and by suitable reduction of any of the carbon–carbon double bonds shown with the exception of those in the two middle rings *B* and *C*. Rings *B* and *C*, together with the linking methene group, *b*, are assumed to constitute a resonating dipyrrylmethene unit; reduction of this by means of two atoms of hydrogen produces a dipyrrylmethane structure in which rings *B* and *C* are truly pyrrolic. The systematic names which result from the use of this system of nomenclature have been used in Table 1.

Table 1

Compounds oxidized	Acids obtained II	III	IV
Bilirubin 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2,8-divinyl-(*b*-13)-dihydrobilenone	++	–	–
Mesobilirubin 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2,8-diethyl-(*b*-13)-dihydrobilenone	++	–	–
Biliverdin 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2,8-divinyl-bilenone	++	–	–
Mesobiliviolin* 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2,8-diethyl-(*c*-16) dihydrobilenone	++	–	–
d-Urobilin † (ref. 7) 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2 (or 8)-ethyl-8-(or 2)-vinyl-(9-*a*),(*c*-16)-tetrahydrobilenone	+	—	–
Stercobilin 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2,8-diethyl-(1-2),(9-*a*),(*c*-16),(7-8)-octahydrobilenone	–	–	–
Glaucobilin 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2,8-diethyl-bilenone	++	–	–
Stercobilinogen 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2,8-diethyl-(1-2),(9-*a*),(*b*-13),(*c*-16),(7-8)-decahydrobilenone	–	–	–
Mesobilirubinogen 1,3,6,7-tetramethyl-4,5-dicarboxyethyl-2,8-diethyl-(9-*a*),(*b*-13),(*c*-16)hexahydrobilenone	+	–	–
Glaucobilin-XIII-*α* 1,3,6,8-tetramethyl-4,5-dicarboxyethyl-2,7-diethyl-bilenone	++	–	–
2,4-dimethyl-3-carboxyethylpyrrole-5-carboxylic acid	–	–	–

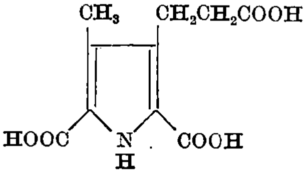
* Probably a mixture of mesobilirhodin and mesobiliviolin

† The positions of the ethyl- and vinyl-groups are not yet known with certainty.

About 30 mgm. of each of the bile pigments mentioned in Table 1 were oxidized with alkaline potassium permanganate and the products were identified by chromatographic comparison with authentic 4-methyl-3-carboxyethylpyrrole-2,5-dicarboxylic acid (II), 4-methyl-3-ethylpyrrole-2,5-dicarboxylic acid (III) and 4-methylpyrrole-2,3,5-tricarboxylic acid (IV). With the exceptions of stercobilin and stercobilinogen all the pigments examined gave the acid (II) on oxidation; the same acid was obtained from the glaucobilin produced from stercobilin by treatment with sulphuric acid and from synthetic glaucobilin. The acids III and IV, which would be expected to arise from bile pigments derived from protoporphyrin on fission at the β-, γ- or δ-linkages, could not be detected in the products of oxidation of any of the pure bile pigments or of the mother liquors from the isolation of *d*-urobilin. The yields of the acid II indicated in Table 1, are those obtained from equivalent quantities of pigment and were assessed by inspection of the size of the chromatogram spots. The results permit the following conclusions to be drawn:

(*a*) The common bile pigments, including bilirubin, *d*-urobilin and stercobilin (after conversion to glaucobilin) are wholly IX-α in structure.

(*b*) Oxidation of stercobilin and stercobilinogen proceeds without the formation of pyrrolic acids. This is an interesting indication that the two end-rings *A* and *D* are completely hydrogenated and of a stable aliphatic nature. In agreement it was found that the monopyrrole V, which resembles the latest structure postulated for stercobilin[6] in having a saturated α-substituent, furnishes no trace of acid II under the conditions of oxidation used for the bile pigments. In contrast, the oxidation of mesobilirubinogen and *d*-urobilin (in which the groups attached to the dipyrrylmethene unit have an element of unsaturation) produced acid II. The



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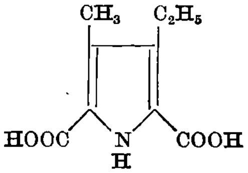

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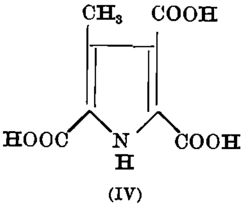

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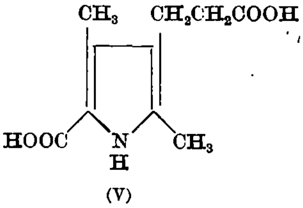

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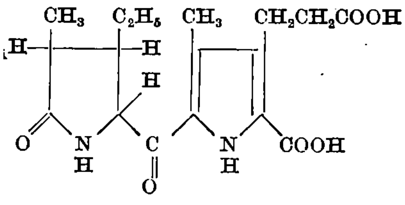

(VI)

product arising from stercobilin appears to be a water-soluble acid which forms an optically active, 2,4-dinitrophenylhydrazone. It is possible that stercobilin undergoes fission at the *b*·12 or *b*-13 bond with formation of a product of the type VI. A study of the nature of this product is being undertaken.

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A Ribonucleoprotein from Amphibian Gastrulæ

Disaggregation of amphibian embryos by agents which chelate calcium is succeeded by re-aggregation if the cells are returned to a medium containing calcium[1]. It is customary to consider that the removal of calcium from the environment of the cells is responsible for the loss of adhesion displayed in disaggregation. An attempt has been made to find out whether any organic material is removed from the embryos during disaggregation. Such organic material might lie on the cell surfaces or between the cells and assist in their adhesion, or it might be removed from within the cells during disaggregation. Batches of 250–260 late gastrulæ of *Xenopus laevis* were disaggregated in 0·001 *M* ethylene diamine tetraacetate at *p*H 8·03 in *tris*-hydrochloric acid buffer (0·001 *M* in *tris*) made up in calcium-free Holtfreter solution. The embryos were gently agitated on a rocker for 40 min. at 19–21° C., and at the end of this period the cells of the completely disaggregated embryos were allowed to settle. No evidence of cytolysis of the cells could be found. The supernatant was removed and centrifuged at 300–400 *g* for 10 min. A small number of intact cells, and a few yolk platelets probably of extracellular origin, formed the residue. The clear supernatant from this centrifugation was examined spectrophotometrically, and the absorption curve suggested the presence of nucleic acids. The preparation was frozen-dried.

Estimations of the total nitrogen by the Lubochinsky test, phosphorus as phosphate after digestion in concentrated sulphuric acid, ribose by the orcinol reaction, and α-amino nitrogen by the ninhydrin method were made. Deoxyribose and hexose sugars were absent. After hydrolysis in perchloric acid the material was run on a chromatogram using *iso*propanol/hydrochloric acid/water (170 : 41 : to 250 vol.) as the solvent. Adenine, guanine, cytosine and uracil were recognized from the R_F values and from the absorption curves of the eluates of the spots. The extinction values of the various bases suggest that the nucleic acid forms 25 per cent of the dry weight of the material. This value is in agreement with the results of the other tests, and with the 260/280 mμ absorption ratio for the untreated material, which all give 75 per cent of protein in the preparation. A sample of the material was hydrolysed in 6 *N* hydrochloric acid, and a chromatogram of this hydrolysate was run in phenol saturated with water. Qualitatively, arginine, histidine and tyrosine have been recognized from R_F values and from specific reactions; exact identifications of the remaining amino-acids have not yet been done.

Embryos of this stage disaggregate in calcium-free media at or above *p*H 9·8, forming a clear jelly between the cells in the process, and show a certain amount of cytolysis. On returning the cells to *p*H 6·8 in the absence of calcium, the jelly slowly dissolves; if the return to *p*H 6·8 is done in the presence of calcium, the jelly remains. At this lower *p*H the jelly is dissolved by trypsin and by ribonuclease. It is possible that the jelly is at least in part identical with the ribonucleic acid and protein described above, though there is undoubtedly some degree of contamination with cytolytic products. Since ethylene diamine tetraacetate removes the ribonucleic acid and protein components from the embryos without visible damage to the cells, the suggestion is that they are derived from the surface of the cells or from between them. This is supported by histochemical evidence for the presence of ribonucleoproteins on or between the cells from methyl-green pyronin and toluidine blue staining (cf. ref. 2). The constant proportion that existed between the ribonucleic acid and protein components from batch to batch favours the view that they exist as a ribonucleoprotein in the embryo. Until the matter has been further investigated, it is probably most convenient to refer to the material as a ribonucleoprotein. It may be connected in function with the adhesion of cells to one another and with the binding of calcium on the cell surface, which is important in adhesion[3]. This function of ribonucleic acid on the cell surface has been suggested for *Elodea*[4]. It is of interest that if the disaggregated cells are treated with trypsin or ribonuclease they fail to re-aggregate, which suggests that there is a ribonucleoprotein on the cell surface connected with adhesion. It might also be concerned with induction and be related to the substance described by Niu[5].

I thank Prof. C. H. Waddington for his interest and for providing facilities for the work in the Institute of Animal Genetics, Edinburgh, Prof. J. N. Davidson for his interest and advice, and the Department of Scientific and Industrial Research for a maintenance grant.

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β-Glucuronidase, Lipase and Esterase in the Testis of the Cryptorchid Rat

ALTHOUGH considerable attention has been paid to lipase and esterase in the testis[1], comparatively little is known of β-glucuronidase in this organ. This communication is concerned with some relationships between testicular β-glucuronidase, lipase and esterase of the rat in artificial cryptorchidism.

Thirty-four albino rats of the Wistar stock bred in this laboratory were used and grouped as follows: normal control (13), unilateral cryptorchidism (9), bilateral cryptorchidism (12). Determinations of enzyme activity in tissue homogenates were made according to the method of Talalay *et al.*[2] for β-glucuronidase, of Nachlas *et al.*[3] for lipase and for esterase; the units used were the amount of enzyme which liberates 1 μgm. of phenolic substance in 1 hr. for β-glucuronidase and for lipase, and in 20 min. for esterase[4].

Table 1

	Normal control	Cryptorchidism		
		Unilateral		Bilateral cryptorchid testes
		Normally located testis	Cryptorchid testis	
No. of rats	13	9		12
Body-weight (gm.)	132±10*	136±6·8		160±8·9
Testicular weight (mgm.)	742±80	1,078±100	567±69	541±58
β-Glucuronidase activity†	146±14	222±44	722±242	1,333±136
Lipase activity†	12±1·6	29±4·2	52±3·8	34±4·2
Esterase activity†	7,341±126	7,284±447	9,179±502	9,178±639

* Mean ± standard error of the mean.
† Units per gm. of wet tissue.

In the testis of the cryptorchid rat four weeks after operation, the concentrations of all three enzymes showed an increase. The most striking change was seen in the β-glucuronidase level. The concentration of this enzyme in the testis increased nine-fold in the bilaterally cryptorchid rat and five-fold in the unilaterally operated animal. Lipase concentration, however, increased much more in the cryptorchid testis of the unilaterally cryptorchid animal than in the bilaterally operated animal. The increase in the concentration of esterase was slight and the same in both groups. It should also be noted that β-glucuronidase and lipase activities were significantly ($P < 0·05$) elevated in the normally located testis of the unilaterally cryptorchid animal. Results are shown in Table 1.

A full account of this work will appear elsewhere.

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Inhibition of 5-Hydroxytryptophan Decarboxylase by Phenylalanine Metabolites

EVIDENCE has recently been presented which demonstrated a lowered level of circulating 5-hydroxytryptamine in patients with phenylketonuria[1]. The condition is associated with production of an excess of certain aromatic acid metabolites of phenylalanine, which it has been claimed inhibit dihydroxyphenylalanine decarboxylase[2]. It was suggested that this inhibitory effect was an explanation of the low plasma levels of adrenaline found in phenylketonuria. As 5-hydroxytryptamine is derived from 5-hydroxytryptophan by the action of 5-hydroxytryptophan decarboxylase[3] it was decided to examine the effects of these aromatic acids on this enzyme system also.

Table 1. INHIBITION OF 5-HYDROXYTRYPTOPHAN DECARBOXYLASE BY PHENYLALANINE METABOLITES

Additions	Conc. (μmoles/ 3 ml.)	μl.CO$_2$/ 40 min.	Inhibition (per cent)	Inhibition of dihydroxyphenylalanine decarboxylase* (per cent)
Control	—	75·7	—	—
Phenylpyruvic acid	100	15·7	79·3	100
	50	38·3	49·5	100
	10	74·2	2	77
Phenyl-lactic acid	100	36	52·5	100
	50	66	13	77
	10	71·2	6	50
Phenylacetic acid	100	12·5	83·5	50
	50	24·2	68	0
	10	—	—	0
L-Phenylalanine	100	65·7	13	0

Guinea pig kidneys were homogenized in ice-cold *M*/30 Sørensen's phosphate buffer *p*H 6·8. The homogenate was centrifuged in the cold for 5 min. and 2 ml. of the supernatant (equivalent to 2 gm. of original wet tissue) used in each Warburg flask. 25 μgm. of pyridoxal phosphate and the inhibitor, dissolved in phosphate buffer, was added. The volume was adjusted to 2·75 ml. with phosphate buffer. After gassing for 2 min. with nitrogen, the flasks were equilibrated at 37° for 10 min. and 0·25 ml. of DL-5-hydroxytryptophan (10 μmoles) added from the side-arm. Controls and blanks were also used. Carbon dioxide output was determined for 40 min.

* After Fellman (ref. 2). Dihydroxyphenylalanine (20 μmoles) as substrate.

Phenylacetic acid was found to be more active and phenylpyruvic and phenyl-lactic acids were less active as inhibitors of 5-hydroxytryptophan decarboxylase when compared with the results presented by Fellman[2] for dihydroxyphenylalanine decarboxylase, which is similar to but not identical with 5-hydroxytryptophan decarboxylase[3].

These results, although preliminary, suggest the possibility that such an inhibition, *in vivo*, might be responsible for the decreased production of 5-hydroxytryptamine observed in patients with phenylketonuria. As there is a large body of evidence to suggest that 5-hydroxytryptamine plays a part in normal brain function, inhibition of 5-hydroxytryptophan decarboxylase, present in some areas of the brain in high concentration[4], might thus contribute to the cause of the mental defect in this disease.

It is of interest to note that ingestion of phenylacetic acid in man is followed by transitory mental disturbance[5]. But before the inference can be drawn that this effect is due to inhibition of 5-hydroxytryptophan decarboxylase more work must be done on the mechanism of this inhibition, and the possible inhibitory action on other enzyme systems[6] must be studied.

We are grateful to Dr. L. I. Woolf for gifts of the aromatic acids used.

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Role of Ferrous Iron in Enzymatic Transamination

Although the part played by metals in non-enzymatic transaminations is known, its role in the enzymatic reaction of this type is still to be proved. Aluminium, nickel, copper and iron are known to catalyse the non-enzymatic reaction between an amino-acid and pyridoxal, or a keto-acid and pyridoxamine. Recently, Fasella *et al.*[1] have isolated the intermediates involved. This preliminary communication reports the possibility of iron (in its reduced state) being involved in the enzymatic transamination.

The source of the enzyme was the fresh green beans of *Dolichos lablab*. From the residue after acetone extraction of the beans, aspartic–glutamic transaminase was purified by 'Dowex-2' (in chloride form), calcium phosphate gel and alumina $C\gamma$ treatment. Electrophoresis (on paper) showed that the enzyme moved as a single component (*p*H 9·0, glycine–sodium hydroxide buffer, 4 cm. in 4 hr., 440 V., 26° C.) indicating a high state of purity. This purified preparation was used in the present work.

Preliminary experiments showed that metals such as aluminium, nickel, copper, magnesium, manganese and cobalt had no appreciable effect on the activity of the enzyme. Ferrous sulphate produced an increase in its activity, whereas mercury (as mercurous chloride) completely inhibited it.

As shown in Table 1, dialysis against 8-oxyquinoline solution (0·005 *M*) for 17 hr. in the cold reduced the activity of the enzyme considerably, but it was completely restored by addition of about 5 μgm. of ferrous iron (as $FeSO_4.7\,H_2O$) to the reaction mixture. Also there was no non-enzymatic transamination either in the presence or the absence of ferrous iron. Ferric iron (as $Fe_2(SO_4)_3$) was not active. Addition of ferrous iron to the undialysed enzyme had no effect. Among the various iron binders studied it was noticed that addition of glutathione, versene (disodium salt), O-phenanthroline and α-α-dipyridyl inhibited the activity by 10–20 per cent. Cyanide completely destroyed the activity, whereas 8-oxyquinoline had no effect at all.

Table 1. Effect of Ferrous Iron on Aspartic–Glutamic Transaminase

Reaction carried out at 37° C. for half an hour under nitrogen. Activity estimated by the method of Tonhazy (ref. 3)

Additions	Pyruvate formed (μgm.) per mgm. protein
Enzyme (undialysed) + asp. + KG	1,120
Enzyme (undialysed) + asp. + KG + 5 μgm. Fe^{2+}	1,160
Enzyme (dialysed) + asp. + KG	400
Enzyme (dialysed) + asp. + KG + 5 μgm. Fe^{2+}	1,230
Enzyme (boiled) + asp. + KG	Nil
Enzyme (boiled) + asp. + KG + 5 μgm. Fe^{2+}	Nil
Asp. + KG	Nil
Asp. + KG + 5 μgm. Fe^{2+}	Nil

asp. = DL-aspartic acid. KG = α-ketoglutaric acid.

Thus there appears to be an indication, for the first time, that a metal is involved in enzymatic transamination. In this connexion it can be stated that Dr. Cohen reported the presence of a strong Fe band in one of the Merck preparations of pyridoxal phosphate which was found to be twice as active as pyridoxal phosphate from other sources[2]. No exogenous coenzyme was used in the present investigation. Further work is in progress to isolate the enzyme in a high state of purity, in order to find whether there is iron in the enzyme, and also its mode of action.

I wish to thank Dr. M. Srinivasan and Mr. Nagabhushanam for their helpful discussions, and Dr. V. Subrahmanyan, director of this Institute, for his interest in the present investigation. Thanks are also due to Glyco Products Inc., New York, for a gift of versene.

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Effect of Testosterone and Orchidectomy on the Activity of the Melanocytes in the Skin

It is well known that there is an increased pigmentation of the skin in certain areas of the body in pregnancy. It has also been established that the occurrence of a malignant change in benign pigmented tumours or moles is rare before puberty in both sexes. Furthermore it is accepted that the growth of malignant melanomas and the formation of metastases is accelerated during pregnancy[1]. All these facts suggest that the activity of the melanocyte is under hormonal influence. Edwards, Hamilton, Duntley and Hubert[2] reported that the human male castrate has a reduced amount of melanin in the skin. Treatment of these men with testosterone usually increased the melanin content in all areas, although the response was of small degree. Kupperman[3], working on the male golden hamster, showed that testosterone increases the pigmentation of the skin, whereas castration causes a reduction in pigmentation. Wheeler *et al.*[4] found by macroscopical and microscopical observations that topical application of testosterone to the nipples and areolæ of immature castrated male guinea pigs produced no increased pigmentation. The present investigation was designed to investigate histochemically the effect of testosterone and orchidectomy on the activity of the melanocyte.

Eighteen male guinea pigs weighing about 400 gm. were used. The animals were divided into three groups, each consisting of three pure black and three red guinea pigs. Skin biopsies were taken from all the animals from the right ear, right side of the anterior abdominal wall in the hypochondriac region and from the sole of the right foot. In addition, the right areola, including the nipple, was excised. The first group of animals was orchidectomized, received no hormone treatment, and was left for four weeks. The second group of animals was also orchidectomized, and four weeks later a course of testosterone was commenced. The animals were given 2 mgm. of testosterone propionate (Organon) intramuscularly once daily for 5 days a week for a period of 4 weeks. The third group of animals was left intact and was given a 4-week course of testosterone injections identical with that received by the animals of the second group. The animals were killed by a blow on the back of the neck, and a further series of skin specimens was removed from areas adjacent to those taken previously, and the left areola, including the nipple, was excised.

Most of the sheets of skin were left intact after excess subcutaneous fat and the deeper part of the dermis had been excised under a dissecting microscope. A few of the specimens, however, were treated with trypsin to disengage the epidermis. The skin was then incubated with the dopa reagent after preliminary fixation. The greater part of each skin sheet was then mounted; the remainder was embedded in paraffin and sagittal sections were cut. The hormonal influence on the melanocytes was studied by assessing the number and size of the melanocytes and the amount and position of the melanin within the cells in the skin specimens removed before and after treatment. The number, length and complexity of the dendritic processes were also noted, and an attempt was made to assess the amount of free melanin present in the vicinity of the cells.

The results were as follows:

Skin of ear. Following orchidectomy, no definite changes were noted. In the orchidectomized animals which received testosterone, in 2 of the animals the size of the melanocytes became reduced. In 3 of the animals, which included the 2 with a reduction in cell size, the dendrites were increased in length. The amount of melanin in the basal layer of the epidermis was increased in all the animals, but it was impossible to determine whether this increase had occurred within the melanocytes or in the surrounding tissue. In the intact animals which received testosterone the number of melanocytes became reduced in three of the animals and it was seen that the length and complexity of the dendrites of these cells were reduced. Furthermore it was noted that the amount of free melanin in these animals was increased.

Skin of anterior abdominal wall. Orchidectomy increased the number of melanocytes in 5 of the animals. In 2 of these the size of the melanocytes become reduced and in one it was increased. It was also seen that in 3 of the animals the amount of free melanin had increased, but this could not be correlated with the melanocyte changes. In the orchidectomized animals which received testosterone no uniform change occurred. There was a slight tendency for the size of the melanocytes and the amount of intracellular melanin, and the length and complexity of the dendrites, to become reduced. In the intact animals which received testosterone, no definite changes were seen.

Skin of areola. In the orchidectomized animals the changes noted were inconsistent. In 2 of the animals, however, the number of melanocytes and the amount of free melanin increased. In another 2 animals the length and complexity of the dendrites increased. In the orchidectomized animals which received testosterone no uniform changes occurred. In the intact animals which received testosterone, in 3 of the animals the number of melanocytes became increased. In 4 animals the amount of free melanin was increased, but in one animal it was reduced.

Sole of foot. In all three groups of animals the amount of melanin in the basal layer of the epidermis showed a definite increase.

The above findings show that orchidectomy, orchidectomy followed by testosterone, or testosterone alone, are incapable of producing uniform changes in the melanocytes and in the intra- and extra-cellular melanin in the skin of the ear, anterior abdominal wall and areola. It is therefore concluded that the melanocytes in the skin of these regions are not directly influenced by the male sex hormone. The results in the skin of the sole of the foot are, however, constant, and indicate that any change in the amount of male sex hormone will produce an increase in melanogenic activity. This is of particular interest in view of the high incidence of malignant change in pigmented lesions of the sole of the foot in man.

We gratefully acknowledge financial assistance from the Medical Research Council for this work.

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Effect of some Nitrogen Mustard Derivatives on Growth of Rabbit's Hair

THE stimulating effect of ionizing radiations on the growth of rabbit's hair has been noted recently[1]. It may be of interest to record that similar effects have been found following the application of certain nitrogen mustard derivatives to rabbit skin.

In 1948, the preparation of mustard derivatives of desylamine, $C_6H_5COCH(NH_2)C_6H_5$, was undertaken for studies in cancer chemotherapy. Desyl chloride, $C_6H_5COCHClC_6H_5$, and the *p*-methoxy bromo compound, $CH_3OC_6H_4COCHBrC_6H_5$, were prepared by standard methods and allowed to react with diethanolamine. The resulting bases,

$$RC_6H_4COCH\{N[(CH_2)_2OH]_2\}C_6H_5$$

had the following properties: for $R = H$, m.p. = 136 – 137° C., N per cent found = 4·46, N per cent calc. = 4·68; for $R = CH_3O$, m.p. = 108 – 109° C., N per cent found = 4·40, N per cent calc. = 4·26. Cold chloroform solutions of these products were treated with thionyl chloride (in the case of the methoxy derivative, the reaction mixture exhibited a transient deep blue-green colour) and, after removal of chloroform, white substances were obtained.

These compounds, which were hygroscopic and seemed to be susceptible to decomposition, were stored *in vacuo*. Analyses were unsatisfactory, but indicated that the products probably consisted mainly of hydrochlorides of the mustard derivatives,

$$RC_6H_4COCH\{N[(CH_2)_2Cl]_2\}C_6H_5$$

No further chemical studies were made with the substances; but their ability to produce blisters on the shaved skin of rabbits was investigated.

On November 17, 1948, a drop of a chloroform solution of the desyl mustard derivative ($R = H$; ~20 mgm.) was placed in the middle of a shaved area on the belly of a Dutch rabbit. The skin reddened at the site of application, and, 3 days later, a yellow area of thickened skin (blister) had formed at this site. On November 23, a thick keratinous layer was observed along the line of application of the mustard solution and by November 29 the keratin had sloughed off leaving a mark resembling a knife incision. On December 9, it was observed that hair about 1 cm. in length had grown on this mark, but the surrounding shaved area remained free from hair. On December 16, hair on the 'wound' site had grown to normal length and by February 21, 1949, a thick tuft of hair was growing on the site of application of the mustard while the rest of the shaved area remained hairless. On this day, fur was shaved from a fresh area of the experimental animal and a control animal was shaved on the belly. By March 3, 1949, there was a light growth of hair on the shaved area of the control animal and the site was completely covered with hair on March 10. At this time the recently shaved area on the mustard-treated rabbit showed no growth of hair.

Other rabbits were shaved on both flanks and one flank of each was treated with desyl or methoxy-desyl mustard on December 11, 1948. On February 28, 1949, growth of hair was observed on the painted site but scarcely any on the surrounding shaved area or on the control shaved flank.

Experiments with di-2-chloroethyl sulphide and di-2-chloroethylamine led to early death of the treated rabbits, so it remains uncertain whether these substances have the same action as the desyl mustards. It should be of interest to determine whether the observed effects can be obtained with other radiomimetic agents or carcinogenic substances.

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Effects of Gibberellic Acid on Soil Micro-organisms

GIBBERELLIC acid, a metabolic product of the fungus, *Gibberella fujikuroi*, has shown marked effects on plant growth, stimulating stem and leaf elongation. British investigators[1] have studied its influence on a number of bacteria and moulds and have briefly stated they were unable to detect any effect, either inhibitory or stimulatory. Although there is indirect evidence that gibberellic acid is rapidly decomposed in the soil[1], there have been no reports concerning action of the acid on soil micro-organisms and their activities. The following preliminary experiments were carried out to determine if gibberellic acid had any effect on terminal respiration of the soil microbial population in conventional Warburg runs.

5-gm. portions of air-dry sandy loam soil passing a 10-mesh sieve were placed in Warburg vessels[2]. The soil had a water-holding capacity of 37 per cent; 0·80 per cent total carbon and 0·06 per cent total nitrogen were present. Gibberellic acid, dissolved in a drop of ethanol, was added to duplicate flasks of the soil to give concentrations of 0, 1, 3, 5, 50 and 100 p.p.m. Glucose treatments at 2,000 p.p.m. carbon and ethanol controls in duplicate were included. In addition to the soil (vol., 2·5 ml.), each flask contained 0·5 ml. substrate and 0·2 ml. 20 per cent potassium hydroxide. Runs were made for 15 hr. at 29·8° C. and all values were corrected. The $Q_{O_2}N$ values were considerably increased by the ethanol. No significant increases were given by gibberellic acid; in some instances it gave slight decreases.

At the close of the respiration experiment, soil from the Warburg flasks was removed, appropriately diluted, and plated in quadruplicate for microbial counts and incubated at 28° C. Sodium albuminate agar was used as the medium for bacteria and *Streptomyces*, and peptone–glucose agar acidified to pH 3·9 was used for soil fungi. Plates were counted as soon as colonies could be well differentiated. Results were analysed statistically. The F values for treatments and interactions were significant at the 1 per cent level. The results disclosed that gibberellic acid in comparison with ethanol controls apparently induced some stimulations and some inhibitions not consistent with the rates of application. An explanation of these variations cannot be given from present information.

The most significant observation was that with the ethanolic gibberellic acid treatment at 50 p.p.m. + glucose, and ethanolic gibberellic acid at 100 p.p.m. + glucose, numerous colonies of *Azotobacter chroococcum* (as determined by cultural and microscopic examination), a non-symbiotic nitrogen-fixing bacterium, occurred on all replicate sodium albuminate agar plates. No such colonies were found on dilution plates from any of the soil treatments which did not include gibberellic acid. It is evident, however, that *Azotobacter*, in lesser numbers, must have been present in the original soil. This was confirmed by observation of typical *Azotobacter* colonies that developed on plaques of soil–starch paste. Therefore, in another experiment, which confirmed the first Warburg results, soil from the flasks was air-dried, sieved and tested for *Azotobacter*, using the nitrogen-free agar plate method[3]. After five days, *Azotobacter* were found to be numerous in all samples, but appeared most abundant with ethanolic gibberellic acid at 50 p.p.m. + glucose (Table 1).

Table 1. *Azotobacter* COLONIES FROM SOILS AFTER 15-HR. RESPIRATION IN WARBURG FLASKS

Treatment	Colonies per gm. soil*
Soil + gibberellic acid, 1 p.p.m.	2,200
Soil + gibberellic acid, 3 p.p.m.	3,200
Soil + gibberellic acid, 5 p.p.m.	2,600
Soil + gibberellic acid, 25 p.p.m. + glucose at 2,000 p.p.m. C.	2,400
Soil + gibberellic acid, 50 p.p.m. + glucose at 2,000 p.p.m. C.	3,400
Soil + glucose at 2,000 p.p.m. C.	2,000
Soil + ethanol, 14 p.p.m.	2,400
Soil only	2,000

* Average of duplicates

Further studies are in progress to determine if 'Gibrel', a water-soluble potassium salt of gibberellic acid, has a significant effect on nitrogen fixation by *Azotobacter*.

The gibberellic acid was kindly supplied by Dr. L. T. Blaney of the Horticulture Department. It was originally obtained from Dr. P. W. Brian of Imperial Chemical Industries, Ltd., England. The 'Gibrel' was supplied by Merck and Co., Inc., New Jersey.

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Enzymes in the Ileal Juice of the Horse

So far as can be ascertained there is no information about the enzymes secreted by the horse's small intestine. Since a pony with a Thiry–Vella loop in the middle of the ileum was available[1] the opportunity was taken to determine whether the enzymes present in man and dogs were present in the horse. The juice was obtained by gently rubbing the mucosa with a rubber catheter. Juice thus obtained was, on occasion, slightly contaminated with blood. However, the enzymic activity of such samples did not differ from the uncontaminated.

Ileal juice is a watery fluid with a yellow tinge and sometimes contained mucus. The pH was 7·8–8·5. Enzymic activity was measured on the supernatant fluid from juice centrifuged at 3,000 r.p.m. for 5 min.

Amylase, lactase, maltase, and sucrase activity was detected by Lagerlof's[2] method, lipase activity by Cherry and Crandall's[3] method, peptidase by Cajori's[4] technique using a peptone substrate and protease by Lagerlof's[5] method with casein as substrate. Enterokinase activity was detected by using the protease method after adding 2 ml. of 0·01 per cent trypsinogen (Worthington Biochemical Corporation) to 6 ml. incubating mixture and using controls without trypsinogen and also, with boiled juice. This method showed marked enterokinase activity in the ileal juice of freshly killed rats and guinea pigs. The experimental findings are shown in Table 1; the dilution of juice was the highest at which activity could be detected by the methods used.

Table 1. Enzymes in Horse Ileal Juice

Enzyme	No. of observations	Activity present	Dilution of juice
Amylase	18	14	1 : 1,000
Sucrase	14	12	1 : 20
Lactase	19	17	1 : 1,000
Maltase	19	16	1 : 1,000
Lipase	4	0	Undiluted
Lipase	6	0	1 : 5
Protease	16	15	1 : 10
Peptidase	14	14	1 : 10
Enterokinase	7	1	Undiluted

It was interesting to compare the results of these experiments with those of Doller and Porter[6], who studied the enzymes of the calf's digestive tract. They found no sucrase activity in the calf's ileum and that the lactase activity decreased with age.

The absence from the horse juice of lipase activity was noteworthy, although Reale[7] has stated that lipase was absent from fresh ileal juice in man but increased with cellular autolysis, and Roger and Binet[8] suggested that bile increased lipolytic activity by destroying cells. However, in our experiments both centrifuged juice, macerated mucus and cellular debris were free from lipolytic activity. In control experiments the method employed showed marked lipolytic activity in ileal juice of rats and guinea pigs.

The absence of enterokinase activity could be explained by the Thiry–Vella loop being six years old, as Foa[9] showed the enzyme to disappear from fistulæ of dogs within six months of operation, and Sawitsch[10] found the enzyme to disappear from fistulæ deprived of pancreatic juice.

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Effect of Electrolytes on the Uptake by Bacteria of Labelled Glutamate

In a recent paper, Krebs, Whittam and Hems[1] reported an accelerating effect of potassium salts on the rate of oxidation of various substrates by *Alcaligenes faecalis*. All the potassium salts tested were equally active. The ionic composition of the medium was found to affect respiration also in *Escherichia coli* (strain *B*), and *Pasteurella tularensis* (strain $S + D$)[2]. The effect of the anion was also apparent with these two micro-organisms. For the maximal rate of oxidation of glutamate and glucose by *P. tularensis* the halogen salts of potassium and rubidium were found to be required; in the case of *E. coli* potassium chloride or sulphate was needed. In *E. coli* addition of minute amounts (10^{-4} M) of sodium salts rendered the accelerating effect of potassium independent of the nature of the anion. Conditions known to diminish the rate of penetration of metabolites into the bacterial cell (rising pH, low substrate concentration) rendered the accelerating effect of potassium more pronounced. The latter observation suggested regulation of permeability as a possible mode of action of the electrolytes. In order to test the validity of this assumption, the effect of electrolytes on the rate of uptake of labelled glutamate was examined.

The composition of the reaction mixture was as follows: 15 mgm./ml. (wet weight) of the bacterial cells, washed thoroughly with 0·25 M sucrose, 10^{-2} M of the electrolytes and 0·25 M sucrose.

Table 1. EFFECT OF CATIONS ON THE RATE OF PENETRATION OF GLUTAMATE INTO THE CELLS OF *E. coli* AND *P. tularensis*

Time	Counts/10 min.*									
	No electrolyte added		KCl		NaCl		LiCl		RbCl	
	E.	*P.*	*E.*	*P.*	*E.*	*P.*	*E.*	*P.*	*E.*	*P.*
30 sec.	40	36	240	210	50	80	50	80	70	150
3 min.	60	60	530	566	50	170	50	170	110	310
6 min.	70	80	500	560	140	260	130	260	160	410

* After the deduction of the background count (200/10 min.). 100 counts/10 min. represent approximately 3×10^{-3} μmole of glutamate.

After thermal equilibration (28° C.) 0·03 *M tris* glutamate and glutamate uniformly labelled with carbon-14 (0·01 μc./ml.) were added, samples of 3·0 ml. were withdrawn at various time-intervals, chilled to 0° C. and centrifuged (30,000*g*). The radioactivity of the well-drained but unwashed cell mass was determined by a method essentially identical with the procedure adopted by Krebs *et al.*[1].

Results which show the effect of various monovalent cations (tested as their chlorides) on the rate of increase of the radioactivity in the bacterial cell mass (*E. coli*; *P. tularensis*) are given in Table 1. The modifying influence of the anions on this process is shown in Table 2. It can be seen that potassium chloride in *E. coli* and potassium chloride and rubidium chloride in *P. tularensis* which accelerate the oxidation of glutamate also increased the rate of its accumulation. Cations which were found ineffective on the respiration also had no effect on the accumulation. A mixture of potassium and sodium nitrates was as effective as potassium chloride, while each compound separately accelerated neither accumulation nor the oxidation of the substrate. The nature of the anion affected respiration and accumulation in a parallel manner.

Table 2. EFFECT OF ANIONS ON THE RATE OF PENETRATION OF GLUTAMATE INTO THE CELLS OF *E. coli* AND *P. tularensis*

Time	Counts/10 min.*											
	No electrolyte added		KCl		KBr		KNO_3		K_2SO_4		KNO_3 + $NaNO_3$	
	E.	*P.*	*E.*	*P.*	*E.*	*P.*	*E.*	*P.*	*E.*	*P.*	*E.*	*P.*
30 sec.	40	70	190	200	110	250	80	68	190	60	180	—
3 min	70	100	480	540	120	542	150	260	410	270	410	—
6 min.	90	90	560	560	130	613	180	260	440	270	595	—

* After the deduction of the background count (200/10 min.). 100 counts/10 min. represent approximately 3×10^{-3} μmole of glutamate.

In view of similarity of effect of the ionic environment on the respiration and on the 'uptake' of the substrate, consideration has to be given to the possibility that the electrolytes regulate the rate of respiration by controlling a process directly connected with the penetration of the substrate.

It remains, however, to be shown that increase in radioactivity in the cell mass is due to the penetration of the substrate into the bacteria, and furthermore, that penetration is the rate-limiting factor in the reaction sequence.

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Novel Action of Potassium on a Yeast and a Counteraction by Aluminium

A PAPER[1] from this laboratory described an improved method for the estimation of *Oospora lactis* Fres. (formerly known as *Oidium lactis*) in pressed bakers' yeast, using a medium consisting of ammonium succinate, mineral salts and agar. The method worked well with most yeasts, but one strain (*Saccharomyces cerevisiae* D.C.L. 557) prevented the growth of visible colonies of *Oospora* on the above medium. This effect has been further studied, and it has been found that the immediate cause of the inhibition was the presence in the medium of 2×10^{-2} *M* potassium (as the dihydrogen phosphate). This was demonstrated by excluding potassium from the medium, adding the phosphate as the sodium or ammonium salt. The mould then developed into dense colonies; these were not, however, quite so large as those grown on normal medium (containing potassium) in the absence of yeast. This reduction in size was due to the fact that *Oospora* required 3×10^{-4} *M* potassium ions for optimal growth on ammonium succinate, mineral salts, agar medium. When Yeast 557 was present, however, this concentration of potassium, added as sulphate or chloride to the medium (containing sodium or ammonium dihydrogen phosphate), inhibited the growth of the mould. The inhibition was largely overcome by the addition of 5×10^{-4} *M* aluminium (as ammonium alum) to the normal medium.

A similar effect was obtained with other salts of aluminium, but not with salts of other multivalent elements, calcium, magnesium, manganese or silicon. The concentration of aluminium required to counteract the inhibition indicated that the action was not a trace-element effect. In fact there was sufficient aluminium to envelop each yeast cell 10^3 times. The mechanism of the action of potassium and the counteraction by aluminium has not been elucidated.

The suggestion[2] that potassium might regulate cell permeability offered no obvious clue to the problem. Rossi[3] showed that potassium ions stimulated the oxidation of succinic acid in resting cells of *Escherichia coli* in the Warburg apparatus. It seemed possible that some oxidation product of succinic acid might be formed in this way by Yeast 557 and be inhibitory to the growth of *Oospora*. The addition to the medium of 4×10^{-3} *M* fumaric acid or of 4×10^{-2} *M* maleic acid produced no inhibition of the mould.

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Detection of Uric Acid in the Tissue Homogenates of Earthworms

LESSER[1], working on *Lumbricus agricola* and *Allolobophora foetida*, Ackermann and Kutscher[2] on extracts of tissues of earthworms, Delaunay[3] on excreta of earthworms, Heidermanns[4] on tissues of *Lumbricus*, Bahl[5] on excreta of *Pheretima*, Abdel Fattah[6] on tissue homogenate of *Lumbricus*, were all unable to detect the presence of even traces of uric acid in these worms. Only Cohen and Lewis[7] found that the non-protein nitrogen excreted by *Lumbricus* *terrestris* was mainly in the form of ammonia together with small traces of both urea and uric acid.

Uric acid is known to be very sparingly soluble in water, and it is possible that the previous authors, working with water extracts of tissues, have overlooked the presence of uric acid.

As uric acid is readily soluble in lithium hydroxide, the following technique was used in the present study on *Allolobophora caliginosa* f. *tropezoides*. The worms were homogenized with water in a Potter–Elvehjem[8] homogenizer, and the homogenate was made up to a known volume. Homogenate portions were digested in a Kjeldahl apparatus for estimating its total nitrogen content, to relate the concentration of the homogenate constituents to the total nitrogen of the tissues. This was carried out since the fresh weight of the worms is not constant, owing to the different rates of desiccation of the worms. Another homogenate portion was centrifuged and the supernatant was tested for uric acid using Brown's[9] method. The residue was afterwards dissolved in 1 per cent lithium hydroxide and recentrifuged, and the centrifugate was examined again for uric acid. Both uric acid values, the water-soluble and the lithium hydroxide-soluble, were added together and related to the nitrogen content of the tissues of the worms.

It was found that the uric acid content of the tissues of the worms examined was 3·34 mgm. per gm.[3] tissue nitrogen. Further details will appear elsewhere.

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Electrical Noise from 'Polarization Cells' and from Human Tissues

IN electromyography, metal electrodes are attached to the skin to detect the electrical changes associated with the activity of the underlying muscles. It has often been stated that a resting muscle is 'electrically silent'. However, if the amplifier noise is reduced sufficiently, electrical fluctuations of a random nature with an amplitude of about 5 μV. (peak to peak) are observed even when the subject is lying comfortably at rest on a bed[1]. The first possible explanation that comes to mind is that these fluctuations represent the random thermal noise of the source, which in this case is the skin and muscle tissue in series with the electrodes. This suggestion has been tested by simultaneous measurements of the impedance between the electrodes and the spectrum of the fluctuations.

Analysis of measurements of the impedance of the tissues with the aid of Cole impedance diagrams[2] before and after rubbing away the horny layer of the skin confirmed that the skin and underlying tissues could each be represented by a fixed resistance in parallel with a 'polarization cell' containing a resistance and capacitance the values of which were dependent on frequency. The next problem was, therefore, to estimate the noise produced by a 'polarization cell'. This was investigated experimentally. A stainless-steel concentric needle electrode, consisting of a hypodermic needle 0·64 mm. in diameter with a central wire 0·126 mm. in diameter, insulated by 'Araldite' cement, dipped into 1 per cent sodium chloride, was chosen as a convenient 'polarization cell' the impedance of which was almost entirely attributable to the metal-solution interfaces and only to a negligible degree to the resistance of the electrolyte. The impedance was measured at a given frequency at a current density of a few m.amp. per sq. cm. of electrode area, and the noise generated by the cell in a narrow band centred at that frequency was determined with the aid of the low-noise amplifier and a Muirhead–Pametrada wave analyser. The cell was then replaced by its equivalent impedance consisting of a resistance in parallel with a condenser, and the noise again measured; this was found to be equal within the expected error of the measurements (about 4 per cent), to the noise produced by the cell, in the range 125–4,000 c./s. At higher frequencies the noise produced by the cell was too small to observe above amplifier noise. At lower frequencies the cell produced more noise than the equivalent impedance. This was probably caused by slight movements of the needle set up by vibration; the discrepancy was reduced, though not eliminated, by fixing the needle more rigidly to the vessel containing the solution. It was concluded tentatively that the component at a given frequency of the noise produced by a 'polarization cell' is equal to the component of the thermal noise arising from the equivalent impedance measured at that frequency. Incidentally, this confirms an observation made by Wien as long ago as 1896[3] that the impedance of a metal-electrode system is independent of the current density up to a certain limit of a few m.amp. per sq. cm. (Above this limit the impedance decreases with increasing current density.) Indeed, the noise measurement may be regarded as a method of determining the impedance at the lowest possible current density, that is, the current density caused by thermal agitation.

Since the frequency-dependent component of the tissue impedance may have a physical basis similar at any rate in part to a polarization impedance, it seemed reasonable to expect that the tissues would generate the thermal noise which could be calculated from the values of their measured impedance. In fact it was found that the tissue noise was greater than this expected value, particularly at low frequencies. Measurements with surface electrodes 1 cm. in diameter before and after rubbing away the horny layer of the skin made it possible to show that both skin and underlying tissues contributed to the 'excess' fluctuations. Spectra of the excess fluctuations for three different subjects, for rubbed skin, are shown in Fig. 1. Above about 1,000 c./s. the components of the fluctuations were too small to measure in the presence of the amplifier noise. Excess fluctuations were also found when the needle electrode was inserted into a resting muscle.

It is possible that the excess fluctuations are caused in part by small movements of the electrodes relative to the tissues, by fluctuating streaming potentials set up by the ebb and flow of blood in the small vessels[4], by the miniature end-plate potentials

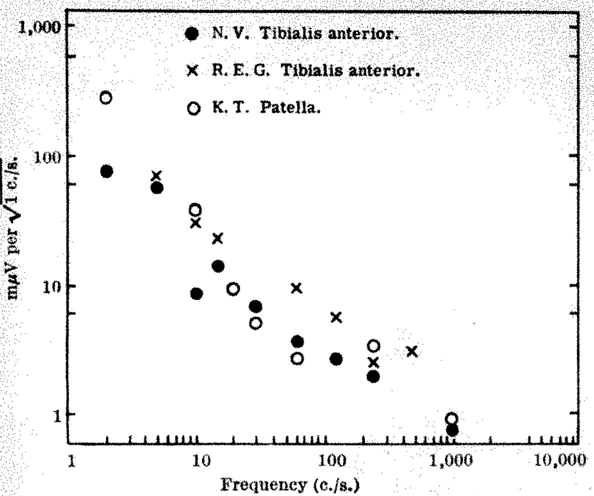

Fig. 1. Spectra of the excess fluctuations detected by silver suction electrodes 1 cm. in diameter, placed 5 cm. apart on the sites indicated. The skin was scraped with fine sandpaper to remove the horny layer, and rubbed with electrode jelly before the electrodes were attached. The excess fluctuation is the total observed fluctuation less the contributions caused by amplifier noise and thermal noise in the tissue impedance. The ordinate represents the square root of the mean square potential difference in a band 1 c./s. wide

reported by Fatt and Katz[5], by the 'biological noise' reported by Brock, Coombs and Eccles[6], and by discharges in sensory nerve fibres. The fact that they are found when the electrodes are placed over non-muscular sites such as the patella suggests that they are not caused by the continuous firing of a few motor units in a muscle. This result is of interest in relation to the hypothesis that muscular 'tone' is caused by just such a background of active contraction, persisting in a normal muscle even when resting, and supports the view expressed by Ralston[7] that this classical concept of tone should be reconsidered.

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Nervous Control of Cilia in Amphioxus (*Branchiostoma*)

One of the clearest cases of the nervous control of cilia was provided by Fedele's[1] work upon the cilia of the gill bars of the pelagic tunicate *Doliolum*; in the sessile tunicates also it seems that the gill bar cilia may be inhibited by the peripheral nervous system, for they may be observed to beat intermittently in the intact animal, and D. B. Carlisle (personal communication) has found that several species of sessile ascidian occasionally show both branchial apertures open with no water current passing through the atrium, that is, the gill bar cilia are presumably at rest. Knight-Jones[2] has shown that in the Enteropneusta the gut cilia exhibit bursts of activity alternating with periods of rest; in this group, the gill bar cilia also appear to be under the control of the nervous system.

It is interesting that all these animals are more or less closely related to the Acrania, and that all feed in a somewhat similar manner. It is not surprising that in amphioxus also the cilia producing the feeding current are under nervous control. In amphioxus, however, the evidence is perhaps more striking, for ciliary inhibition may be produced by a specific stimulus, and it may be observed in the intact animal; in dissected preparations (as, for example, in the experiments upon the Enteropneusta), the dissection inevitably involves derangement of the normal blood supply to the ciliary tissue, and it is not certain, therefore, that the ciliary inhibition may not be a secondary effect.

When a small amphioxus is placed in a Petri dish of sea-water under a binocular, the lateral cilia of the gill bars are clearly visible through the transparent body-wall. Even in the largest animals some of the gill apparatus is visible. When the animal is anæsthetized with dilute solutions of benzamine hydrochloride, magnesium chloride, or urethane, all the lateral cilia of the gill bars exhibit metachronal beat, of the kind discussed by Knight-Jones[3].

Isolated parts of the gill apparatus also show metachronal beat when anæsthetized.

In the normal animal, which has been feeding, it is invariably the case that some parts of the gill apparatus do not exhibit metachrony. The cilia of some parts of some gill bars or of all of some gill bars are either found to be at rest or else feebly vibrating non-metachronously. Upon the addition of anæsthetic, the parts of the gill apparatus which are at rest begin to beat and soon achieve metachrony.

In the normal unanæsthetized animal, certain stimuli, for example, the addition of carmine suspensions to the water, result in complete or nearly complete cessation of ciliary beat. This takes place rapidly; a minute after the carmine particles have entered the atrium, all the cilia are at rest. If the animal is now placed in an anæsthetic, metachronal beat is resumed as soon as anæsthesia has proceeded so far that the reflex responses of the buccal cirrhi and velar tentacles have been abolished. Addition of carmine suspensions to anæsthetized animals does not inhibit the metachronal beat.

These facts strongly suggest that the lateral cilia of the gill bars (those chiefly instrumental in producing the feeding current) are under nervous control, and that this control is inhibitory upon a fundamental metachronal rhythm. It is interesting that other ciliary tracts which are concerned in a subsidiary way with the feeding process, the wheel organ and the pharyngeal cilia of the gill bars are never observed to stop beating under any stimuli such as the addition of carmine particles.

It is less easy to observe the cilia of the gut in the intact animal, but in very small specimens the metachronal beat of the gut cilia can be observed; it does not appear to alter when the lateral cilia of the gill bars are inhibited.

The significance of the nervous control of the cilia producing the feeding current in the normal life of the animal is not certainly known, but it is probable that it is related, as Rice[4] long ago suggested, to intermittent patterns of activity in the feeding process. He supposed that amphioxus alternated feeding periods with periods of rest when it hid beneath the sand, and pointed out that this hypothesis implied that the animals could in some manner control the rate of beating of the cilia producing the feeding current.

The manner in which this control is exerted is extremely obscure; it is not known, for example, whether the rate of beat is controlled, or whether the control is simply of an on–off type. In amphioxus, unlike the other early chordate-like groups in which nervous control of cilia has been suggested, the peripheral nervous system is fairly well known; Dogiel[5] and Kutchin[6] have shown that there are many multipolar nerve cells lying upon the gill bars, and under the endostyle; I have shown that it is probable that these cells are connected with the central nervous system by their own axons[7]. That metachrony is not resumed at the same parts of the gill bars where it was first inhibited, when an animal that has been in a carmine suspension is placed in anæsthesia, does not suggest that the inhibition can be a local effect, related to the dendrite fields of particular neurons.

A detailed account of these observations will be published elsewhere with other observations upon the muscular patterns in the feeding process of amphioxus.

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Neurosecretory Cells in some Cirripedes

THE occurrence of neurosecretory cells or their products has not hitherto been demonstrated in the Cirripedia. By analogy with the situation in many other crustaceans the neurosecretory organs of which have recently been the object of much investigation, control of many of the metabolic processes in the Cirripedes might be expected to be under hormonal control originating in neurosecretory activities[1].

We have recently shown the presence of typical neurosecretory cells containing abundant granules (Fig. 1) that stain deeply with the paraldehyde–fuchsin of Gabe's modification[2] of Gomori's technique. In *Pollicipes polymerus* J. B. Sowerby, the cells are large (about 30–40μ largest diameter) and prolific in the sub- and supra-œsophageal ganglia where they appear to be localized in discrete areas. Release of the granules appears to take place both through the cell membrane and by axon transport. It has been possible to follow the development of these cells and the formation and discharge of the granules. Further, cross-sections of the sub-œsophageal, but no other ganglion, show discrete paired areas where the deeply staining granules are concentrated and nuclei are absent.

The following operculate barnacles have also been examined, *Balanus glandula* Darwin, *B. hesperius lævidomus* Pilsbry, *B. nubilis* Darwin, *B. rostratus* Hoek and *Chthamalus dalli* Pilsbry. In all these, deeply staining granules are found in the major ganglia but the neurosecretory cells are much smaller and less well defined than in *Pollicipes polymerus*; this could be related to the season when collected.

The investigation of neurosecretion in the Cirripedia would seem to offer a new and profitable approach to many problems of their physiology and ecology. Further, since most of the species, unlike almost all other crustacean groups, are hermaphrodite and yet normally cross-fertilizing, the relation of their neurosecretory activities to their reproductive activities presents problems of unusual interest, as does its relation to the uncommon moulting behaviour.

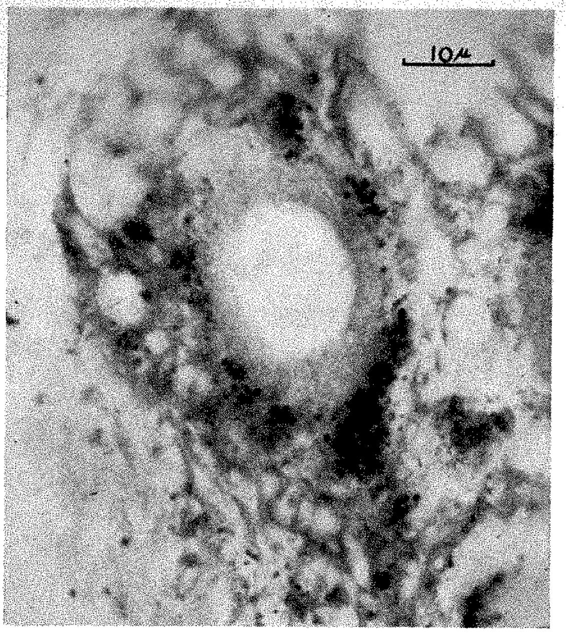

Fig. 1. *Pollicipes polymerus* J. B. Sowerby. Photomicrograph (green light) taken from transverse section of ganglion showing large neurosecretory cell. Paraldehyde–fuchsin stained; note large unstained nucleus and numbers of deeply staining granules around periphery, in blood spaces and in the axon hillock

A detailed account of this work and the results of further related observations will be published elsewhere.

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Connective-Tissue Pigment of the Centipede, *Lithobius forficatus* (L.)

THE connective-tissue pigment of the centipede *Lithobius forficatus* is violet in colour and occurs in abundant granules in the connective tissue cells[1]. Little is known of its nature and properties. On dissecting the animal[2] it was noticed that the intensity of colour increased, implying that *in vivo* some of the pigment is in a colourless, reduced form. Interest in the pigment was renewed by the demonstration of a tissue-pigment with a redox colour change in the isopod Crustacea[3]. The pigment cells of the latter are of mesodermal origin, like those of *Lithobius*.

The pigment has been extracted by mild treatment and further purified by precipitation and chromatographic procedures. The absorption spectrum of the oxidized form, in neutral aqueous medium, shows a peak around 580 mμ and a trough around 495 mμ.

With decrease in wave-length beyond this point absorption increases, without incident, to a peak at 258 mμ, probably indicating the presence of nucleic acid. There is a shallow trough at 245 mμ, beyond which point absorption increases sharply. The reduced pigment is pale yellow in colour; in the visible range its absorption of light shows a monotonous increase as wave-length decreases.

The colours, and the absorption spectra of oxidized and reduced forms in the visible range, resemble those of hæmocyanin[4]. The resemblance extends also to solubility properties, both being soluble in water and being precipitated at about *p*H 5·0, the isoelectric point of a protein moiety. Phenolic amino-acids and arginine are demonstrable in the unhydrolysed pigment of *Lithobius*. It also contains about 0·2 per cent copper, that is, approximately the same concentration as in hæmocyanin.

The pigment therefore may prove to be a 'cytocyanin', related to hæmocyanin as myoglobin and the cytochromes are related to hæmoglobin. Until recently no such intracellular copper-pigment was recognized[4]. It is now known[5] that a number of copper-containing enzymes and pigments are closely related to hæmocyanin in colour and composition, and may occur intracellularly. The *Lithobius* pigment probably differs from these in its high concentration in the body and possibly in acting as a normal oxygen-mediator for the tissues generally, which carry a rich investment of the pigment-tissue. *In vitro* it is rapidly and reversibly reduced by chemical reducing agents, including ascorbic acid, but it remains oxidized down to very low oxygen tensions. It catalyses the oxidation of hydroquinone, though not of tyrosine. It appears to be an active redox agent *in vivo*.

The pigment differs from hæmocyanin in several essentials. The colour is normally violet, and not blue, and the absorption spectrum in the visible range differs in detail. In the ultra-violet range the spectrum differs considerably, showing peaks at 346 and 278 mμ in hæmocyanin[4]. The 278-mμ peak indicates a higher percentage of protein than in the *Lithobius* pigment, and this is confirmed by the estimation of total nitrogen. The pigment is more stable than hæmocyanin, for example, towards strong alkali; it is not decolorized by carbon monoxide or by hydrocyanic acid and is only slowly destroyed by trichloracetic acid at 95° C. It withstands boiling for a long period: in this it resembles phosphoproteins and, in fact, contains abundant phosphorus. Like phosphoproteins it redissolves on the acid side of its isoelectric point, giving an apricot-coloured solution. The hæmocyanin of *Helix* remains greenish-blue under this condition.

I am greatly indebted to colleagues in the Department of Biochemistry for the use of spectrophotometers.

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A Two-stage Transfer of Pathogenicity between the *MEL* and *NWS* Strains of Influenza *A* Virus

IN genetic interaction between the *MEL* and *NWS* strains of influenza *A* virus it is convenient to regard the production of specific lesions in the chick embryo and pathogenicity for the mouse which has been inoculated intra-cerebrally with the virus as separate heritable characteristics, both of which are transferable from *NWS* to *MEL*[1]. It has been a feature of Australian work that recombinant, *N–M*, strains produced by double infection of the allantoic cavity of the chick embryo are not pathogenic for the mouse (Fraser, K. B., and Burnet, F. M., unpublished work). On the other hand, American work records combination forms, produced in the fertile egg, which are virulent for the mouse[2], but the methods of production of *N–M* strains in the two laboratories are not strictly comparable. Our techniques concentrated on limiting the time of virus production to a short infectious cycle of about eight hours, which was initiated in the washed allantoic cavity[3] and from which the original inoculum was largely removed before the new yield became available, whereas American methods used both the washed and the intact allantois, variable reproductive times up to forty hours and inocula irradiated with ultra-violet. The precise source of the most virulent recombinant of the *MEL* type is not described; but in general, transfer of pathogenicity was most effective with small doses and after long reproductive cycles[2]. The most likely explanations of the failure of our hybrid strains to acquire pathogenicity to the mouse were thus the washing out of the allantoic sac or the limiting of reproduction to one cycle.

In order to investigate the results of multiple cycles of double infection, each of three hybrid *N–M* strains which had originally been isolated from double infection of the chick embryo with *MEL* and *NWS* and which were non-pathogenic on intracerebral inoculation of the mouse, was subjected, in the chick allantois, to a series of four separate growth-cycles of nine hours duration in the presence of an adequate inoculum of the pathogenic 'parent' *NWS*. Groups of three eggs were used and the presence of double-neutralizing hæmagglutinin in all eggs was taken as a criterion of successful double infection[4]. Between each cycle of infection the *N–M* strain was re-isolated from the pooled allantoic fluids of each group by two allantoic passages at the limit of infectivity in the presence of sufficient anti-*NWS* serum to neutralize $10^{4\cdot5}ID50$ of *NWS* virus. This ensured that the heterogeneous product of each infectious cycle was not passed from one pool of fluids into the next according to the following scheme:

$$\left.\begin{matrix}N\text{–}M\\ \times\\ NWS\end{matrix}\right\}\begin{matrix}\text{Pool}\\ 1\end{matrix}\quad 2LD\quad \left.\begin{matrix}N\text{–}M\\ \times\\ NWS\end{matrix}\right\}\begin{matrix}\text{Pool}\\ 2\end{matrix}\quad 2LD\quad \left.\begin{matrix}N\text{–}M\\ \times\\ NWS\end{matrix}\right\}\begin{matrix}\text{Pool}\\ 3\end{matrix}\quad 2LD\quad \left.\begin{matrix}N\text{–}M\\ \times\\ NWS\end{matrix}\right\}\begin{matrix}\text{Pool}\\ 4\end{matrix}$$

$2LD$ = 2 passages at limiting infectivity in anti-*NWS* serum.

$\overset{\times}{NWS}$ = 9-hr. growth cycle in the presence of *NWS*.

There were three such series, one for each strain of *N–M* virus, and a pool of three fluids was preserved from each cycle in all series. The mouse pathogenicity of limit dilution fluids from pool 4 of each series was compared with that of the original *N–M*'s in the first instance. Test fluids were grown in anti-*NWS* serum. As Table 1 shows, each fluid from the fourth

Table 1. Comparison of Intra-cerebral Pathogenicity in Mice of Original and Fourth-cycle *N–M* Virus Strains

	Starting fluids	Fourth-passage fluids
Series 1	0/6	1. = 2/6* (+ 1 sick) 2. = 3/6 (+ 1 sick)
Series 2	0/6	1. = 2/6 (+ 1 sick) 2. = 3/6 (+ 1 sick)
Series 3	0/6	1. = 3/6 (+ 1 sick) 2. = 2/6 (+ 1 sick)

* Fractions indicate dead/survivors.

pools in the three series was pathogenic to mice. To eliminate spontaneous mutation to neuro-tropism as a cause and also contamination by *NWS* virus, the same *N–M* strains in high dosage, $10^{4 \cdot 0} ID50$, were given four successive cycles of four days each in mouse-brain. They failed to become pathogenic to mice and no *NWS* grew.

Since *N–M* strains are pathogenic for the chick when first isolated, these results are evidence of at least a two-stage transfer of pathogenicity between the *NWS* and *MEL* strains of influenza virus. This might be expected from the distribution of virulence in recombinant influenza viruses which Burnet has stressed[5].

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Gestational Changes in Connective Tissue in the Ewe

In a previous communication[1], various gross changes in the pelvic region of the pregnant ewe were described. Studies on pelvic relaxation in this animal have now been extended to include microscopic examination of pelvic connective tissue structures at different gestational stages.

Histological preparations were made of samples from the broad ligament of the uterus, the sacrosciatic ligament, the ischiococcygeus muscle and its tendon of origin, the fibrous portion of the sacroiliac joint, the lumbosacral joint, and the pubic symphysis. For comparison, similar tissue from an area outside the pelvic region was included, the gastrocnemius muscle and the tendon of origin of the deep flexor muscle of the lower limb being selected for this purpose. In addition, the connective tissue layers in the different parts of the urogenital tract were examined.

Several standard connective tissue stains, including a silver impregnation method, were used. Histochemical techniques were not applicable in this instance. The observations have thus been confined largely to fibroblasts and collagen fibres.

For the broad and sacrosciatic ligaments, samples were taken from a total of nine non-pregnant ewes, two in œstrus and the others in mid-cycle, 29 pregnant animals at different stages throughout gestation, and five immediately post-partum. The remaining tissues were available from four of the non-pregnant ewes and nine of the pregnant ewes at stages between 88 days and full-term.

Marked effects of pregnancy were observed in the connective tissue of the broad uterine and sacrosciatic ligaments, the ischiococcygeus muscle and the sacroiliac joint. Similar microscopic differences occurred in the connective tissue of the uterus, cervix and vagina of pregnant and of œstrous ewes, in comparison with non-pregnant animals in the mid-phase of the œstrous cycle. No such changes were seen, however, in the pubic symphysis, the lumbosacral joint, the Fallopian tubes, bladder or ureters, or in the connective tissue of the gastrocnemius muscle and the tendon of the deep flexor of the lower limb.

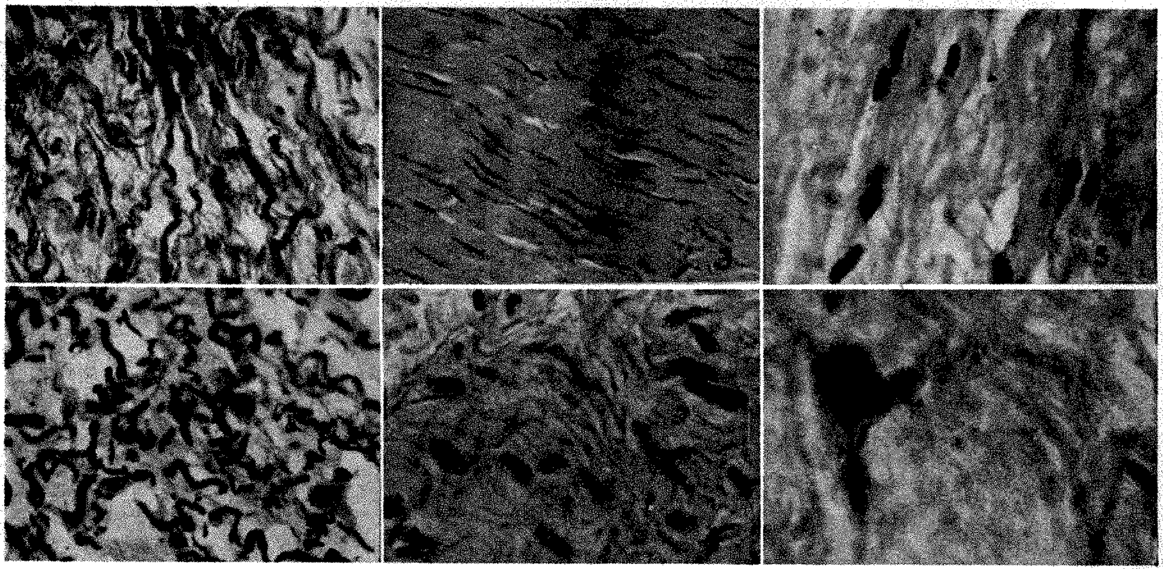
These gestational effects revealed themselves particularly in intense activity of the fibroblast cells. The most pronounced changes were seen in the broad ligament, in which the fibroblast changes were accompanied by disappearance of fibres staining with 'collagen' dyes, such as light green, and the appearance of argyrophil fibres (Figs. 1 and 2). A considerable relative increase in ground substance also occurred, the fibres and cells in sections from full-term ewes being sparsely distributed through the matrix, in comparison with preparations from non-pregnant animals. Similar, although less extensive, changes occurred in the other affected structures (Figs. 3 and 4).

In connective tissue from non-pregnant ewes, the fibroblasts consisted of small dense nuclei, with no visible cytoplasm (Fig. 5). In the broad and sacrosciatic ligaments, for which samples were available at early gestational stages, changes in the fibroblasts were apparent by 60 days. The nuclei were now oval to round and less dense than in non-pregnant preparations. These nuclear changes, which continued progressively throughout pregnancy, were associated with increasing amounts of visible cellular cytoplasm. At full-term, these cells were large, with heavily stained cytoplasm which, especially in the broad ligament, were commonly extended into long pseudopodial processes (Fig. 6).

In terms of parturition problems in the ewe, these observations are significant in that the affected tissues are chiefly those concerned in enlargement of the pelvic canal prior to parturition. Previous studies[2] showed that relaxation of the sacroiliac joints results in potential horizontal movement of the sacrum. Gross anatomical dissections (unpublished work) have indicated that the sacrosciatic ligament and the ischiococcygeus muscle are important components of the pelvic outlet in the ewe. Changes in the connective tissue of the reproductive tract are not unexpected in view of its direct role in pregnancy.

With regard to the structure of the pelvic tissues which do not change, the bony surfaces of the ischiopubic symphysis are united by a single layer of hyaline cartilage, no fibrous tissue being present; in the lumbosacral joint, the collagenous annulus lamellosus contains a sparse distribution of small pycnotic nuclei with no visible cytoplasm which do not closely resemble the fibroblasts of the other tissues described. The increased flexibility of this joint, which has previously been observed in pregnancy, may thus be an indirect effect due to changes in ligaments associated with this region.

Many histological and especially histochemical studies have been carried out on the pubic symphysis of the guinea pig and mouse in pregnancy, experi-



Figs. 1 and 2. Broad ligament. (1) Non-pregnant; collagen fibres only. (2) Pregnant, full-term; many argyrophil fibres, collagen scarce. (Silver impregnation with Weigert's hæmatoxylin and light green. × 375)
Figs. 3 and 4. Sacrosciatic ligament. (3) Non-pregnant; flattened fibroblast nuclei with no cytoplasm, dense parallel collagen fibres. (4) Post-partum; clear oval fibroblast nuclei with much cytoplasm, loosened collagen fibres. (Weigert's hæmatoxylin and van Giesen. × 375)
Figs. 5 and 6. Broad ligament. (5) Non-pregnant; small dense fibroblast nuclei with no cytoplasm. (6) Pregnant, full-term; oval-round clear fibroblast nuclei, pseudopial cytoplasm. (Weigert's hæmatoxylin and van Giesen. × 780)

mental evidence indicating that the changes are due to hormone action (see ref. 3 for reviews).

Mechanical loosening of the sacroiliac joints has been described for these species and for some other mammals, including man, in which relaxation of the pubic symphysis also occurs, and cattle. No reference can be found to microscopic gestational changes in the sacroiliac joints of any species, or to other pelvic connective tissues which might be of importance in parturition.

Other investigations concerning hormones and connective tissue have been concerned chiefly with disease processes (see ref. 4 for review). Relatively less attention has been given to the different connective tissue components in normal variations of body processes, such as pregnancy and the œstrous cycle.

Thus, in addition to their possible application to obstetrics in ewes and other mammals of social or economic importance, the findings from this investigation are of some interest in connective tissue physiology in general. It is well established that the fibroblast cells are responsible for the production of collagen fibres and that under proliferative conditions, such as tissue culture and wound healing, the fibres are at first argyrophilic, losing this capacity as they mature and acquiring instead an affinity for standard 'collagen' stains. The changes in the broad ligament of the pregnant ewe emphasize the fact that in the normal mature animal collagen is not in a static state, but under suitable stimulus is capable of reversible change, to form argyrophil fibres and vice versa. The regional specificity of response of the connective tissues suggests a differential sensitivity of fibroblast cells to the hormones of pregnancy.

Further studies are in progress, using histochemical as well as histological methods, to determine the gestational effects on other connective tissue components, such as the ground-substance and mast cells.

These investigations were carried out at the Anatomy School, University of Cambridge. A full account will be submitted for publication elsewhere.

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Hæmoglobins in Monkeys

We recently described[1] the finding of some abnormal hæmoglobins in two species of monkeys. Work has continued since then, and we wish to report some further abnormal findings. All but one *Cercocebus albigena* were collected within a few miles of Epulu in the Belgian Congo.

The numbers examined in the different species of monkeys can be seen from Table 1.

The doubtful specimen of *Cercopithecus mona* and one of *Cercocebus albigena* are so designated in spite

Table 1

Species	No.	Result of paper strip electrophoresis of hæmoglobin solutions at pH 8·6
Cercopithecus mitis	2	Both normal
,, *ascanius*	3	All normal
,, *mona*	7	6 normal and 1 doubtful
,, *l'hoesti*	1	Normal
Cercocebus albigena	2	Both abnormal
,, *galeritus*	4	All abnormal
Papio doguera	1	Normal

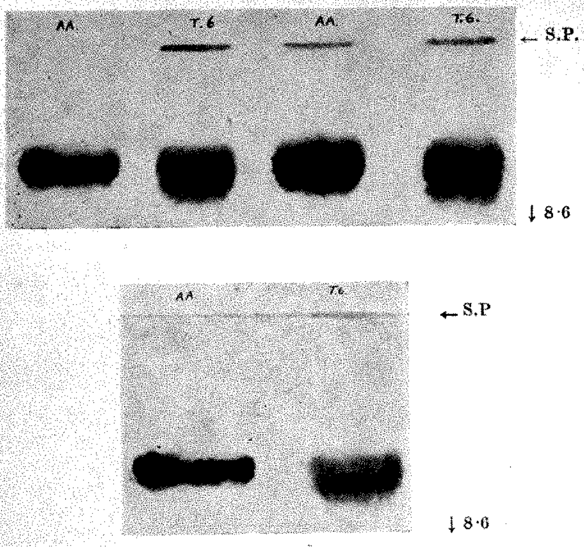

Fig. 1

of the actual numbering of the bottles. Because the hæmoglobin actually labelled as *C. mona* behaves exactly like seventeen other *Cercocebus albigena* samples we have assumed that the numbers were inverted in the field. Both animals were shot on the same day.

Cercopithecus mona. One specimen (*T*.6) gave a blurred pattern and appeared to have a forward component running slightly faster than the normal. This blood was in poor condition when it arrived in the laboratory and contained quite an amount of methæmoglobin. However, since methæmoglobin usually causes slowing of a specimen at *p*H 8·6, it seems probable that this specimen does contain a fast-running component. Its true position on electrophoresis remains uncertain. Fig. 1 shows *T*.6 in comparison with a normal blood.

Cercocebus galeritus. All four specimens from this species (which included a mother and son) were identical in pattern. The hæmoglobin separated into two distinct components. The faster component was the smaller of the two and lay just behind the normal position in the same place as the abnormal hæmoglobin of *Cercocebus albigena*. The slower component was the larger of the two and lay just behind human hæmoglobin *S* or *D*. Fig. 2 shows a sample of hæmoglobin from *Cercocebus galeritus* (*T*.12) running between human sickle-cell trait on the left and a normal blood on the right.

Cercocebus albigena. Both specimens were abnormal and showed exactly the same pattern as the sixteen specimens from this species previously described[1]. Since our earlier communication was written, a sample of *Cercocebus albigena* has been sent to Dr. H. Lehmann. He reports that on paper electrophoresis at *p*H 8·6 it lies slightly nearer the normal or *A* position than human hæmoglobin *G*.

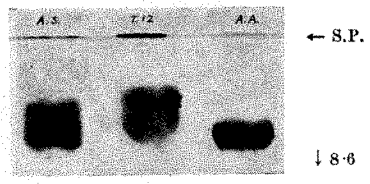

Fig. 2

The solubilities of the hæmoglobin solutions from seven *Cercocebus albigena* were determined in 2·58 *M* phosphate buffer; they were 2·60, 2·66, 2·72, 1·63, 2·23, 2·84, 2·32 gm./litre. The hæmoglobin solubilities of six *Cercopithecus ascanius* were: 2·65, 2·23, 2·76, 2·07, 1·51, 2·09 gm./litre. It seems that the slow-moving hæmoglobin of *Cercocebus albigena* does not differ appreciably in solubility from the normal-moving hæmoglobin of *Cercopithecus ascanius*.

The small size of the sample of *Cercocebus galeritus* does not give enough information to decide whether the two electrophoretic components are the effect of alleles or or fixation of genes at one or more loci. The second condition has not been observed in man. If the first is the case, both alleles are probably of high frequency in the population. All four specimens were part of the same group and were collected on the same day. The collection of more animals of this species would be of great interest.

If it should prove possible to cross-breed these two species of mangabeys, more evidence on the genetic control of their hæmoglobins could be accumulated. Zuckerman[2] has reported numerous examples of viable hybrids of different species, and even genera, from the records of zoological gardens. At present the chromosomal complements of both species are being studied to assess their suitability for hybridization experiments.

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Hormonal Regulation of Reproduction in the Milkweed Bug, *Oncopeltus fasciatus* (Dallas)

Reproductive processes in insects are controlled by hormones[1]. The corpus allatum has for some time been known as an organ of internal secretion necessary for the normal development of eggs in many insects; in some species it also influences the secretion from accessory sex glands. The medial groups of neurosecretory cells in the brain have been demonstrated to have a hormonal influence on egg development in the fly *Calliphora*[2].

In the milkweed bug, *Oncopeltus fasciatus*, the corpus allatum is an unpaired organ situated closely behind the corpora cardiaca and the hypocerebral ganglion. This organ complex, which is intimately associated with the walls of aorta, has nervous connexions with the pars intercerebralis region of the brain, the subœsophageal ganglion, the stomodæal nervous system, and probably the tritocerebrum. The nervi corporis cardiaci I originate from two groups, each consisting of five neurosecretory cells, close to the median line in the pars intercerebralis region of the brain. These cells, the so-called *A* cells[3], which stain dark purple with the aldehyde-fuchsin technique, are visible in the living adult, and are distinct from other types of neurosecretory cells in the brain. Extirpation of the *A* cells was tried in 149 females, adult age

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less than 1 hr.–2 days, and in 59 males, adult age 2–12 hr. The operated animals were kept separately at about 30° C. Of the operated females 48 survived and were killed at intervals of 10–146 days after the operation. 18 males survived and were examined at intervals from 10–80 days after the operation. 43 of the surviving females produced mature eggs, and in the males the reproductive organs looked normal. Thus the extirpation of these cells, when performed in young adults, does not prevent egg development, a result which is supported by similar experiments in phasmids[4]. Quantitative differences, namely, a reduction in the number of eggs produced, were observed in females deprived of the *A* cells as compared with normal animals or with operated controls. In females with a complete removal of the *A* cells, corpus allatum was usually of subnormal size. As in *Calliphora*[2], the neurosecretory cells in the brain seem to activate the corpus allatum.

In females allatectomized during the first day of adult life, normal egg development did not take place, and secretory material was not visible in the oviducts. Implantation of one corpus allatum taken from a sexually mature donor induced egg development in allatectomized individuals. Thus the corpus allatum seems to be necessary for normal egg development and oviducal secretion in *Oncopeltus*. The reproductive organs of allatectomized males had a normal appearance.

Starvation usually prevents egg development in *Oncopeltus*. This is due to an insufficiency of corpus allatum in starved individuals. Implantation of one corpus allatum taken from a sexually mature donor induces egg development in animals deprived of food[5].

The regulatory function of the corpus allatum in starved females was studied in a series of experiments performed on animals during the first day of adult life. The operated specimens were given only water and were examined 10 days later. Implantation of one corpora cardiaca–corpus allatum complex taken from a newly emerged female induced egg development in 10 out of 20 surviving specimens. The results obtained after implantation of a complex consisting of brain, subœsophageal ganglion, and corpora cardiaca–corpus allatum from a newly emerged specimen depended upon the innervation of the corpora cardiaca–corpus allatum complex in the implant. If the connexions between this complex and the head ganglia were severed before implantation, 16 out of 28 specimens produced eggs, whereas this happened in only 4 out of 24 females which received implants where the nerves were left intact. Other experiments where the starved female had its own corpus allatum denervated also resulted in a stimulation of egg development. Thus in starved female *Oncopeltus* the corpus allatum seems to be inhibited by its nervous connexions to the brain.

It has been emphasized that the corpus allatum is not an autonomous organ, but that its activity is under the control of the central nervous system[6]. The present report indicates that in *Oncopeltus* this holds for both fed and starved females.

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Laboratory Variations in Mortality of the Mosquito, *Culex fatigans* Wied., exposed to DDT

It is a common experience that in the same laboratory the susceptibility of test insects to insecticides varies from one occasion to another, but few attempts appear to have been made to study the causative factors in detail. In these laboratories, we have investigated the variation in the susceptibility of *Culex fatigans* Wied. to DDT since September 1949. In view of the recent communication of Burnett[1] describing the influence of atmospheric humidity on the mortality-rate of mosquitoes exposed to certain residual insecticides, our results may be of interest.

Our experiments were carried out with the insects drawn from a colony which was established from a single egg raft on September 17, 1945[2]. The breeding of insects as well as the assay of toxicity were carried out in a partially conditioned room in which, while the variations in temperature and humidity during any one day or succeeding days were not appreciable, they varied particularly in respect of humidity in the different months or seasons of the year. Over a period of seven years ending September 1956, the temperature and relative humidity ranged between 80° and 90° F. and 48 and 92 per cent respectively. Female mosquitoes 40 ± 5 hr. old were exposed at fortnightly intervals to filter papers impregnated with solutions of pure *pp*′-DDT in liquid paraffin in varying concentrations. The contact period was 1 hr., and observations on mortality were recorded 24 hr. afterwards. The mortality of mosquitoes in the control sets was nil. In Fig. 1 are presented the values of *LD*50 and of relative humidity and temperature on the days of assessment. For comparison with Burnett's results[1], the rainfall also has been indicated.

The results show that while such variations in temperature as there have been cannot account for the rise and fall in the values of *LD*50, relative humidity has a positive role. With higher humidities, particularly during the period of August–October in any year, greater values of *LD*50 are registered. With lower humidities during November–February the values for *LD*50 are also lower. In this connexion, the results obtained by Barlow and Hadaway[3] are of interest.

In order to provide confirmatory proof of the role of humidity in influencing the mortality, two experiments were conducted at the same temperature, 29 ± 1° C., but at two different controlled levels of humidity: 49 ± 6 per cent and 88 ± 4 per cent. Pupæ of *C. fatigans* drawn from the laboratory culture were placed in the respective humidity cabinets, and on emergence the adults (40 ± 5 hr. old) were exposed to the filter papers impregnated with varying concentrations of *pp*′-DDT. Dosage–mortality relationship is shown in Fig. 2. It will be seen that humidity bears an inverse relation to the mortality affected.

The work of Burnett[1] and the earlier work of Bordas and Navarro[4] have shown that with dieldrin and BHC the susceptibility of certain species of *Anopheles* is enhanced by an increase in relative humidity. The results described above with DDT using *C. fatigans* show a reverse trend. The difference can perhaps be understood on the basis of two competing influences coming into operation. One of these is connected with the availability of the insec-

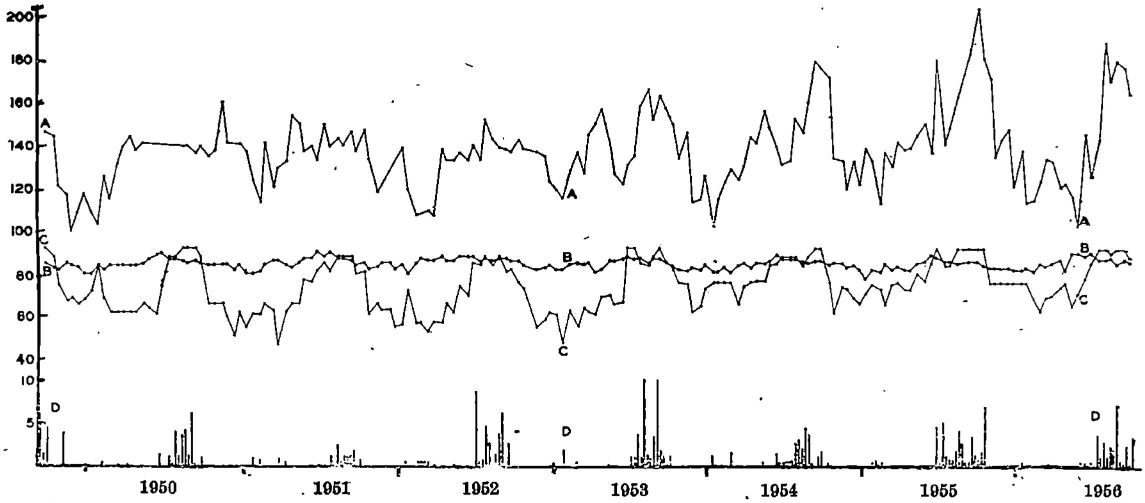

Fig. 1. Laboratory variations in mortality of the mosquito, *Culex fatigans* Wied., exposed to DDT at fortnightly intervals. *A*, *LD*50 mgm./ft.^{2}; *B*, temperature (° F.); *C*, relative humidity; *D*, rainfall. (• denotes trace)

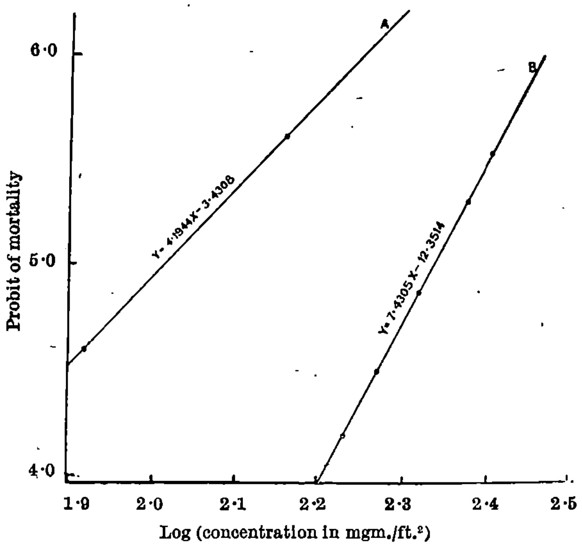

Fig. 2. Contact toxicity of *pp'*-DDT in liquid paraffin to *Culex fatigans* Wied. *A*, 29° C. ± 1° and 49 ± 6 per cent relative humidity; *B*, 29° C. ± 1° and 88 ± 4 per cent relative humidity

ticide on the surface treated, and the other is the variation in susceptibility of the test insect on account of the humidity of the environment. It appears that in Burnett's field trials[1] the former of the two factors takes a predominant role whereas in the experiments now reported the second factor takes the lead. Further work is in progress.

We thank Mr. Ali Ausat for technical assistance, and we are indebted to Dr. T. S. Subramanian, former chief superintendent of these laboratories, for interest in the work.

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Reversibility of the Red – Far-red Reaction by Irradiation at Different Sites

Since the discovery that red light promotes and far-red light inhibits the germination of lettuce seeds[1,2] this reversible photoreaction has been studied in detail[3,4] and has been found to be identical with that involved in controlling flowering and other biological processes. Because of the widespread occurrence and importance of this reaction, a detailed understanding of its mechanism is of the utmost importance, and attempts to explain it have been made by a number of workers. Most recently, the available knowledge has been summed up by Hendricks in a formula of general terms[5]. The form in which this process is usually stated makes it appear that the same pigment molecules which, for example, have been brought to the far-red absorbing form by red radiation are directly reversed to their former state by the absorption of far-red light.

In all the experiments upon which this type of explanation is based, red and infra-red light were always given on the same side of the seeds. In order to discover whether an illumination active in reversing a previous light effect has to be applied at the same site or not, a simple experiment was carried out, that is, the seeds were turned over between the two kinds of illumination. 50–100 lettuce seeds were laid out in rows on dry filter paper and 2·5 c.c. water added. The seeds were allowed to imbibe for two hours in the dark at 25° C. and were then exposed to red light ('Sylvania' red fluorescent tube wrapped in red 'Cellophane') for various periods between 5 sec. and 10 min., the light intensity being about 19 kilo-erg./cm.^{2}/min. Immediately after the light treatment, the seeds were turned over with a tapered blunt spatula under a weak green safelight ('Sylvania' green fluorescent wrapped in yellow and green 'Cellophane'), while control lots were exposed to the same intensity of green light, but not turned over. Between 1·5 and 2·5 min. are required to turn over 50–100 seeds. Both the 'inverted' seeds and the controls received various amounts of far-red radiation (incandescent illumination filtered through blue and red 'Cellophane') 10 min. after the light treatment. Other controls were inverted, but not given subsequent far-red illumination.

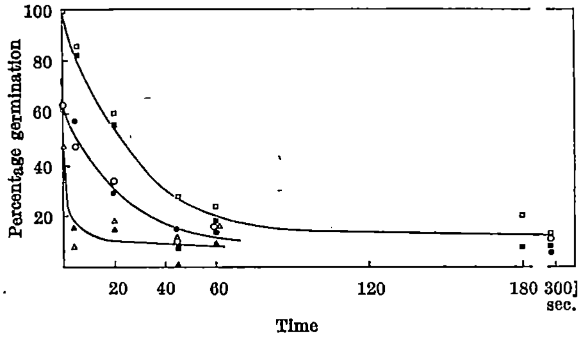

Fig. 1. Germination percentage of lettuce seeds after irradiation with red light, followed by far-red. □, Red-light treatment given for 60 sec.; ○, for 30 sec.; △, for 5 sec. Closed symbols: seeds received red irradiation on one side and far-red on the other. Open symbols: both light treatments given to same side

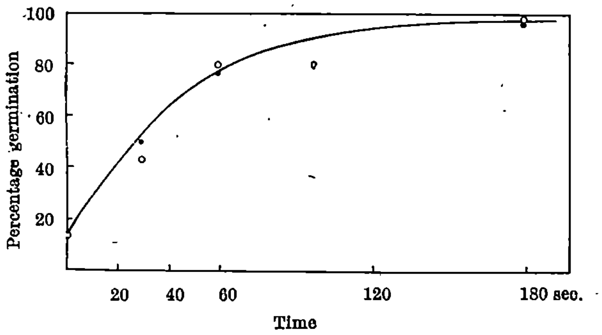

Fig. 2. Germination percentage of lettuce seeds after irradiation with far-red light for 1 min., followed by treatment with red light. Open and closed symbols as in Fig. 1

Fig. 1 shows that far-red radiation depresses the red light effect as well as, or even somewhat better, when applied on the reverse side of the seed than when given to the same side which had received the red light. The same is true for the reverse sequence of light irradiation, as can be seen from Fig. 2.

It is highly improbable that the seeds received the same amount of any irradiation on both sides owing to the optical properties of the wet filter paper. Neither can penetration of the light through the seed itself make this possible. When penetration of light through whole or bisected seeds was measured by photographing them on spectroscopic plates with the same light source as used in the experiments, it was found that at least 90 per cent of the incident light was absorbed by the seed halves.

The findings permit a number of interpretations: for example, the photoreceptor and/or photoproducts may diffuse rapidly after illumination throughout the seed. Another conclusion may be that although the photoreceptor molecules on one side of the seeds remain in the state determined by the first irradiation, illumination in a different site, that is, involving different photoreceptor molecules, will bring about reversal of the effect caused by the first illumination.

Further experiments, including the use of collimated light sources and irradiation with red as well as far-red light on both sides of the seed, will be carried out to gain more information on the system involved.

This investigation was part of the research carried out by one of us (S. K.) under the Atypical Growth Grant (*INSTR* 47H-962) to Dr. A. W. Galston, to whom our thanks for his interest and advice are due. The work of J. W. P. was supported by the John A. Hartford Foundation.

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Effect of Transmitted Ribonucleic Acid from Healthy Pear Trees upon the Synthesis and Composition of Protein

QUITE recently it has been shown that ribonucleic acid, derived from tobacco mosaic virus, is infectious[1,2], that is, when inoculated into plants it induces typical metabolic changes.

In a previous paper the effect of uracil upon the synthesis of ribonucleic acid and the importance of the acid for protein synthesis in fruit trees was demonstrated[3]. The question now arises whether the effect of ribonucleic acid upon protein synthesis occurs *in situ* only, or whether it is possible, considering the above reports, to induce this effect in other trees by transmitting ribonucleic acid from one tree to another. This problem was investigated by testing ribonucleic acid derived from trees in a certain physiological condition upon those in a different physiological condition.

It is well known that pear trees grafted on pear seedlings differentiate flower buds much later than do those grafted on quince. Thus, though both types of trees are of the same age, they are in different physiological stages. This provides a situation suitable for the above tests.

Leaves were collected in May at the time of natural flower-bud differentiation from bearing pear trees (grafted on quince), and the *p*H quickly determined. For the extraction of ribonucleic acid, the leaves were minced in a Waring blendor for 1 min.; sufficient ice-cold water was added to produce a crude mash which was adjusted to the previously determined *p*H of the leaves. The minced material was washed several times with ice-cold 0·1 *N* sodium chloride and then with a 3/1 mixture of cold ethanol/ether. After separation of the organic solvent phase the material was transferred to twice its volume of ice-cold 0·4 *N* sodium chloride containing 0·5 per cent sodium dodecyl sulphate, and the whole adjusted to *p*H 7·5. The suspension, frequently shaken, was then kept for 6 hr. at 4° C. The aqueous fraction was separated, and the extraction procedure was repeated once more. The aqueous fractions from both extractions were combined and ammonium sulphate added to 0·4 saturation. The protein precipitate was separated and the supernatant was now shaken with an equal volume of ice-cold water-saturated phenol. The aqueous phase containing ribonucleic acid was decanted and the phenol was extracted with ether[1,2]. The refrigerated solution was adjusted to *p*H 6-3, and the acid was precipitated by saturation with sodium chloride. After separation the ribonucleic acid was dissolved in a *p*H 6 acetate buffer; the resulting ribonucleic acid–buffer solution was then applied to the non-bearing 'acceptor' (pear on pear) trees. The aqueous solution of ribonucleic acid was light yellowish, and Folin's phenol reagent[4] gave no indication of the presence of proteins.

The leaves of selected branches of the acceptor trees were first treated with 'Carborundum', and then immersed in the solution of ribonucleic acid, followed by gentle brushing of the leaf surface. This procedure was performed on two branches and repeated five times. Three weeks after the treatments leaves from bearing and non-bearing trees were collected. The dried leaves were then analysed for alcohol-soluble and -insoluble nitrogen fractions and amino-acid composition[3]. Table 1 summarizes the effect of the extracted and transmitted ribonucleic acid upon the soluble and insoluble nitrogen fractions of the acceptor.

Table 1. THE EFFECT OF RIBONUCLEIC ACID FROM BEARING PEAR-TREES UPON THE TOTAL; 'SOLUBLE' AND 'INSOLUBLE' NITROGEN OF NON-BEARING PEAR TREES

Treatment	Total nitrogen	Soluble nitrogen		Insoluble nitrogen	
	Dry matter (per cent)	Dry matter (per cent)	Total nitrogen (per cent)	Dry matter (per cent)	Total nitrogen (per cent)
Control*	1·75	0·170	10·0	1·58	90·0
Control†	1·57	0·160	10·2	1·41	89·0
Ribonucleic acid‡	2·17	0·143	6·6	2·03	93·4
Ribonucleic acid§	1·60	0·190	11·8	1·41	88·2
Standard error	0·16	—	—	0·11	—

* Leaves of untreated bearing (pear on quince) trees.
† Leaves of untreated non-bearing (pear on quince) trees.
‡ Leaves of non-bearing trees treated with ribonucleic acid from bearing trees.
§ Leaves of non-bearing trees treated with degraded ribonucleic acid (the acid was boiled with 0·5 *N* potassium hydroxide before transmittance).

It is seen from Table 1 that the transmitted ribonucleic acid markedly effects the metabolism of nitrogen in the acceptor tissue. The absorption of total nitrogen into the leaves was considerably increased; the total level of protein was increased, as well as its percentage of total nitrogen.

In order to establish whether the latter effects were the results of the biological activity of the applied ribonucleic acid, the acid was inactivated before application. Part of the extracted ribonucleic acid solution was boiled for 5 min. with 0·5 *N* potassium hydroxide. The *p*H was adjusted as outlined previously, and the solution was applied to the acceptor trees in exactly the same manner as the unboiled solution of ribonucleic acid. As seen from Table 1 the boiling of ribonucleic acid annuls its effect completely. It has been shown[3] that uracil induces the synthesis of protein when the ratio of uracil to guanine is increased. The addition of inactivated ribonucleic acid supplies uracil to the leaves but does not change the ratio of uracil to guanine and possibly therefore no protein synthesis was induced. Hence it is probable that a specific configuration of the intact ribonucleic acid is necessary to induce protein synthesis in the acceptor tree after transmission.

In a previous communication[3] it was shown that uracil affects, via ribonucleic acid, the amino-acid composition of the leaves. This was now also found true for transmitted ribonucleic acid as shown in Table 2.

Table 2. THE EFFECT OF TRANSMITTED RIBONUCLEIC ACID UPON THE COMPOSITION OF THE LEAF PROTEIN OF NON-BEARING PEAR TREES

Amino-acid	μgm. nitrogen per dry matter		Nitrogen as per cent of total nitrogen	
	Control*	Ribonucleic acid†	Control*	Ribonucleic acid†
Alanine	1,283·10	1,382·10	8·1	6·3
Arginine	1,890·25	3,073·25	12·0	14·1
Aspartic acid	3,748·85	3,466·05	23·8	16·0
Cystine	traces	traces	0·0	0·0
Glutamic acid	572·80	1,520·65	3·6	7·1
Glycine	1,398·70	932·45	8·2	4·3
Histidine	traces	traces	—	—
*iso*Leucine	0·0	842·05	0·0	3·9
Kynurenine	0·0	951·00	0·0	4·0
Leucine	1,029·40	1,448·35	6·5	6·7
Lysine	2,351·80	971·35	14·9	4·5
*nor*Leucine	0·0	1,027·15	0·0	4·8
Phenylalanine	374·00	841·50	2·4	3·9
Proline	912·00	1,013·55	5·8	4·7
Threonine	699·30	629·35	4·5	2·9
Tryptophan	342·75	822·60	2·1	3·7
Tyrosine	321·80	572·15	2·0	2·6
Valine	1,254·80	2,159·60	8·0	10·0
Unidentified	421·45	246·85	2·6	1·6

* Leaves from non-bearing (pear on pear) trees.
† Leaves from non-bearing trees which were treated with ribonucleic acid from bearing trees.

The values obtained for the amounts of the different amino-acids making up the leaf protein are greatly affected by the treatment. Especially the amount of *iso*leucine, of which only traces were found in the untreated leaves, was increased due to ribonucleic acid. Of special interest is the appearance of *nor*leucine and a quinoline derivative—kynurenine—which in certain animals is an oxidative product of L-tryptophan[5–7] and a precursor of nicotinic acid in plants[8]. The significance of the appearance of kynurenine will be discussed in a separate paper.

The above results demonstrated the possibility of transmitting ribonucleic acid in its 'native' state from one tree to another; the transmitted acid then causes certain changes in the synthetic activity of the acceptor tree. Hence one might consider whether there are not certain similarities between the effect of normal and viral ribonucleic acid, the 'normal' and 'abnormal' activities of a plant being often only a matter of degree.

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Planting Distance and Number of Seedlings in Rice Cultivation

FOR early paddy a planting distance[1] of 6 in. × 6 in. using six seedlings[2] at each spot has been recommended. But this narrow row-spacing limits the use of interculture implements like rotary weeders, thereby affecting the economy of paddy cultivation. In order to find out if the row spacing could be increased without a detrimental effect on yield, and also to determine the corresponding number of seedlings to be planted at each spot, a field experiment was designed with rice variety *N*22, planted at 6 in. × 6 in., 8 in. × 4½ in. and 12 in. × 3 in., using

Table 1. Analysis of Variance

Due to	Degrees of freedom	Variance for grain yield	Variance for straw yield
Block	3	750·3*	6,723·0
Planting distance	2	8·1	677·8
Error (*a*)	6	91·9	1,999·9
No. of seedlings	2	28·6	2,192·5
Interaction	4	281·9†	5,377·8*
Error (*b*)	18	61·5	1,220·9

* Significant at 5 per cent level
† Significant at 1 per cent level

Table 2. Paddy Yield (oz.) per Plot

Planting distance \ No. of seedlings	Grain				Straw			
	2	4	6	Mean	2	4	6	Mean
6 in. × 6 in.	43·25	44·50	*55·00*	47·58	121·0	124·0	*151·0*	130·3
8 in. × 4½ in.	45·25	*53·25*	39·50	46·00	125·0	*190·0*	101·0	138·8
12 in. × 3 in.	*55·00*	44·00	40·25	45·42	*154·0*	118·0	99·0	123·7
Mean	47·83	47·25	44·92	46·67	131·7	144·0	117·0	130·9

Least significant difference for interaction: Grain, 8·20; straw, 14·26

two, four and six seedlings. The nine treatment-combinations were replicated four times in split plot design, with an ultimate plot-size of 6 ft. × 9 ft. Crop was harvested on October 6, 1956, ten weeks after transplanting. Results of analysis of variance of yield and of grain and straw yields are represented in Tables 1 and 2 respectively.

Only interactions were found to be significant. From a comparison of italic figures in Table 2, it is evident that distance between rows can be increased without a deleterious effect on the yield of rain-fed early rice by a corresponding decrease in the number of seedlings planted at each spot—thereby also deriving benefit of a much lower seed-rate. In other words, at a given area for a clump of rice plants, the optimum number of seedlings planted at each spot is a function of, and directly proportional to, the shorter side of planting distance.

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Apparent Requirement for Vitamin K of Rumen Strains of *Fusiformis nigrescens*

An organism producing coal-black colonies on blood agar has been isolated in numbers of 10^{4-5}/gm. from the rumen contents of six cows fed on kale, hay and concentrates or grass diets and from the rumens of two abbatoir-killed cows. It may therefore be a normal component of the flora of the bovine rumen.

The organism is a Gram-negative cocco-bacillus and a strict anaerobe, producing a black pigment and a foul odour from blood. The cells measure about 0·4 × 0·3–0·2μ, occurring singly or in pairs. Longer forms and chain formation were found at minimum concentrations of menaphthone. These characteristics suggest its identity with *Fusiformis nigrescens*[1]. It was grown on 10 per cent horse blood 'Lemco' agar in an atmosphere of 90 per cent hydrogen and 10 per cent carbon dioxide at 39° C. and was first isolated in association with an anaerogenic rumen strain of *Proteus*[2]. When grown in pure culture, *F. nigrescens* died out after giving rise to various atypical forms, for example, where growth occurred at isolated points on the plate; maximum growth did not coincide with points of maximum inoculation, or where growth occurred in the form of minute colourless colonies. Other workers[3] have remarked on the variability in growth of this organism. When *Proteus* was inoculated into blood plates showing atypical growth, or plates inoculated with *F. nigrescens* which did not show growth after incubation for one week, good growth of *F. nigrescens* with typical colony formation developed on further incubation; control atypical plates remained the same.

Attempts were made to determine the growth-promoting factor. Filtrates of *Proteus* grown under aerobic and anaerobic conditions were added to blood plates, but no consistent stimulation was obtained. Attempts to remove a possible growth-inhibiting substance in the medium by the addition of 0·1 per cent soluble starch, 0·03 per cent ethylene diamine tetra-acetic acid and urease were without effect. Chocolate agar and laked blood[3] also failed to influence the growth of the organism.

This difficulty in cultivating *F. nigrescens* is analogous in a number of ways to that existing in the culture of *Mycobacterium johnei* without *M. phlei*. The growth of certain strains of *M. johnei* is enhanced by the addition of vitamin K to the medium[4]. An autoclaved suspension of menaphthone in water was therefore added to a blood 'Lemco' agar plate to give a final concentration of 5γ/ml. Good growth was obtained after six days incubation and *F. nigrescens* has been subcultured serially on this medium. Moreover, menaphthone was able to revive atypically growing cultures in the same manner as *Proteus*. In liquid medium dense growth was obtained after three days incubation in 1 per cent blood 'Lemco' broth + 15γ/ml. menaphthone and also at ranges of menaphthone and menaphthone sodium bisulphite of 0·25–25γ/ml. after three days. No growth or very poor growth was obtained in 'Lemco' blood broth alone, and no growth was obtained in 'Lemco' broth containing a range of menaphthone concentrations.

Preliminary experiments suggest that this requirement for vitamin K by rumen strains of *F. nigrescens* is specific, and the inhibition of the growth of *F. nigrescens* by the natural antagonist of vitamin K, dicoumarin, is competitive. Thus, inhibition occurred when the amount of dicoumarin was equal to the amount of menaphthone added at a level of 0·25γ/ml., and 1·5 times the amount of menaphthone when the latter was added at 25γ/ml.; that is, approximately equal proportions of dicoumarin/menaphthone result in inhibition at both levels.

Many organisms, including *Proteus*, are known to synthesize vitamins of the K group[5], and synthesis by rumen micro-organisms supplies the requirements of the cow for this vitamin[6]. These preliminary experiments give an example of vitamin interdependence among micro-organisms in the rumen. A more detailed study of the nutrition of *F. nigrescens* and experiments to develop a microbiological assay technique for vitamin K with this organism are in progress.

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Importance of Photoperiod and Temperature in inducing Diapause in the European Corn Borer, *Pyrausta nubilalis* (Hbn.)

The European corn borer was first found in Ontario in 1920[1] and, until recently, was primarily a single-generation species, producing one larval brood each summer and overwintering in diapause in the final larval instar. Beginning about 1941, a marked change in the seasonal history of the corn borer occurred. The numbers of larvæ completing development without diapause and giving rise to second-generation larvæ increased until it now constitutes a substantial part of the total borer population[2]. As one approach to an understanding of this divergence in seasonal history, we initiated a study on factors in diapause in the corn borer, including environment.

The larvæ used in this study were obtained from a laboratory culture of borers that were multivoltine at normal rearing temperatures. All larvæ in the culture were reared individually in one-dram shell vials containing a modification of Beck's[3] diet. Eight successive generations have been reared at 85° F. and approximately 70 per cent relative humidity without interruption by diapause and with no apparent reduction in vigour.

In an initial experiment, groups of newly hatched borers were reared at 45°, 55°, 65°, 75° or 85° F. to determine the effect of temperature on larval development and on the occurrence of diapause. The borers reared at 45° and 55° F. died in the second instar; those reared at 75° and 85° F. developed normally and pupated, whereas those reared at 65° F. entered a diapause. These results indicate that diapause in laboratory-reared borers can be induced by controlling the larval rearing temperature. An experiment in which larvæ in each of the five instars were reared at 65° F. for one instar and at 85° F. for the remaining instars showed that the low-temperature treatment is relatively ineffective in inducing diapause unless the treatment occurs in the fifth instar. Furthermore, fewer borers enter diapause if the larvæ have been more than one day in the fifth instar at the beginning of the low-temperature treatment.

In the foregoing experiments a photoperiod of 8·5 hr. light per day was used. Failure to induce diapause in comparable numbers of larvæ under continuous illumination at 65° F. turned our attention to the possible role of photoperiod in diapause induction. Groups of larvæ reared to the end of the fourth instar at 85° F. and constant light were transferred to 65° F., and a photoperiod of 0, 4, 8, 16, 20 or 24 hr. light per day until they had either pupated or entered diapause. The results of this experiment are compared with data for photoperiods of 8·5 and 9·5 hr. light per day, and are summarized in Table 1. The number of borers entering diapause at 65° F. increased with increasing light periods up to 9·5 hr. light per day; photoperiods of 16–24 hr. light per day were relatively ineffective. A similar experiment at 75° F., in which light periods of 0, 8, 16 and 24 hr. light per day were tested, induced diapause in no larvæ.

Table 1. Influence of Photoperiod, at 65° F., on Induction of Diapause in the European Corn Borer, *Pyrausta nubilalis* (Hbn.)

Hr. light per day	Initial No. of larvæ	Percentage mortality	Survivors entering diapause (per cent)
0	37	43	0
0	50	10	7
4	44	12	32
8	45	2	59
8·5	75	7	69
9·5	65	22	96
9·5	58	7	94
16	39	3	3
20	39	8	3
24	41	2	8
24	25	16	5

The stock used in these experiments, though multivoltine at normal rearing temperatures, thus has a facultative diapause. Furthermore, it is clear that temperature and photoperiod are factors of importance in the initiation of diapause in the borer.

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Blackhead Toppling Disease of Bananas

Blackhead disease of bananas was described by Ashby[1] as occurring in Jamaica in 1915 and being caused by a nematode, identified by Cobb[2] as *Tylenchus similis* Cobb, now renamed *Radopholus similis*. It was not sufficiently serious on the Gros Michel variety in 1942 to be listed by Martyn[3] among the banana diseases of Jamaica.

Ever since Panama disease necessitated the replacement of the Gros Michel banana by a resistant variety in Jamaica, Lacatan bananas have been grown more and more extensively there, notably since the 1951 hurricane. Lacatan bananas have, however, recently been found highly susceptible to the old blackhead disease. This has been well demonstrated where an experimental acre plot of Gros Michel bananas on one estate is practically free of the disease whereas the Lacatan bananas of the same age, in the same field, are riddled with it.

The presence of blackhead disease has only been realized since high winds have uprooted a large number of banana plants without causing 'breakneck' of the pseudostems. Investigations have shown that the roots of such plants have been so extensively invaded by *Radopholus similis* that they have been killed by the entry of secondary organisms into the stele. Where infection is not very severe, plants may produce good grades of fruit, and the heaviest losses from toppling often occur in such circumstances. Present indications are that, where the disease is particularly severe, losses from toppling may not be so serious because the plants are backward in growth and bear light bunches. The roots of young suckers tend to be less heavily invaded than those of the parent plants and these healthier roots are able to assist in anchoring the parent. In the taller plants, bearing heavier fruit, this assistance is inadequate to prevent toppling.

Radopholus similis is a burrowing nematode which soon leaves tissue rotted by secondary organisms, with the result that examination of blackened roots and heads (corms) frequently yields remarkably few parasitic nematodes. To find *R. similis* readily in the banana plant it should be sought in two regions, namely, where purplish streak lesions (less than $\frac{1}{16}$ in. wide and often not more than $\frac{1}{4}$ in. long) occur on young roots and, also, at the junction of diseased and healthy tissue near the surface of the corm, which is seldom invaded to a depth of more than half an inch. Invaded tissue is isolated by the formation of wound cambium. Although able to confine the nematodes to the surface layers of the head in this way, the banana plant is unable to resist penetration into the comparatively loose-celled parenchyma of the root cortex, so that the nematodes readily enter as far as the endodermis, where secondary organisms gain access to the vascular system, resulting in death of the roots.

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Leucocytozoon spp. in some Hertfordshire Birds

During the course of some work on the blood parasites of birds[1] (some of which has been or will shortly be published[2]) gametocytes of several species of *Leucocytozoon* were observed in the blood of seven species of birds. In the absence of reports of the incidence of this parasite in British birds since those of Seligman and Sambon[3] (in grouse), Woodcock[4] (in chaffinches and redpolls) and Coles[5] (in thrush, blackbird, jay, pigeon, starling, moorhen and "many others") it is thought that results from the present investigation (which took place between 1953 and 1955) might be of interest.

All the birds were shot or trapped near St. Albans, Hertfordshire, and thin films of their peripheral blood (stained with Giemsa's stain) were examined under a magnification of about 100 diameters for at least 10 min. The term 'adult' in Table 1 refers to all birds which had left the nest and were able to fly.

Details of the birds which were found to be infected are recorded in Table 1. No parasites were found in nine adult and four nestling song thrushes (*Turdus e. ericetorum* Turton), eight adult and one nestling starlings (*Sturnus v. vulgaris* L.), or seven adult house sparrows (*Passer d. domesticus* L.). (Species of which fewer than five individuals were examined are excluded from this list.)

Table 1. Incidence of *Leucocytozoon* spp. in some Hertfordshire Birds

Species of bird	Age group	No. examined	No. infected	Percentage infected
Rook (*Corvus f. frugilegus* L.)	Adult	52	8	15
	Nestling	25	0	0
Jackdaw (*C. monedula spermologus* Vieill.)	Adult	27	1	4
Blackbird (*Turdus m. merula* L.)	Adult	33	9	27
	Nestling	12	0	0
Wood pigeon (*Columba p. palumbus* L.)	Adult	12	2	17
	Nestling	1	0	0
Blue tit (*Parus caeruleus obscurus* Pražak)	Adult	5	1	20
Carrion crow (*Corvus c. corone* L.)	Adult	2	2	—
Tawny owl (*Strix aluco sylvatica* Shaw)	Adult	1	1	—

The species of *Leucocytozoon* found were identified as follows: *L. sakharoffi* Sambon 1908 in rook, jackdaw and carrion crow; *L. dubreuili* Mathis and Leger 1911 in blackbird; *L. marchouxi* Mathis and Leger 1910 in wood pigeon; *L. majoris* (Laveran 1902) in blue tit; and *L. danilewskyi* Ziemann 1898 in tawny owl. This last species was found inhabiting both round and elongated host cells in the blood, whereas all the other species were found in round cells only.

It is interesting to note that no nestling birds were found to be infected. Of the 52 adult rooks examined, 48 were known to be less than one year old (because they possessed a forwardly directed tuft of feathers at the base of the beak which is lost at the beginning of the second year[6]), and all the infected birds were among this group. This suggests that infection of British rooks (and probably other species) does not occur until either just before or after they leave the nest.

I wish to thank Prof. P. C. C. Garnham for his advice and interest throughout this work.

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Influence of Parasitization on Form Determination in Aphids

Parasitization of the immature stages of some insects and Crustacea is known to result in structural abnormalities in the adults. Examples from insects are the production of 'intersexes' in certain Homoptera and Hymenoptera when parasitized by Strepsiptera[1], and of 'intercastes' of ants parasitized by nematodes[2]. Unparasitized aphids intermediate in structure between alate and apterous forms have been observed and described a number of times[3], and

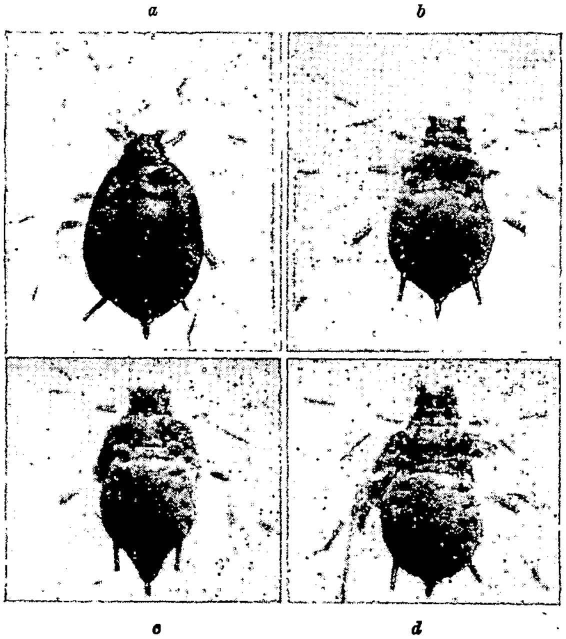

Fig. 1. Extent of suppression of alate structures in adult aphids by parasitization at different stages of development. These aphids were parasitized at (*a*) second instar; (*b* and *c*) early third instar; (*d*) late third instar

it has now been found that in *Aphis craccivora* Koch this kind of intermediate can be produced by parasitization of alatiform nymphs by the braconid wasp *Lysiphlebus testaceipes* (Cresson).

In a series of experiments, aphid nymphs which would normally have developed into alatæ were parasitized at various stages of their development, and the structural characters of the ensuing adults were observed. Until the third nymphal cutical is laid down there is no apparent structural difference between nymphs which will develop into alatæ or apteræ, and early instar alatiform nymphs were obtained by subjecting adult aphids to conditions which were known to result in the production of alatiform progeny. Adults of *A. craccivora* which had been kept for several days on cuttings of *Vicia faba* bearing only mature leaves were found to produce more than 90 per cent alatiform nymphs, whereas aphids kept on seedlings produced almost exclusively apteriform nymphs.

The extent to which alate structures were suppressed by parasitization depended upon the stage of development at which the aphids were parasitized. Aphids parasitized in the third and early fourth instars developed into intermediates in which the size of the wing pads and degree of differentiation of the thorax varied according to when they were parasitized; but they all had lateral ocelli and secondary sensoria on the antennæ, both of which are typically alate structures. Aphids parasitized in the third instar became adults without wing pads and having greatly reduced lateral ocelli and no antennal sensoria. Aphids parasitized in the first instar did not survive the fourth instar in which they had no alatiform structures and were indistinguishable from normal fourth instar apteriform nymphs except that they showed some degree of prothetely: in a number of them the form of the cauda was intermediate between those of the nymph and the adult, and they all had some typically adult pigmentation. The only apparent effect of parasitization on the structure of apteriform nymphs was in nymphs parasitized in the first instar which in the fourth instar had some adult structures.

The means by which interference with the determination of alate structure in aphids is effected is not known. Attempts to simulate the effects of parasitization by puncturing the aphids with a fine needle were unsuccessful, although severe burn injuries to parts of the abdomen of third instar nymphs did in a number of cases result in the aphids becoming intermediate between alatæ and apteræ. Ultimately form determination is probably due to the availability to the epidermal cells which produce the polymorphic structures of some substance or substances at optimum concentration at certain more-or-less critical times during development. Nutrition, which has been shown to influence form determination in a number of insects, is not likely to be involved here, as starvation of developing aphids, for example, by allowing them to develop on wilting plants, or removing them from the plants for considerable periods, merely results in smaller adults and does not cause a reversal of form. It seems more reasonable, in the light of present knowledge of the role of hormones in insect development, to suspect that the presence of the parasite causes interference with the hormone system of the nymphs. The occurrence in some parasitized aphids of prothetely, which can be caused by hormonal upsets[4], supports this, but experimental proof is lacking.

This work is being continued in the hope that it may throw some light on the mechanism of determination of form in aphids.

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Balanus tulipiformis Ellis on the Atlantic Coast of France and an Unusual Situation for *B. amphitrite* Darwin

In June 1956, a stone carrying a large red barnacle was brought up by a trawler from a depth of about 25 m., between the mouth of the Adour and Cap Breton. The specimen was identified by Dr. J. P. Harding of the British Museum (Natural History) as *Balanus tulipiformis* Ellis. So far as can be ascertained, *B. tulipiformis* has not previously been reported from any part of the Atlantic coast of Europe. Its distribution is given by Darwin[1] as Sicily, Malta, Malaga (associated with *B. perforatus*) and Madeira. Gruvel[2] gives the same distribution. Nilsson-Cantell[3] adds one further habitat, Wasin (West Africa).

Further, the specimen, with a basal diameter of 50 mm., would appear to be the largest of the species so far recorded from any locality. Darwin gives the measurement of the largest specimen (from Malta) as 1·4 in. (about 35 mm.) in basal diameter, and adds that, usually, full-sized specimens are about $\frac{3}{4}$ in. (about 20 mm.) in basal diameter. Gruvel gives the basal diameter as 18 mm.

Since the discovery of this specimen, it has become apparent that the species is well established on the south-west coast of France.

There is a 'whistling' buoy outside the bay of Saint-Jean-de-Luz moored in 25 m. of water. Each year this buoy is taken up, usually in September, being immediately replaced by another. The buoy was examined for cirripeds in September 1956 and again in September 1957.

When the buoy was taken from the water in September 1956 there was a number of isolated *Balanus* scattered over the surface below the water-line. These included a score or more *B. tulipiformis*, some of which had a basal diameter of 35 mm. There was a much greater number of *B. perforatus* Bruguière, and there were a few of a third species, identified by Dr. Harding as *B. amphitrite* Darwin. In September 1957, 36 *B. tulipiformis* were counted on the buoy. They were concentrated on or near the junction of the tube with the floating part of the buoy, that is to say somewhat deeper in the water than the rounded part of the buoy on which they had mostly settled the year before. The basal diameters of the largest specimens were 40 mm. (2), 38 mm. (3), 37 mm. (3). These sizes were attained in a single year, the buoy having been in the water from September 8, 1956, until September 18, 1957. As in the previous year there was a far larger number of *B. perforatus*, but on this occasion only one *B. amphitrite* (juv.) was observed. There was also a quantity of *Lepas anatifera* L. This species had not been seen in the previous year.

The buoy is situated at least 25 km. from the area from which the first example of *B. tulipiformis* was obtained. From more or less that same area and depth—25 m. or more—the same trawler, in July 1957, brought up a very old anchor on which were fixed a number of *B. tulipiformis* of various sizes. On the anchor was found the outer shell of what appears to have been a *B. tulipiformis* of great size, with a basal diameter of more than 75 mm. Young specimens of this species have also been found on shells of *Ostrea rugosa* Gmelin taken from crayfish traps set in 30 m. of water, or deeper, off Saint-Jean-de-Luz.

The presence of *B. amphitrite* on the buoy in 1956 is worthy of note. In a recent study of the cirripeds on the north coast of Spain, E. Fischer-Piette and M. Prenant[4] have noted the presence of *B. amphitrite* in certain ports and estuaries and its absence in others. This is explained as due to the fact that, to establish itself, this species requires a certain amount of turbidity in the water and is not to be found where the water is very clear. In an earlier work on the distribution of the principal intertidal species on the north coast of Spain, Fischer-Piette[5] remarks that in the situations known to him he has found this species living only in ports, estuaries and lagoons, and never on the open coast. In a letter to me he has stated that, except on the hulls of ships, he has only seen the species "dans des milieux souillés ou confinés".

It is probable that, in the case of the *B. amphitrite* on the buoy, the condition of turbidity of the water at the time of settlement may have been satisfied. Although more than a kilometre from the nearest land, the buoy is in direct line with the entrance of the harbour of Saint-Jean-de-Luz in the estuary of the River Nivelle. After heavy rain, an area of turbidity can be seen to extend up to and beyond the buoy, and sometimes to remain visible for several days. One cannot, therefore, exclude the possibility that, at the time of settlement of the larvæ of *B. amphitrite*, there may have been sufficient turbidity in the water around the buoy to permit of their establishment. On the other hand, the buoy is well out in the open sea, 1,200 m. from the nearest land. So there is no question here of a confined space. As noted above, only one young specimen of *B. amphitrite* was found on the buoy in 1957.

My sincere thanks are due to Dr. J. P. Harding for his identifications and for his kind advice in the preparation of this communication. I also wish to acknowledge the assistance received from Prof. E. Fischer-Piette and Monsieur M. Prenant.

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A Possible Ecologial Effect of Upwelling in a Submarine Canyon

During July–November 1956, an exploratory ecological survey along the south-west edge of the La Jolla submarine canyon was conducted over a sandy bottom using self-contained underwater breathing apparatus[1] diving techniques (for a chart of the region see Shepard and Emery[2]), and the following preliminary information may be of general interest.

There are sharp changes in the dominant species of animals as one swims toward the north-west along the canyon axis between the 27- to 37-m. contours. In the shoreward regions (area 1) abundant populations of the sea-pen, *Stylatula elongata*, and the sea-star, *Astropecten californicus*, exist. Abruptly the community changes and is almost entirely *Astropecten* for about 50 m. (area 2). Continuing farther (area 3), brittle stars, *Ophiura lütkeni*, are found almost exclusively. On the broad, sandy continental shelf to the north *Ophiura* are not found until a depth of 47–50 m. is reached; *Astropecten* here occurs at 40–23 m. and *Stylatula* at 23–10 m. Boundaries between communities on the shelf appear to run parallel to the depth contours; at the canyon they run across the contours.

100–150 m. traverses were swum near the 30-m. contour along the edge of the canyon through the regions mentioned above. Centrally within these regions counts of animals were made in areas chosen at random by quadrats cast down blindly. Table 1 presents the marked differences which were found.

Table 1

Animal	Size of quadrat (m.^{2})	No. of individuals in each sample	Individuals (per m.^{2})
Area 1			
Astropecten	1	0, 0, 0, 0, 0, 0, 0, 2, 0, 3, 3	1
Stylatula	1	2, 1, 2, 1, 0, 0, 3, 5, 7, 6, 0	2
Ophiura	1	0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,	0
Area 2			
Astropecten	1	1, 6, 4, 10, 2, 1	4
Stylatula	1	0, 0, 0, 0, 0, 0	0
Ophiura	1	0, 0, 0, 0, 0, 0	0
Area 3			
Astropecten	1	0, 0, 0, ½, 0, 0, 0, 0, 0, 0	0
Stylatula	(three observed during a 50-m. swim)		0
Ophiura	0·05	4, 5, 4, 3, 2, 0, 3, 0, 5, 3, 0, 4	60

The areas on the canyon rim are not characterized by any large differences in substrate, depth and temperature. We have, however, while on the bottom in area 3, observed water currents coming from the direction of the canyon travelling up slopes as steep as 26°. Current velocities are variable both in magnitude and direction; but this is characteristic of near-shore currents in southern California. Velocity measurements, determined by timing the progress of a cloud of permanganate solution for 1 m., yielded vertical components as great as 45 cm./min. upwards. Studies of area 1 have as yet failed to give evidence of upwelling; this difference may be an important factor influencing the distributions discussed above. The commercially harvested kelp beds of *Macrocystis pyrifera* just south of area 3 may also be affected by the upwelling.

Tides, internal waves, and northerly currents could contribute to the upwelling; the biological data suggest that northerly currents may play an important part. Ophiuran populations occurring at 50 m. depth on the shelf and at 30 m. in the canyon allow the possibility of a water mass common to both places. Currents from the north at the 50 m. depth would run into the south wall of the canyon below area 3 and may upwell and flow across this region. Area 1 and possibly area 2, however, below 27 m. are protected from northerly currents by the shoal opposite wall of the canyon.

We are grateful for criticism and assistance to Prof. D. L. Fox and to Dr. E. W. Fager. The work was supported by the George A. Bisbee Donation and a Rockefeller Foundation donation for research in marine biology.

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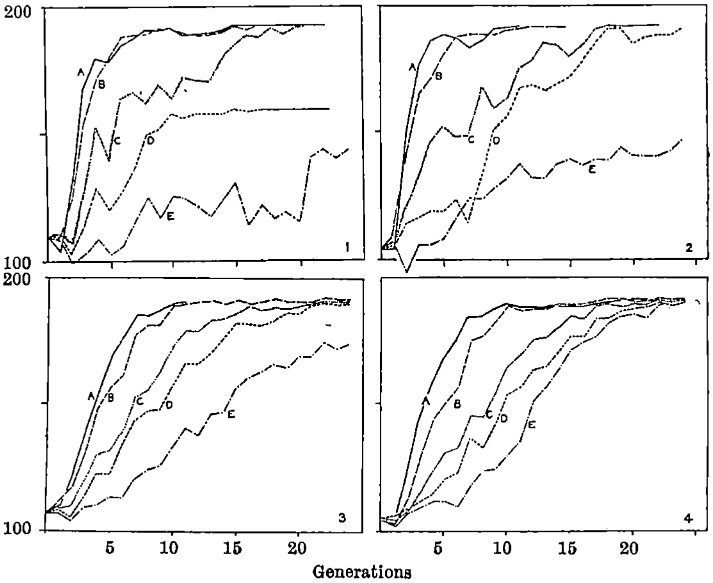
Monte Carlo Analyses of Genetic Models

AUTOMATIC digital electronic computers, such as the SILLIAC, have several features which are of use in simulation of genetic systems. These are the ability to form sets of pseudo-random numbers[1], the ability to perform the operations of logical summation, equivalence, etc., and particularly the ability to perform a sequence of operations repeatedly at high speeds. A programme[2] has been written for the SILLIAC which simulates the action of selection on a population segregating for six loci. The programme has been run for complete dominance, equal effects at all loci, and no interactions between loci. The number of progeny was set at 100, and of parents at 50. Mating was at random. The initial population was set to contain the gametic types listed in binary notation in Table 1.



Figs. 1–4. Rates of advance under selection calculated by the SILLIAC. In each figure there are five lines representing different degrees of recombination. Figs. 1–2 are at high intensity of selection, small population size. Figs. 3–4 are at low intensity of selection, large population size

Table 1. FREQUENCIES OF GAMETIC TYPES IN PARENT POPULATIONS

Location

a	*b*	*c*	*d*	*e*	*f*	Frequency
0	0	1	0	0	1	0·11111
0	0	1	0	1	0	,,
0	0	1	1	0	0	,,
0	1	0	0	0	1	,,
0	1	0	0	1	0	,,
0	1	0	1	0	0	,,
1	0	0	0	0	1	,,
1	0	0	0	1	0	,,
1	0	0	1	0	0	,,

The values of recombination between the six loci were set at the values given in Table 2.

Table 2. RECOMBINATION VALUES

Location

a	*b*	*c*	*d*	*e*	*f*	
0·5	0·5	0·5	0·5	0·5		*A*
0·25	0·25	0·5	0·25	0·25		*B*
0·05	0·05	0·5	0·05	0·05		*C*
0·025	0·025	0·5	0·025	0·025		*D*
0·005	0·005	0·5	0·005	0·005		*E*

The programme therefore simulates conditions of recombination from complete independence (*A*), to tight linkage in two chromosomes, each containing three loci. Two runs were made at each set of recombination values, starting at different points in the set of pseudo-random numbers. The results are shown in Figs. 3 and 4.

As would be expected on general grounds, and from the analyses of Wright, Haldane and Fisher, there is a decrease in the rate of advance with increasing tightness of linkage. None of the runs showed any periods of no advance as were found by Mather[3] and used by him as the basis for the polygene concept. The programme was run again, changing the number of progeny to 40, of parents to 4 (that is, approximating the values of Mather's experiment). The results are shown in Figs. 1 and 2.

In these runs a more marked retardation of the rate of advance by increasing tightness of linkage was found. This is particularly the case in the runs at recombination values of 0·005, where distinct lags occurred in the advance under selection which are analogous to those found by Mather[3] in his second selection line which is illustrated in Fig. 5.

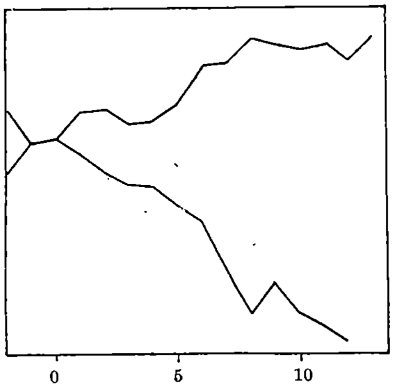


Fig. 5. Rates of advance under selection in *Drosophila*, from Mather, ref. 3

These runs indicate that any effects of linkage on the amount of variability present in a population will be slight at recombination values greater than 0·005 in populations of reasonable size. In small populations, the effects of linkage of this intensity are sufficiently great to produce qualitative changes in the curve of advance under selection, considerably reducing the efficiency of selection.

The above analyses are sufficiently encouraging to justify writing further programmes for Monte Carlo analyses of genetic systems. Three are being written covering (*a*) single loci, multiple populations with migration, (*b*) several loci, with variation of dominance, interactions, linkage, and number of chromosomes, and (*c*) several loci, no linkage, several phenotypes, environmental variation, non-random mating. Monte Carlo analyses can never be a substitute for complete mathematical simplifications. They can, however, be regarded as complementary to the present incomplete mathematical solutions, and provide an easily used tool for those geneticists, such as myself, who cannot otherwise add to the mathematical theory of natural selection.

A. S. FRASER

Animal Genetics Section,
Commonwealth Scientific and
Industrial Research Organization,
Zoology Department,
University of Sydney.

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An Experimental Design for Three Factors at Three Levels

IN an experiment with three factors at three levels each, the experimenter may be willing to sacrifice information on certain components of the two-factor interactions and to ignore the three-factor interactions completely except as an estimate of error[1]. A possibly useful experimental design for this purpose is detailed below.

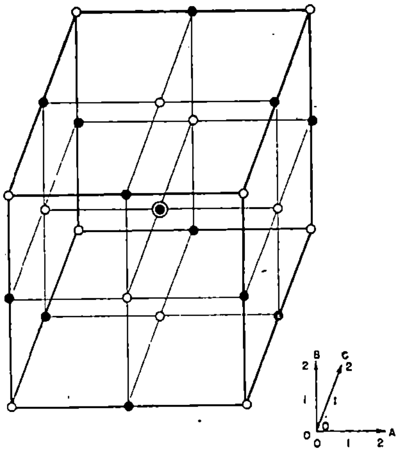

Fig. 1. The 3^3 factorial design and the cuboctahedron plus centre point. ○, ● + ⊙, 3^3 factorial; ●, cuboctahedron; ⊙, centre point

The experimental arrangement permits independent estimation of and tests of significance on both the 'linear' and 'quadratic' components of the main effects and on the 'linear × linear' components of the three two-factor interactions. As the basic experimental design requires only 16 observations, it can be used in 'mixed series' experiments with other factors at two or four levels each in partial replication of the whole (De Baun, R. M., unpublished). Moreover, quadruplicate replication of one experimental combination permits an estimate of true experimental error. The experimental design and appropriate orthogonal polynomials are detailed in Table 1. We may compare the power of estimation in this design to that of the 27 point 3^3 factorial design in single replication, by taking the variances of the several effects corrected by the ratio of the numbers of observations in each experiment. These variances relative to those of the 3^3 factorial design are: linear effects 1·333, quadratic effects 0·888 and linear times linear interaction effects 1·185. We thus gain information on the quadratic effects while sustaining an information loss on the linear effects and their interactions.

The experimental design cannot be further blocked independently of the previously cited effects. However, omission of a (111) point permits blocking into three blocks of 5 with the block contrasts partially confounded with the quadratic effects.

The basic experimental design can be seen to be a symmetrical fraction of the 3^3 factorial, as is shown in Fig. 1. Geometrically, the design may be viewed as a cuboctahedron in single replication with quadruplicate observations at the centre.

Table 1. EXPERIMENTAL COMBINATIONS AND ORTHOGONAL POLYNOMIALS

Observation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A level	0	2	0	2	1	1	1	1	0	0	2	2	1	1	1	1
B level	0	0	2	2	0	2	0	2	1	1	1	1	1	1	1	1
C level	1	1	1	1	0	0	2	2	0	2	0	2	1	1	1	1
A effect	−1	+1	−1	+1	0	0	0	0	−1	−1	+1	+1	0	0	0	0
A^2 effect	+1	+1	+1	+1	−1	−1	−1	−1	+1	+1	+1	+1	−1	−1	−1	−1
B effect	−1	−1	+1	+1	−1	+1	−1	+1	0	0	0	0	0	0	0	0
B^2 effect	+1	+1	+1	+1	+1	+1	+1	+1	−1	−1	−1	−1	−1	−1	−1	−1
AB effect	+1	−1	−1	+1	0	0	0	0	0	0	0	0	0	0	0	0

The analysis of the variance breaks down to nine degrees of freedom for treatments (three linear, three quadratic and three interaction), three degrees of freedom for lack of fit, that is, higher-order interactions and three degrees of freedom for true error, if properly randomized.

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Vowel Recognition in Clipped Speech

It would be a great advantage if computers used for translation from one language into another could be provided with voice-operated input equipment. This development, however, depends on the isolation of information-bearing factors in speech, that is, a distinction among different sounds produced by a speaker and an identification of the same sound produced by different speakers.

In the course of work on speech-input devices for a translating machine, clipped speech was examined for the possible extraction of information-bearing factors. Since it is reported to be intelligible[1–4] while carrying information solely in the temporal pattern of zero-crossings, an apparatus was constructed to analyse the fine structure of the zero-crossings. The apparatus consisted of a magnetic tape player followed by amplifying and clipping circuits. The output was taken through a variable gate to a scaler so that the number of pulses in short intervals of time (of the order of 0·02 sec.) could be counted. The width of the gate was measured by passing generator pulses through it and counting them by means of the scaler. This arrangement, with routine precautions, allowed the number of pulses and time to be determined to an accuracy of about 1 per cent.

The first elementary sounds to be analysed were the vowels, because of their stability[5–8] and comparatively easy aural intelligibility. As a result of the experiment it was found that the plots of the number of pulses versus gate-width for the various vowels spoken by different persons were perfect straight lines. The slopes of these lines increased regularly from the vowel *i* (as in 'meet') to the vowel *a* (as in 'father'). Furthermore, the slopes were found to be reproducible within the limits of error of the apparatus. The vowels were thus recognizable singly as well as in combinations. Some of these results are shown in Figs. 1 and 2.

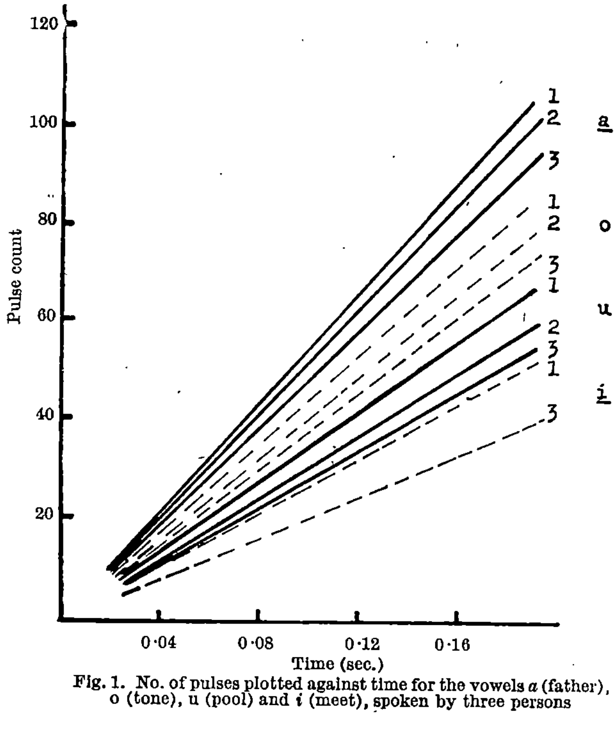

Fig. 1. No. of pulses plotted against time for the vowels *a* (father), o (tone), u (pool) and *i* (meet), spoken by three persons

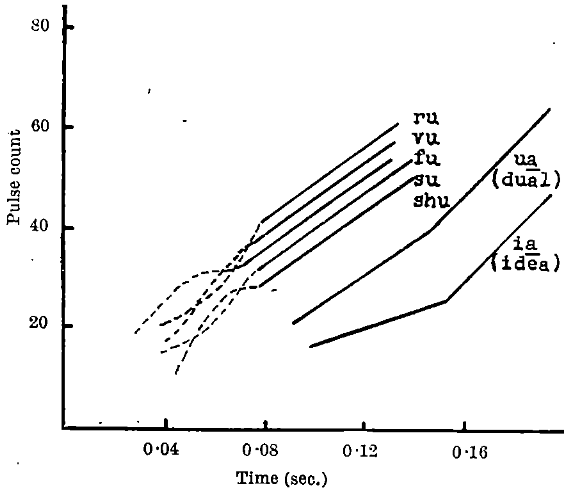

Fig. 2. Characteristic slopes of vowels in combination

Counts per sec.

	a	o	u	*i*
Voice 1	558	450	350	283
,, 2	533	417	317	—
,, 3	491	384	292	218

The constancy of pulse count per second for the various vowels throws some light on the particular feature by which clipped speech conveys information. Since vowels are made up of recurring trains of pulses (and yet they cannot be copied by pulses taken from a generator), it seems obvious that they carry information by: (1) the number of pulses in the interval of fundamental frequency and (2) the width-modulation of these pulses. It is interesting that the number of width-modulated pulses in the fundamental interval may be as small as two to three, as in the case of the vowel *i*.

Further work is being done on width-modulation within the fundamental period, and detailed results of the present study will appear elsewhere.

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[1] Licklider, J. C. R., *J. Acous. Soc. Amer.*, **20**, 42 (1948).

[2] Licklider, J. C. R., *J. Acous. Soc. Amer.*, **22**, 820 (1950).

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[4] Sakai, T., and Inoue, S., *J. Inst. Elect. Com. Eng. Japan*, **39**, 404 (1956).

[5] Black, J. W., *Quart. J. Sp.*, **25**, 52 (1939).

[6] Siegenthaler, B. M., *Quart. J. Sp.*, **36**, 202 (1950).

[7] Ladefoged, P., and Broadbent, D. E., *J. Acous. Soc. Amer.*, **29**, 98 (1957).

[8] Flanagan, J. L., *J. Acous. Soc. Amer.*, **29**, 533 (1957).

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, January 20

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. J. W. Birch: "The Economic Geography of the Isle of Man".

British Computer Society (at York Hall, Caxton Hall, Westminster, London, S.W.1), at 6.15 p.m.—Dr. N. Levin: "The Physical Principles of Xerography".

Institute of Metal Finishing (at Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. A. McL. Aitken: "Some Properties and Applications of Chemically Reduced Nickel Coatings".

Royal Institute of Chemistry, London Section (at Enfield Technical College, Queensway, Ponders End), at 7.30 p.m.—Dr. S. F. Birch: "Petroleum Chemicals".

Monday, January 20—Tuesday, January 21

Society of Chemical Industry, Pesticides Group (in collaboration with the Industrial Pest Control Association, at 14 Belgrave Square, London, S.W.1), at 10 a.m. daily—Symposium on "Pests of Stored Products".

Tuesday, January 21

British Nuclear Energy Conference (at The Hoare Memorial Hall, Church House, Westminster, London, S.W.1), at 9.30 a.m.—Symposium on "Nuclear Energy".

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. J. F. Greinig, Mr. R. W. Horseman and Mr. A. N. Kinkead: "The Design and Construction of the Foundations and Pressure Shell of the 8 ft. by 8 ft. High-Speed Wind Tunnel of the R.A.E., Bedford".

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. G. F. Tagg: Informal lecture on "The Effect of Modern Industrial Requirements on Electrical Instrument Design".

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. P. J. Duncton and Mr. T. F. R. George: "Environments and Environmental Testing".

Wednesday, January 22

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. C. H. Holland: "The Ludlovian and Downtonian Rocks of the Knighton District, Radnorshire"; Mr. F. M. Broadhurst: "A New Species of *Anthraconaia*, and a Study of Palæoecology in the Coal Measures of the Oldham Area, Lancashire".

Royal Statistical Society (at the London School of Economics, Houghton Street, London, W.C.2), at 5.15 p.m.—Mr. G. S. Watson: "On Chi-Square Goodness-of-Fit Tests for Continuous Distributions".

Eugenics Society (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. G. C. L. Bertram: "Eugenics in the Age of Crowding".*

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Dr. D. W. Gillings and Mr. W. Lawson: "The Shatter Strength of Cokes from High-Volatile Coals: Use of Plastometer Measurements on Blends for Test-Oven Experiments".*

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. E. Esping: "Special Problems of Broadcasting in Sweden".

Institute of Physics, Education Group (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. B. C. Brookes: "Presenting Science in Physics Text Books".

Institution of Mechanical Engineers, Applied Mechanics Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m. —Discussion on "The Measurement of Noise and Vibration".

British Psychological Society, Medical Section (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 8.30 p.m.—Mr. D. Russell Davis: "Clinical Problems and Experimental Researches" (Chairman's Address).

Thursday, January 23

University College, London (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Dr. E. Lester Smith: "The Biochemical Functions of Vitamin B_{12}".*

University College, London (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. R. E. D. Bishop: "Applied Mechanics in Engineering"* (Inaugural Lecture).

Oil and Colour Chemists' Association (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. J. H. W. Turner, Mr. S. E. Hanson and Mr. S. G. Kemp: "The Function of Aluminium Complexes as Structure Modifers in Paints".

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. L. H. Bedford: "Guidance and Control".

Friday, January 24

British Glaciological Society (at the Geography School, 341 Bristol Road, Birmingham), at 5.30 p.m.—Mr. J. W. Glen: "The Cambridge Austerdalsbre Expedition 1955–57".

Saturday, January 25

Biochemical Society (at the Glaxo Laboratories, Greenford, Middlesex), at 11.15 a.m.– Scientific Papers.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Principal of the Institute of Agriculture, Moulton—Chief Education Officer, County Education Offices, Northampton (January 25).

Research Assistant (qualified biochemist with some research experience) to Sir Rodolph Peters—The Secretary, Institute of Animal Physiology, Babraham, Cambridge (January 25).

Laboratory Steward (familiar with the maintenance and preparation of general equipment and materials for chemistry and physics)—The Registrar, North Oxfordshire Technical College and School of Art, 51 The Green, Banbury, Oxon (January 25).

Lecturer in Mathematics—The Secretary of University Court, The University, Glasgow (January 31).

Lecturer (preferably with special interests in high frequency techniques or in servomechanisms) in Electrical Engineering—The Registrar, The Manchester College of Science and Technology, Manchester 1 (January 31).

Lecturers in Inorganic Chemistry and in Physical Chemistry —The Registrar, The Manchester College of Science and Technology, Manchester 1 (January 31).

Senior Lecturer in Electrical Engineering at Singapore Polytechnic—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (January 31).

Senior Research Fellow (graduate in mining, physics, mathematics or engineering, with postgraduate experience, preferably in the field of applied mechanics) in the Postgraduate School of Mining, to undertake a study of the mechanics of rock fracture in mining processes—The Registrar, The University, Sheffield (January 31).

Assistant Physicist (graduate) in the Physics Department, Coventry Radiotherapy Centre—The Secretary, Group 20 H.M.C., Coventry and Warwickshire Hospital, Coventry (February 1).

Lecturer (Grade I or Grade II) in the Department of Agriculture, University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 3).

Lecturer (with special qualifications in physical chemistry) in the Department of Chemistry—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (February 8).

Analyst (with B.Sc. degree, preferably with honours in organic chemistry or equivalent and an interest in biochemistry and animal nutrition) in the Nutrition Research Laboratory, Department of Agriculture, Glenfield, New South Wales, Australia—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (February 12).

Assistant Lecturer or Lecturer in the Department of Applied Mathematics—The Registrar, The University, Liverpool (February 14).

Reader in Geology at Bedford College—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 14).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Engineering, Pharmacology, Physics, Chemical Technology or Chemical Engineering—The Secretary, The University, Edinburgh (February 15).

Lecturer in Zoology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 15).

Senior Lecturer (with high academic qualifications and/or professional qualifications and some teaching experience) in Chemical Engineering at Neath Technical College—The Director of Education, County Hall, Cardiff (February 17).

Lecturer or Assistant Lecturer (preferably with research interest in some aspect of taxonomy) in Botany at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 25).

Babcock and Wilcox Research Fellow in Nuclear Engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (February 28).

Challis Chair of Philosophy at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (February 28).

Courtaulds' Fellows (2) (with a good honours degree in physics, chemistry or chemical engineering) for research in textile chemistry—The Registrar, The Manchester College of Science and Technology, Manchester 1 (February 28).

Lecturer (graduate with an interest in electronics and preferably a knowledge of experimental stress analysis) in the Department of Textile Industries—The Registrar, The Manchester College of Science and Technology, Manchester 1 (March 1).

Leverhulme Postgraduate Fellows (3), two in the Faculty of Science and one in the Faculty of Engineering—The Registrar, The University, Liverpool (March 1).

Research Fellow for independent research—The Registrar (Room 22, O.R.B.), The University, Reading (March 17).

Assistant (Grade B) to teach Chemistry with some Physics or Mathematics—The Principal, North-West Kent College of Technology, Miskin Road, Dartford.

Electronic Engineer, for the construction of electronic apparatus with special application to biological material—The Secretary, Institute of Ophthalmology, Judd Street, London, W.C.1.

Electronics Technical Assistant (capable of maintaining and servicing existing equipment and assisting with the design and production of new electronic apparatus) in the Interdepartmental Workshop of the Royal Free Hospital School of Medicine—The Secretary, Royal Free Hospital School of Medicine, 8 Hunter Street, London, W.C.1.

Lecturer, Assistant Professor, Postdoctorate Fellow, and a Research Assistant in the Department of Physics—Head of the Department of Physics, University of British Columbia, Vancouver B.C., Canada.

Master to teach Mathematics throughout the School to University Scholarship standard—The Headmaster, The Perse School, Cambridge.

Mathematicians and Physicists (with a good honours degree in mathematics or physics and preferably experience in hydro-dynamics and modern computing techniques), for work on theoretical reactor physics and transport theory—The Recruitment Officer (1002Z/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Research Assistant in the Computing Machine Laboratory—The Registrar, The University, Manchester 13.

Scientific Officer (with a first- or second-class honours degree in physics or natural sciences or equivalent qualification), to undertake research in the physical and mechanical properties of explosives and to apply the data to a study of problems arising in weapon design—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1659/34.

Senior and Junior Research Fellows (with a first- or second-class honours degree in an appropriate subject and evidence of a very high standard of ability in research) at Government Scientific Establishments—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S.4798/58.

Senior Laboratory Technician (male), to be responsible for the Laboratories (Chemistry, Physics, Biology), other Laboratory Staff and equipment and stock—The Principal, North-West Kent College of Technology, Miskin Road, Dartford.

Senior Lecturer in High Polymer Technology—The Principal, Welsh College of Advanced Technology, Cathay's Park, Cardiff.

Senior Lecturer (preferably with an active interest in research in some branch of applied mathematics) in Mathematics—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

Visiting Lecturer in Mathematics—Prof.. A. D. Wallace, Tulane University, New Orleans, La., U.S.A.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Aluminium Development Association. List of Publications. Pp. 32. (London: Aluminium Development Association, 1957.) [1810

Bulletin of the British Museum (Natural History). Entomology. Vol. 5, No. 7: Neuropters and Trichoptera collected by Mr. J. D. Bradley on Guadalcanal Island, 1953–54. By D. E. Kimmins. Pp. 287–308. 7*s*. Vol. 5, No. 8: Odonata collected by Mr. J. D. Bradley on Guadalcanal Island, 1953–54. By D. E. Kimmins. Pp. 309–320. 4*s*. Geology. Vol. 3, No. 2: Eocene Mollusca from Nigeria: a Revision. By Frank E. Eames. Pp. 23–70+plates 5–10. 25*s*. Vol. 5, No. 4: A Revision of the Lake Victoria *Haplochromis* Species (Pisces, Cichlidae). Part 2: *H. sauvagei* (Pfeffer), *H. prodromus* Trewavas, *H. granti Blgr.*, and *H. xenognathus*, SP.N. By P. H. Greenwood. Pp. 76–97+plate 4. 8*s*. (London: British Museum (Natural History), 1957.) [1810

Agricultural Research Institute of Northern Ireland. Thirtieth Annual Report, 1956–1957. Pp. 40. (Hillsborough, Co. Down: Agricultural Research Institute, 1957.) [2110

Solvents, Plasticisers, and Technical Chemicals. Pp. 90. (Ilford: Howards of Ilford, Ltd., 1957.) [2110

Anti-Locust Bulletin 28: Factors Affecting the Rate of Sexual Maturation of the Desert Locust (*Schistocerca gregaria* Forskål) in the Laboratory. By Dr. Maud O. W. Richards. Pp. ii+26. (London: Anti-Locust Research Centre, 1957.) 3*s*. [2110

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 975, Vol. 250 (17 October 1957): Statistical Properties of an Isotropic Random Surface. By M. S. Longuet-Higgins. Pp. 157–174. 6*s*. No. 976, Vol. 250 (17 October 1957): The Statistical Thermodynamics of Mixtures of Lennard-Jones Molecules. 1: Random Mixtures. By W. B. Brown. Pp. 175–246. 22*s*. 6*d*. No. 977, Vol. 250 (17 October 1957): The Aerodynamic Forces on an Aerofoil in Non-Uniform Unsteady Motion in a Closed Tunnel. By S. Rosenblat. Pp. 247–278. 10*s*. (London: Royal Society, 1957.) [2110

The Hydrogen Bomb. Pp. 32. (London: H.M. Stationery Office, 1957.) 9*d*. net. [2210

Federation of British Industries. Report of the Second National Conference between Industry and the Technical Colleges, 15 May, 1956. Pp. vi+71. (London: Federation of British Industries, 1957.) 5*s*. [2310

The Non-Destructive Testing of Engineering Materials (With Particular Reference to their Internal Structure and Properties). Second edition. Pp. 24. (Southall, Mddx.: A. E. Cawkell, 1957.) [2310

Department of Scientific and Industrial Research. Problems of Progress in Industry, No. 1: Men, Steel and Technical Change. By the Industrial Research Section, Department of Social Science, University of Liverpool. Pp. 36. (London: H.M. Stationery Office, 1957.) 2*s*. net. [2410

Other Countries

Food and Agriculture Organization of the United Nations. FAO Forestry Development Paper No. 8: Tree Planting Practices in Tropical Africa. By M. S. Parry. Pp. xii+302. 15*s*.; 3 dollars. FAO Forestry Development Paper No. 11: Tree Planting Practices in Tropical Asia. Prepared by Charles Letourneux. Pp. vii+172. 10*s*.; 2 dollars. (Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1957.) [1810

Current Contents of Pharmaceutical Publications. (Weekly Survey of Chemical, Pharmacological and Clinical Publications.) Pp. 56. (Philadelphia, Pa.: Eugene Garfield Associates, 1957.) [1810

Durban Museum Novitates. Vol. 5, Part 2: Notes on African Bats. 1: Some Systematic and Anatomical Notes on the African Bats of the Genus *Otomops* Thomas. By David L. Harrison. Pp. 17–26 (2 plates). (Durban: Durban Museum, 1957.) 2*s*. 6*d*. net. [2110

New Zealand. Thirty-first Annual Report of the Department of Scientific and Industrial Research, 1957. Pp. 84. (Wellington: Government Printer, 1957.) [2310

Berichte des Deutschen Wetterdienstes. Nr. 38 (Band 5): Symposium über Numerische Wettervorhersage in Frankfurt a, M. vom 23. bis 28. Mai 1956. Pp. 97. (Bad Kissingen: Deutschen Wetterdienstes, 1957.) [2310

Tanganyika: Department of Geological Survey. Geological Survey Maps Nos. 102L, 1021, Lo79, 1093. (Dodoma: Department of Geological Survey, 1957.) [2910

F.A.O. Picture Sheet No. 8: Frontiers Need Not Be Barriers. Pp. 2. (Rome: Food and Agriculture Organization of the United Nations, 1957.) [2910

Conseil Permanent International pour l'Exploration de la Mer. Rapports et Procès-verbaux des Réunions. Vol. 143, Part 1: On the Herring of the Southern North Sea. (Contributions to Special Herring Meetings, 1956.) Pp. 42. (Copenhague: Andr. Fred. Høst et Fils, 1957.) 10 Kr. [2910

National Vitamin Foundation, Inc. Symposium on Nutrition and Behavior: Proceedings of a Symposium held at the University of Minnesota, School of Public Health, Laboratory of Physiological Hygiene, Minneapolis, Minnesota, April 27, 1956. Pp. iv+124. (Nutrition Symposium Series, No. 14.) (New York, N.Y.: National Vitamin Foundation, Inc., 1957.) 2.50 dollars. [2910

Catholic University of America. Biological Studies, No. 41: Recovery of Texas-1 Coxsackie Virus from the Blood of a Wild Rabbit. By John R. O'Connor, M.S. Pp. v+17. (Washington, D.C.: Catholic University of America, 1957.) 25 cents. [2910

Bulletin of the American Museum of Natural History. Vol. 113, Article 3: On the Anatomy and Relationships of *Fregilupus varius*, an Extinct Starling from the Mascarene Islands. By Andrew J. Berger. Pp. 225–272. 1 dollar. Vol. 113, Article 4: The Fishes of Labrador. By Richard H. Backus. Pp. 273–338+plates 4 and 5. 2 dollars. (New York: American Museum of Natural History, 1957.) [2910

Records of the Australian Museum, Sydney. Vol. 24, No. 2 (23 November, 1956): A Revision of the New South Wales Leptonidae (Mollusca: Pelecypoda). By Charles F. Laseron. Pp. 7–22. Vol. 24, No. 3 (23 November, 1956): Fishes from Inland New Guinea. By Gilbert F. Whitley. Pp. 23–30+plate 2. Vol. 24, No. 4 (23 November, 1956): Additional Remarks on Australian Gyrinidae. By Georg Ochs. Pp. 31–36. Vol. 24, No. 5 (23 November, 1956): Rock Engravings of the Sydney-Hawkesbury District. Part 1: Flat Rocks Ridge—a Daruk Ceremonial Ground. By Frederick D. McCarthy. Pp. 37–58+plates 3–6. Vol. 24, No. 6 (23 November, 1956): A New Species of Ascidian (Genus *Culeolus* Herdman, Family *Pyridae*, from the West Coast of Tasmania. By Patricia Kott. Pp. 59–60. Title-Page and Index to Vol. 22. Pp. 13. Title-Page and Index to Vol. 23. Pp. 8. (Sydney: The Australian Museum, 1956.) [2910

South African Council for Scientific and Industrial Research: Library and Information Division. Register of Current Scientific Research at South African Universities, 1956. Pp. vii+251. (Pretoria: South African Council for Scientific and Industrial Research, 1956.) [2910

Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten van België. Klasse der Wetenschappen. 3rd International Conference on Biochemical Problems of Lipids, 26th to 28th July, 1956—The Blood Lipids and the Clearing Factor. Pp. 418. (Brussel: Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten van België, 1957.) [2910

Federation of Nigeria. Annual Report on the Department of Agricultural Research for the year 1955–56. Pp. 24. (Lagos: Federal Government Printer, 1957.) 9*d*. net. [2910

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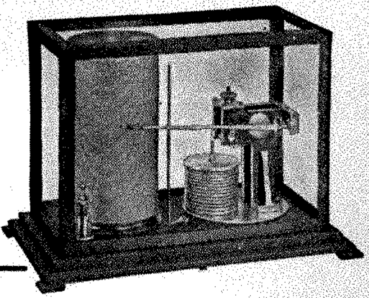

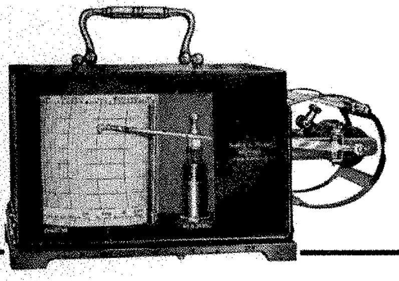

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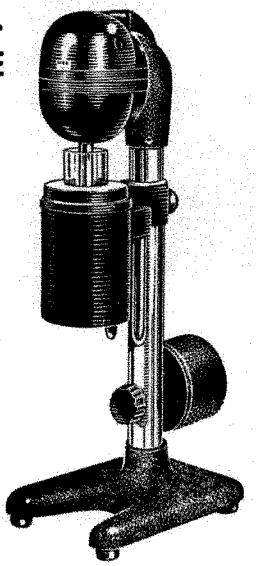

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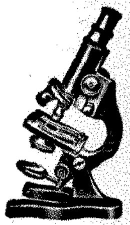

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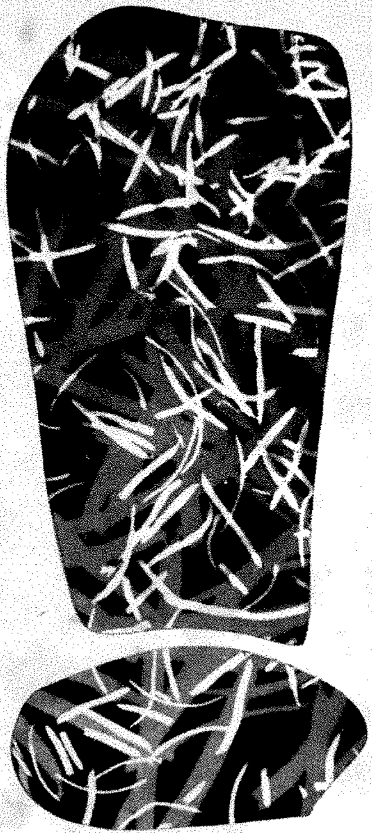

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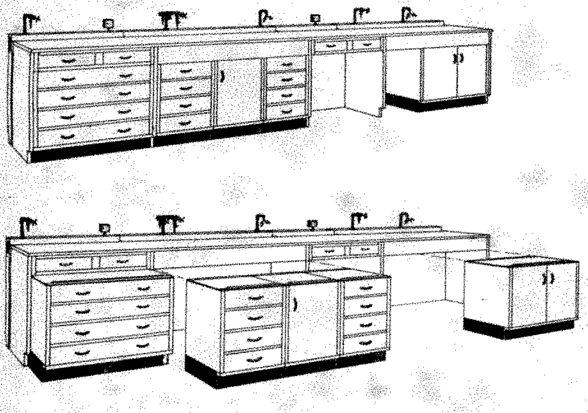

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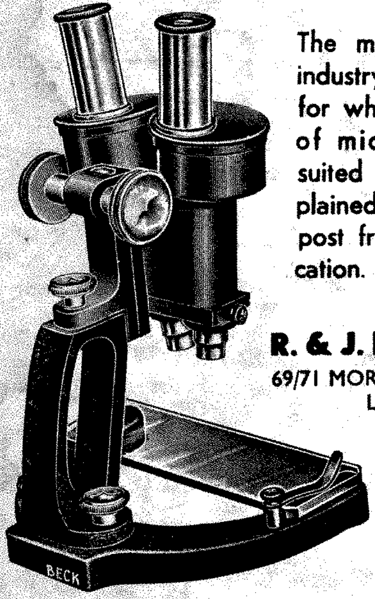

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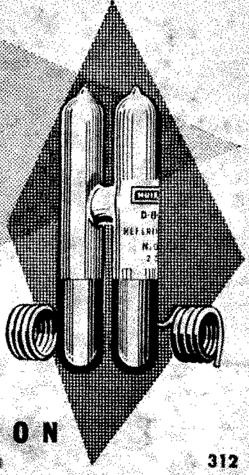

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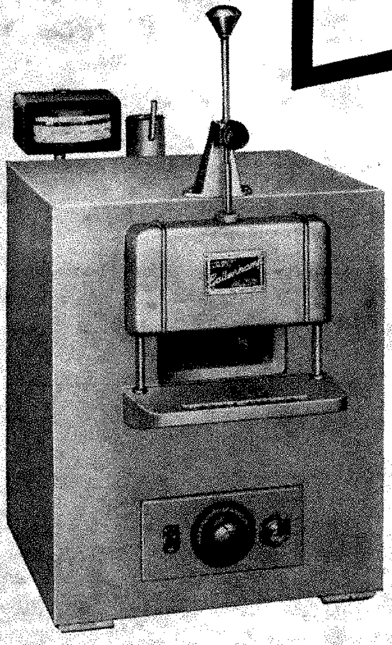

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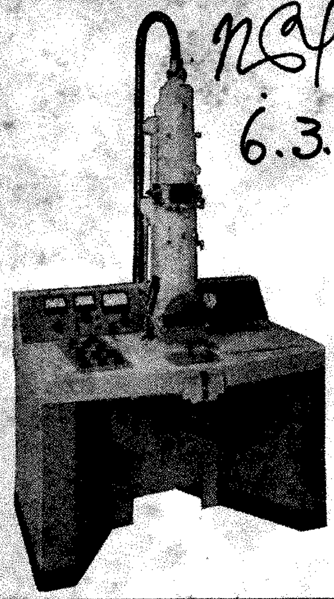

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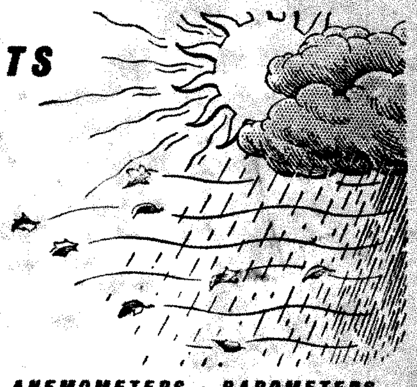

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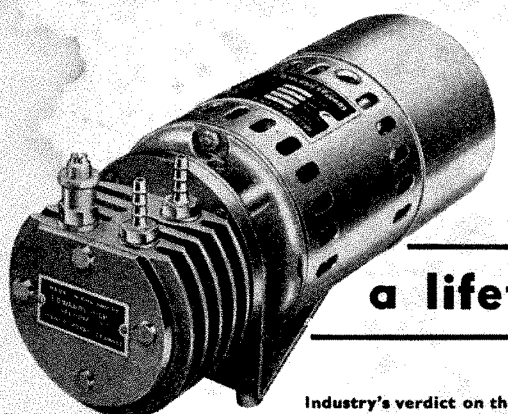

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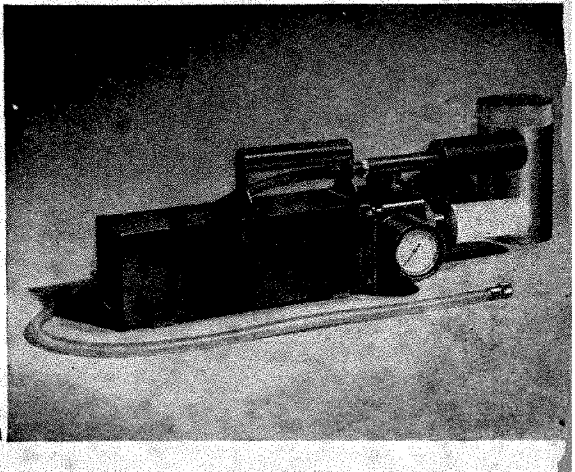

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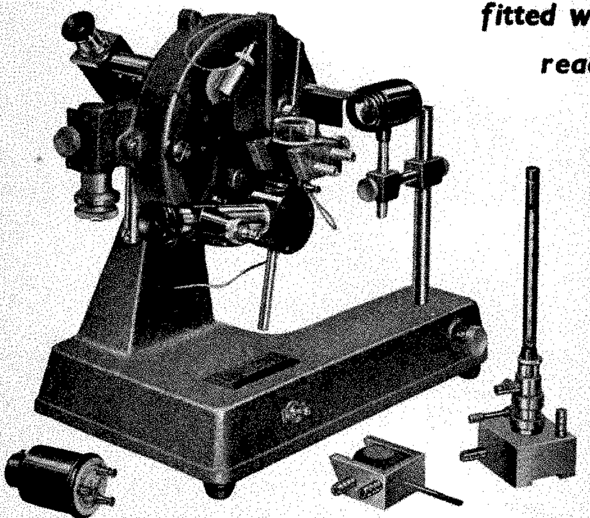

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HARNESSING NUCLEAR FUSION

In replying on November 11 to a question in the House of Commons, the Paymaster-General, speaking for the Government, said that the experimental apparatus known as ZETA at the Atomic Energy Research Establishment, Harwell, was operating successfully, and discharges through heavy hydrogen were giving very high temperatures, accompanied by discharges of neutrons, believed to be due to thermonuclear reactions. It is appropriate that the first detailed account of this work should appear in *Nature*, where it will be read by scientists all over the world (see p. 217 of this issue).

Ever since the possibility of nuclear fission was realized, it was understood that a converse process of fusion of atomic nuclei was possible and would yield a vast amount of energy. This possibility became a fact with the invention of the hydrogen bomb. All the time, however, scientists in many countries were endeavouring to learn more about the mechanism of the reaction with the view of controlling this immense explosive force. A carefully considered account, by one of the Harwell scientists, of the theory involved was published in *Nature* of May 4, 1957, p. 886; this demonstrated the very stringent physical conditions which control of such processes must entail. Although it is generally recognized that we are continually witnessing the results of thermonuclear reactions—for they are believed to be the source of the heat and light given out by the Sun—their production and control in the laboratory present problems hitherto unparalleled.

The communications from British and American scientists appearing in this issue of *Nature* demonstrate that the first steps in this great task have been successfully taken. Teams of scientists at Harwell and Aldermaston have obtained results which led to the brief announcement made in the House of Commons on November 11. American scientists, working on slightly different lines, have also contributed their results, and it is heartening to read the tribute they pay to the Harwell scientists.

Bearing in mind the scientific importance and wide interest of the work already done, the lag between the Government's brief statement and the present publication of British and American results suggests that difficulties other than those of the laboratory have been met. The work was being done, perhaps inevitably in view of its complexity, under government auspices, in the two countries, and was subject to security restrictions. There seems to have been considerable exchange of information between the scientists directly concerned; but it is regrettable that security measures should have been invoked in such a quest, the significance of which for military purposes would not appear to be greater than that of innumerable scientific investigations in progress in various laboratories in both countries. Only those with full knowledge of the situation can give a final answer to this question.

However, the announcement of the successful control of the thermonuclear reaction has now been made, and all the scientists and others concerned are to be congratulated on their magnificent achievement.

Under the stress of military needs during the Second World War, great efforts were concentrated on the production of the atom bomb, leading to the preparation of fissile material of various kinds; the problem of converting this weapon to the production of energy for peaceful purposes was, for the time being, in the background. But with the end of open warfare, its utilization for the production of useful power became an urgent problem. The culmination of this effort was seen in the opening by H.M. The Queen in 1956 of Calder Hall power station, the first in the world to be solely dependent on atomic energy as a source of power. But the use of fissile material for this purpose, though a triumph of scientific and engineering skill, brought its own difficulties in the economic and other fields, for the initial cost of atomic fuel is high and it is a scarce commodity. Atomic energy power stations and the conventional power stations were seen to be complementary rather than competitive. Now we have the possibility of utilizing another 'atomic' fuel, of wonderful potentiality and world-wide occurrence, though whether it becomes the basis of the generation of electrical power, or means are found of making direct use of it as a source of energy, only the future will show. Meanwhile the control of nuclear fusion will be welcomed both as a great advance in science and as a factor of tremendous importance for the future, bringing vast stores of energy into the service of man for his use in the amelioration of his conditions.

In 1831, Michael Faraday discovered electromagnetic induction. His apparatus was of the simplest kind, consisting of a ring of iron on which two coils of wire insulated with "twine and calico" were wound, and a compass needle as detector. The experiment was not a chance affair, for his thoughts had turned repeatedly to the subject, and he had tried some experiments, but without success. Then he hit upon the correct sequence of events, and the experiment succeeded. Electricity had been generated in one simple circuit by making and breaking another simple circuit. From that experiment the electrical industry was born—the electrical age was initiated; and although its growth was at first slow, it now dominates the industrial world.

The new work on thermonuclear reactions is at present a laboratory experiment, albeit with most complex and costly equipment and even the risk of dangerous irradiation; it is clearly a first step, even as Faraday's experiment was. Life on the Earth has always depended on nuclear reactions in the Sun, and now it seems that man is learning to reproduce those reactions in the laboratory. Are we witnessing the birth of a new age—that of the utilization of man-made thermonuclear reactions ?

ENIGMATIC EDDINGTON

The Development and Meaning of Eddington's 'Fundamental Theory'

Including a Compilation from Eddington's Unpublished Manuscripts. By Dr. Noel B. Slater. Pp. xii+300. (Cambridge: At the University Press, 1957.) 40*s*. net.

EDDINGTON regarded physics as the structural knowledge of measures of an external world of objects that can be indicated but the intrinsic nature of which is not discoverable. Fundamental physics was for him the part concerned with properties of measures simply as operations, independently of what they operate on. He claimed to have discovered that fundamental physics in this sense comprises all the general laws of Nature, including the evaluation of all the constants involved. His book, "Fundamental Theory" (Cambridge 1946), was the final account of this work. The manuscript was not quite complete when he died in 1944, but was printed as he had left it, under the editorship of the late Sir Edmund Whittaker (who included one of Eddington's published papers on the intended subject of the missing last chapter).

Large parts of five or six earlier drafts had been preserved by Eddington, and Dr. N. B. Slater has collated these in the present book. After summaries of the main sections of "Fundamental Theory", Dr. Slater gives notes on the various drafts and extensive quotations wherever he considers that they contain a significant variant of an argument or material omitted from the final version. He provides a bibliography of writings on the subject that have been of assistance in preparing the book, and a useful list of the symbols employed by Eddington. He has also noted an error in a statistical argument of Eddington's that calls for one or two amendments in the evaluation of certain constants. His task has been extremely onerous, all the more so because the material reached him piecemeal in the course of the work. Clearly, he has exercised the utmost thoroughness, and the plan he has followed is almost certainly the one making for greatest conciseness. Dr. Slater is not to be blamed for the one regrettable feature of the presentation, the smallness of the type used for all quotations from Eddington.

Most physicists would go some way with Eddington in recognizing that their results are not so much properties of an external world as properties of their own operations upon such a world. A number would be glad to be able to go further. Each major conclusion as Eddington describes it in general terms appeals to them as possessing a high degree of plausibility and, if valid, as being profoundly illuminating. Yet they find insuperable difficulty in seeing very much connexion between any such conclusion and the detailed arguments and calculations that purport to establish it. A few physicists are, indeed, prepared to follow Eddington through separate sections of the work but without being satisfied as to the connexions between the sections. So far as I am aware, however, no physicist professes to understand the arguments of "Fundamental Theory" sufficiently thoroughly to be able to assert or deny that it provides a continuous chain of reasoning.

Were Eddington's work acceptable, it would of course be one of the very great advances in scientific thought. The new book might have led to a better understanding of the work had the available material shown how Eddington proceeded from an early stage to build up his final intricate structure. As Dr. Slater remarks, however, almost all the material at his disposal had been intended as a final version when it was written. One cannot, therefore, see much hope that it will help substantially to resolve the enigma of "Fundamental Theory".

The new material, together with Dr. Slater's commentaries, does make clearer than before what Eddington was trying to achieve. Also it shows that Eddington was wonderfully confident that he had achieved it. One cannot help thinking that he has at least indicated the general character of probable developments in physical theory. Such developments may ultimately come from some completely independent approach, or they may come from work like that of E. W. Bastin and C. W. Kilmister that is probably to some extent inspired by Eddington. But one would hazard the view that they are now scarcely likely to flow directly from Eddington's own treatment. For until acceptable conclusions have been reached by other means, it will probably be impossible to know how far Eddington relied upon his astonishing power of intuition. Nevertheless, Eddington's thought never lost its quality of greatness, even when it was most enigmatic, and we must be grateful to Dr. Slater and the publishers for this additional record of it. W. H. McCREA

HYDROGRAPHY

Hydrography of the Faroe–Shetland Channel, 1927–1952

By Dr. John B. Tait. (Scottish Home Department. Marine Research, 1957, No. 2.) Pp. ix+309. (Edinburgh and London: H.M. Stationery Office, 1957.) 105*s*. net.

FISHERY scientists have good reason to believe that changes in ocean currents and water circulation have an important bearing on variations in local stocks of fish and migration of fish shoals. For the whole of north-west Europe it is important to have a good knowledge of the varying balance between Arctic and Atlantic influences, and for the North Sea itself we must understand the varying influence of oceanic water which mixes with coastal water and flows from north to south across the herring fishing grounds. The first essential is to have measurements of what has taken place, and the most promising method known so far is to make regular surveys of the changing temperature and salinity of the water. The Faroe–Shetland Channel is a particularly informative area because a large proportion of the Atlantic water that warms the northern North Sea and the Arctic Ocean passes through it.

Dr. Tait's large monograph gives a detailed presentation of the vertical distribution of temperature and salinity along two roughly parallel cross-sections from the Faroe Islands to the Shetland Islands and from the Faroe Bank to the Butt of Lewis. On twenty-two occasions between 1927 and 1952 observations were made along both lines, and on a further twenty-five they were made along one or the other. Every now and then other lines were worked. The monograph gives diagrams showing the distribution of temperature and salinity in the vertical plane for every line of observations, and the observations themselves are listed in Appendix 2. It also gives the computed transport of water across each line assuming geostrophic flow and the existence of little or no current at the depth of the 35 parts per 1,000 isohaline. These assumptions are the best that can be made until it is feasible to carry out a very large programme of deep-current measurements, and they are supported by good general agreement between conclusions based on the two lines 120 miles apart, and by a few current measurements described in Appendix 1.

The work reveals large seasonal and long-term variations in the north-eastward transport of water, and opens up large and fascinating fields of research into the energy exchanges and hydrodynamical processes that cause them and into their effect on the complex hydrographic conditions and biology of the area. Linked with the main problem there is much information about the different types of water that are encountered there and practical conclusions as to their origin and formation. Enormous numbers of observations have been made with great care under difficult conditions, and this thorough and detailed study is a work of great value. It is prefaced by a good historical introduction, and it will itself be the foundation of much future work as well as serving present needs. G. E. R. Deacon

PREHISTORIC DENMARK

Denmark Before the Vikings

By Dr. Ole Klindt-Jensen. (Ancient Peoples and Places.) Pp. 212 (73 plates). (London: Thames and Hudson, Ltd., 1957.) 21*s*. net.

Denmark is a small country, but it has bred noted archæologists. As long ago as 1836 Christian Thomsen of the National Museum suggested the well-known triple subdivision of human history into the ages of Stone, Bronze and Iron. Later the names of Worsaae and Sophus Müller became world renowned. Denmark is rich in prehistoric remains and much exploration work has been done there, but no short, satisfactory account of the prehistory of the country has been published for very many years.

The new volume on Denmark by Dr. O. Klindt-Jensen, who is the curator at the National Museum in Copenhagen, is therefore very welcome. After a brief introduction there is a chapter headed "The Palæolithic". But while the term Palæolithic is not entirely inaccurate since some of the earliest cultures found in the country do, like that of Hamburg, overlap with the end of Magdalenian times, there is nothing in these northern regions to compare with the rich upper Palæolithic cultures of France and northern Spain with their wealth of industries in stone and bone and their superb art, both in the prehistoric homes and on the walls of caves. The industries of these northern cultures are at first simple, but there soon appear others belonging to the so-called point cultures which stretched westwards from as far away as Poland, where they occur below some ancient dunes. Later the classic Mesolithic cultures are represented at Maglemosean sites and in the Kitchen Middens. Actually the earliest manifestation of the former (Maglemose) culture is perhaps best seen in Britain at Star Carr, but in Denmark there are many sites and much exploration has taken place. It may be added that digging a late Mesolithic (Kitchen Midden) site is no fun—the fine white dust penetrates everywhere and everything. Denmark is particularly rich in Neolithic remains of all kinds; not least there is a magnificent series of Megalithic monuments. The author's account of these is necessarily brief, but gives a good picture of the situation. Chapters on the Bronze Age up to the Dark Ages follow, and there is a concluding chapter on the prehistoric landscape. Following some notes and a short bibliography there come the plates—no less than 73, occupying 48 full pages. These are well chosen and well illustrate the text.

Doubtless the specialist in one or more of the periods covered will complain that too much has had to be left out. But the ordinary reader will congratulate the general editor of the series, Dr. Glyn Daniel, on having persuaded Dr. Klindt-Jensen to undertake the work, and the author himself for having produced such an excellent little volume. M. C. Burkitt

THE BIOCHEMICAL LESION

Biochemical Disorders in Human Disease

Edited by Prof. R. H. S. Thompson and Prof. E. J. King. Pp. xiv+843. (London: J. and A. Churchill, Ltd.; New York: Academic Press, Inc., 1957.) 90*s*.

The enormous strides made by biochemistry during the past half-century and the ever-increasing application of biochemical concepts, as well as biochemical techniques, to the study of disease, have made important additions to the points of view from which disease can be surveyed, described and examined. From the cellular, we have advanced to the molecular level, and we can now think both of the anatomical or histological lesion and the underlying, more fundamental, 'biochemical lesion'. This convenient term, which we owe to Sir Rudolph Peters, is not actually used by the editors in the preface of this book, but it is implicit in what they say of their aims and lines of approach, and is indeed employed by contributors.

The object of the editors in planning the book was, for the benefit of both physicians and biochemists, to "assemble, relate, and interpret the known facts concerning the biochemical disorders that underlie or are associated with human disease"; the method was to ask each of a number of acknowledged experts to "describe . . . how the various diseases of any given organic system are dependent on biochemical disorders and to indicate the trends of biochemical work now in progress . . .". It can be said at once that the method has proved admirably adapted to a laudable aim. The editors and their fellow-contributors have succeeded in producing an exceedingly valuable addition to medico-biochemical literature and one which, I suspect, is likely to prove the prototype of the 'text-book of medicine' for the next generation.

Each author has been left free to interpret the editors' general directive in his own way, and as a result there is a considerable variety of treatment. This does not necessarily reflect differences in personal outlook, for the subjects are not equally 'advanced' from the biochemical point of view. In every case, however, the interpretation has clearly been that involved in the title of the book and in that of this review. In the past there has been too much emphasis on the function of biochemistry applied to medicine as a provider of diagnostic and prognostic tools, too little emphasis on its use in describing and explaining the nature and development of the disease processes ; yet the latter, which indeed includes, and is a logical extension of, the former, is by far the more important function of 'clinical chemistry' or 'chemical pathology'. In these chapters the diagnostic aids are discussed fully and extremely clearly, not as ends in themselves, nor as helping the physician to tie an appropriate label on his individual patients, but as the means of investigating the fundamental abnormalities whether considered as a general state covered by the label or as they afflict the individual. This is an essentially modern approach, well calculated to lead to a real understanding of disease and, through that, to therapy which can be adjusted rationally to the changing needs of a particular case.

The arrangement of the book is logical in relation to its general theme and it is a remarkable tribute to contributors and editors alike that the various chapters, written by different authors and each a review capable of standing alone, cover the ground fully, connectedly, yet without unnecessary overlapping. Twenty chapters deal with the diseases of the major organs (gastrointestinal tract, liver, kidney, pancreas, major endocrine glands, muscle), with disease groups not referable to particular organs (anæmias, hypertension, etc.) and with suitably grouped metabolic disorders (diseases of nutrition, porphyrias, lipoidosis and the like). Such an arrangement, probably the best for the clinician, means that a single biochemical topic such as acid-base equilibrium may be treated in several chapters by several authors and from various points of view. This is no disadvantage but is, indeed, one of the stimulating features of the book.

One ventures to predict that "Thompson and King" will become a classic, read and studied by senior medical undergraduates, by clinicians who wish to acquire understanding of their work, and by biochemists who, professionally or through interest, are concerned in the application of their science to the study of disease. C. P. STEWART

MECHANISM IN BEHAVIOUR

Behavior Mechanisms in Monkeys

By Heinrich Klüver. Second impression. Pp. xvii+387. (Chicago, Ill.: University of Chicago Press ; London : Cambridge University Press, 1957.) 49*s*. net.

THE study of the mechanisms underlying the activity of the central nervous system has claimed the attention of workers engaged in disciplines as far removed as, for example, psychology and electronic engineering, and it is therefore not surprising that there should be marked differences of emphasis and approach. Thus, of recent years, attention has been focused on mechanisms as they exist at the level of the individual cell, on the way in which neurones influence each other's activity, and on the part played by chemical processes in the specification and patterning of cerebral structure. Concurrently, and from quite a different point of view, mathematicians and communication engineers have been prompted to suggest that many problems of cerebral organization and function can best be treated on a statistical basis and to formulate hypotheses incorporating the established concepts of information theory and conditional probability to replace older views concerning the relationship between stimulus and response. To be fruitful, such advances in knowledge and thinking must be constantly applied to what is known about the reactions of the organism as a whole, and it is therefore particularly timely that Prof. Klüver's classic monograph "Behavior Mechanisms in Monkeys", which has been out of print for many years, has now been re-issued.

Prof. Klüver interprets the mechanism of behaviour in phenomenological terms, and his analysis is based on a study of those "general modes of reaction" from which it is possible "to predict the way an animal is going to react to a specific stimulus". He does not concern himself with the neural processes which underlie behaviour, but stresses, in his opening chapters, that little progress can be made in the investigation of cerebral function at the physiological level in the absence of firmly established experimental data concerning the overt factors governing the reactions of the individual to its environment. It is to this end that his monograph is directed.

The major portion of the book is devoted to a description and analysis of problems "selected chiefly because of their possible significance for neurophysiology". Experimental results are reported in considerable detail and fall into two groups. The first of these deals with investigations into the features of the stimulus situation to which the monkey responds. Variations of the 'pulling-in technique', which has since been extensively applied in experimental psychology, are used for determining the equivalence or non-equivalence of stimuli in the performance of discriminations involving weight, visual appearance and sound. The findings show an incidence of response to the relational aspects of the experimental situation which is consistently high over a wide range of cues ; but there are occasions, particularly in the case of some visual discriminations, in which the animal responds to absolute sensory criteria. The second group of experiments deals in a similar way with such behavioural capacities as visual and tactual acuity, handedness and the ability to use common objects as tools.

Prof. Klüver ends with a thorough and critical analysis of his findings. He concludes that to account for the persistence of certain forms of discriminative behaviour in the face of marked changes in the environment, it is necessary to postulate the presence of some component which is identifiable throughout the range of experimental situations ; but any definition of the property so abstracted as "an element which the stimuli have objectively in common" is unacceptable. Similarly, since the "response to relations" is not invariant, the unmodified concept of 'generalization' as a basic mechanism must be regarded as an over-simplification unless the individual characteristics of each stimulus situation are taken into account.

This book, which first appeared in 1933, is aimed at the serious student of behaviour rather than at the casual reader, and those unfamiliar with the extensive literature cited may have difficulty in following some of the arguments. Later developments are referred to in a new preface, but many of the original issues raised by Prof. Klüver still remain unresolved and it is gratifying that his monograph is once again readily available to a new generation of workers in the field of behavioural research.

J. T. EAYRS

CONTROLLED RELEASE OF THERMONUCLEAR ENERGY

PRODUCTION OF HIGH TEMPERATURES AND NUCLEAR REACTIONS IN A GAS DISCHARGE

By Dr. P. C. THONEMANN, E. P. BUTT, R. CARRUTHERS, Dr. A. N. DELLIS, D. W. FRY,
Dr. A. GIBSON, G. N. HARDING, D. J. LEES, R. W. P. McWHIRTER, R. S. PEASE,
Dr. S. A. RAMSDEN and S. WARD
Atomic Energy Research Establishment, Harwell

Introduction

THE basic conditions which must be established before a thermonuclear reactor is possible are, first, the containment of a high-temperature gas so that it is isolated from the walls of the surrounding vessel, and second, the attainment of temperatures sufficiently high for nuclear reactions to take place between the light elements. These two conditions are interdependent. Poor containment results in energy losses so large that gas temperatures much exceeding 10^6 °K. are unattainable.

The experimental apparatus described was designed to study the containment of ionized hydrogen (or deuterium) by the magnetic field associated with the current flowing in the gas and to reach temperatures sufficiently high for nuclear reactions to be detectable using deuterium. This apparatus, known as ZETA, was built at the Atomic Energy Research Establishment, Harwell.

The principles underlying the containment of a high-temperature gas by means of the 'pinch effect' have been discussed by a number of authors[1-3].

The constricted gas discharge formed by passing a high current through a low-pressure gas, while isolating the gas from the tube walls for short periods of time, rapidly develops instabilities and distortions which lead to bombardment of the walls by electrons and positive ions. The consequent cooling and recombination make it impossible to maintain high temperatures except for a transient period[4-8]. These instabilities can be suppressed by the combination of an axial magnetic field parallel to the direction of the discharge current and by the fields produced by eddy currents induced in the surrounding metal walls when the current channel changes its position.

Theoretical studies of discharge stability in the presence of an axial magnetic field have been published[9-12], together with experimental evidence for stability in a straight discharge tube[13].

The preliminary results reported in this article show that relatively long-time stability can be achieved in a toroidal metal-walled tube. The neutron yield and the kinetic ion temperatures have been measured over a limited range of conditions. The nuclear reaction-rates observed are not inconsistent with those expected from a thermonuclear process.

Apparatus

ZETA is a ring-shaped discharge tube of aluminium, 1-m. bore and 3-m. mean diameter, containing gas at low pressure. The gas, usually at a pressure of about 10^{-4} mm. of mercury, is made weakly conducting by a radio-frequency discharge. The toroidal ionized gas plasma forms the secondary of a large iron-cored pulse transformer. A condenser bank, storing up to a maximum of 5×10^6 joules, is discharged into the primary of the transformer, and produces a unidirectional current pulse in the gas up to a maximum of 200,000 amp. The current pulse in the gas lasts for about 4 msec. and is repeated every 10 sec. A steady axial magnetic field is generated by current-carrying coils wound on the torus. This field can be varied from zero to 400 gauss.

Fig. 1 shows the discharge tube assembled with the transformer. A vacuum spectrograph can be seen connected to the torus body.

Electrical Characteristics

Typical current and voltage oscillograms are shown in Fig. 2. The top trace is the 'voltage per turn' measured by a loop around the iron core enclosed by the discharge tube. The length of the discharge path is approximately 1,000 cm. so that the initial electric field at the boundary of the ionized gas is about 2 V. per cm. The primary winding is short-circuited when the voltage per turn is zero, thus preventing the charge on the condensers reversing. The second trace shows the current flowing in the gas, which persists for about 2 msec. after the transformer primary is short-circuited.

As the current decreases the plasma expands until it reaches the walls. It is then cooled. A sudden increase in resistance accompanies this process and the consequent increase in $|dI/dt|$ produces a severe voltage transient which may rise to tens of kilovolts. Destructive voltage transients of this type are

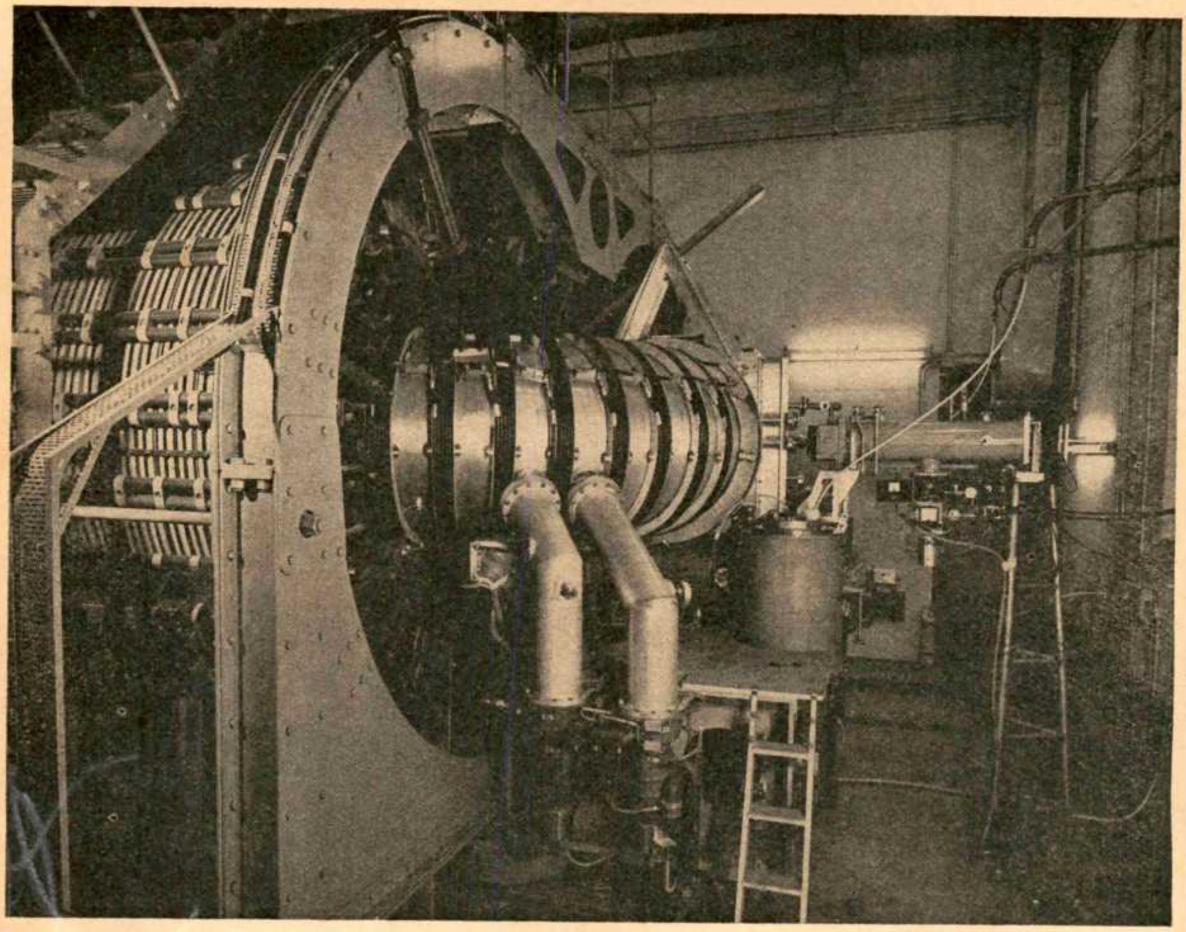

Fig. 1. Photograph of ZETA. The apparatus is enclosed in a room with concrete walls 3 ft. thick for radiation shielding

suppressed by the addition of 5 per cent nitrogen without affecting the neutron yield.

Stability

Measurements with magnetic field-probes and Langmuir probes, together with streak photographs of the current channel taken through a slit in the vacuum vessel, show the current channel to be quasi-stable and clear of the walls for the greater part of the current pulse. Fig. 3 is a reproduction of a streak picture of a helium discharge. The limit of the black area represents the internal diameter of the tube. The light recorded is that of the spark lines of impurities and of (He II) 4686 A. Streak pictures taken of discharges in deuterium are difficult to interpret as the light is emitted by neutral atoms and by impurity ions released into the current channel from the walls.

The centre of the current channel is displaced towards the outer wall due to the tendency of the ring current to expand. This expansion is opposed by eddy currents in the metal walls, which are of 1-in. thick aluminium. Measurements of the internal magnetic fields in the plasma are reproducible and show that the axial magnetic field, B_z, is trapped in the gas. On the axis it increases to approximately ten times the initial value. In general, the resultant lines of magnetic force due to the B_θ and B_z components are helical and vary in pitch over the cross-section of the plasma. The stability of a discharge with this magnetic-field configuration has not been treated theoretically.

The presence of the magnetic field-probe, which is 1 in. in diameter, greatly increases the discharge resistance and reduces the production of neutrons.

The diameter of the current channel estimated from the magnetic-field measurements and the streak photographs is between 20 and 40 cm. at peak current. Transmission measurements with 4-mm. microwaves demonstrate that the electron density

Table 1

Conditions: gas D_2 + 5 per cent N_2. Pressure: $0{\cdot}12 \times 10^{-3}$ mm. $B_z = 160$ gauss

Current (k.amp.)	Total neutron yield per pulse	T_e (calc.)
84	$0{\cdot}4 \times 10^4$	$2{\cdot}4 \times 10^6$ °K.
117	3·1	2·9
126	9·2	3·3
135	14·2	3·6
141	26·5	3·8
150	41·6	4·0
177	108	4·5
178	125	4·6
187	134	4·65

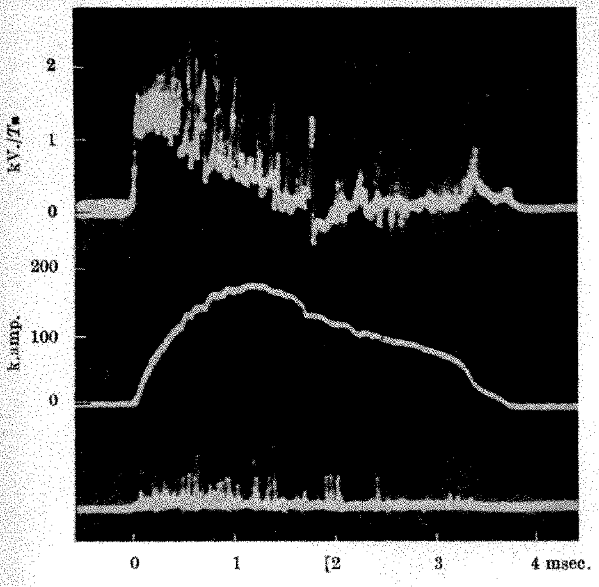

Fig. 2. "Oscillograph recordings of the voltage per turn of the transformer, and the secondary current I_s. The lower trace shows the pulses produced by proton recoil in a scintillation neutron counter. Conditions: gas, deuterium + 5 per cent nitrogen + 10 per cent oxygen; pressure, $0{\cdot}13 \times 10^{-3}$ mm. mercury; axial field, 160 gauss

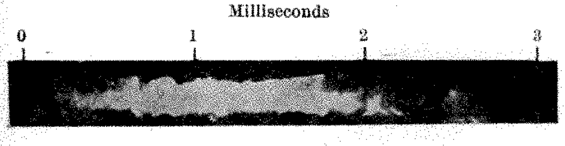

Fig. 3. Streak picture of a helium discharge. Conditions: initial gas pressure, $0{\cdot}25 \times 10^{-3}$ mm. mercury; axial field, 160 gauss; peak current, 130 k.amp. The tube walls lie at the boundary of the dark region

is greater than 6×10^{13} cm.$^{-3}$. This density is consistent with the assumption that all the gas present is ionized and contained in the current channel.

High-Energy Radiations

Neutron emission arising from the D–D reaction is observed for gas currents in deuterium in excess of 84 k.amp. Emission occurs for a period of about 1 msec., centred about the peak current.

Table 1 shows the average number of neutrons emitted per pulse as the peak current is increased.

Fig. 4 is a histogram showing the average rate of neutron emission during the current pulse.

The third column of Table 1 gives the temperatures required to produce the observed neutron yields assuming a thermonuclear process. In calculating these figures, it has been assumed that the current channel is 20 cm. in diameter, emits neutrons uniformly for a period of 1 msec. and all the deuterium initially present is contained in the current channel. Since the reaction-rate is an extremely sensitive function of temperature, variations in these parameters do not greatly affect the calculated temperature T_c. A comparison is made of the calculated and spectroscopically observed temperatures in Fig. 6.

Within the pressure-range investigated ($0{\cdot}8$–$10{\cdot}0 \times 10^{-4}$ mm.) the neutron yield decreased with increasing pressure. Neutrons were observed when 25 per cent of the gas initially present was nitrogen, but the yield was much reduced.

The results obtained with a directional neutron counter moved around the torus showed that, within a factor of two, the neutron emission was uniform and did not arise from localized sources.

No correlation is found between the time of neutron emission and the voltage fluctuations during the current pulse. However, neutrons are produced at the large voltage transient at the end of the pulse, but these can be eliminated by the addition of nitrogen gas.

X-rays are observed towards the beginning of the current pulse. Their average energy lies in the range 20–30 kV. and on the average some 10^6 quanta per pulse are emitted by the whole tube. The number and energy of the X-ray quanta are insensitive to gas pressure and current, but increase in intensity as the axial magnetic field is increased.

Spectroscopic Observations

Both arc and spark line intensities vary greatly over the period of the pulse. In general, emission lines of normal atoms and ions up to three times ionized have a maximum intensity before peak current. Fig. 5 shows the intensity variation of (He II) 4686 A. and (O V) 2781 A.

The Doppler broadening of spark lines emitted in a radial direction is used for estimating the kinetic ion temperature of deuterium and neon discharges. Small quantities of oxygen and nitrogen introduced into deuterium discharges provide spark lines in a convenient part of the spectrum. The breadth of the lines is of the order of 1 A. and can be measured with a quartz spectrograph having a dispersion of 20 A./mm. Calculations show that both Stark and Zeeman effects make a negligible contribution to the line-breadth. Mass motion may contribute to the observed broadening to an appreciable extent, but both probe and streak records show no evidence of

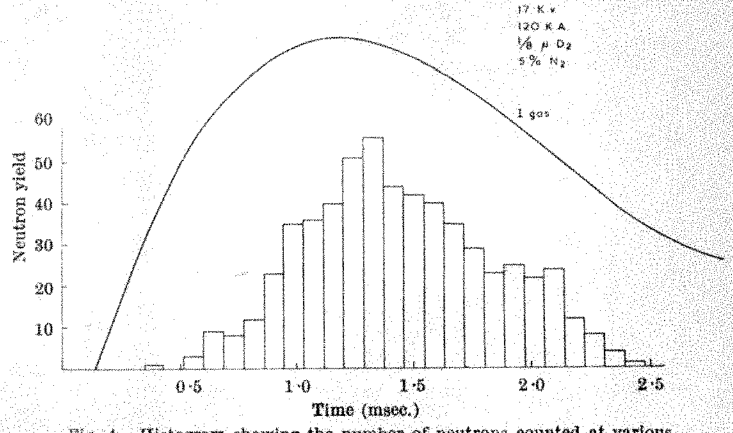

Fig. 4. Histogram showing the number of neutrons counted at various times during the current pulse

gross motion. The contribution to the line breadths of small-scale instabilities and turbulence remains to be measured.

Some 300 emission lines have been identified in the wave-length range 400–2500 A. The most prominent are those of oxygen, nitrogen, aluminium and carbon. Strong lines of (O VI) are recorded. In this wave-length range more than 400 lines remain unidentified.

The (O V) line has been used for Doppler breadth determination without time resolution as it has a maximum intensity in the neighbourhood of peak current. For (N IV) 3479 A. this is not so, and light was admitted to the spectrograph for a period of 1 msec. centred about peak current.

The kinetic temperatures obtained by observation of (O V) and (N IV) lines as a function of peak current are shown in Fig. 6. The ion temperatures are found to decrease with increasing initial pressure of deuterium. No satisfactory measurement of electron temperature has yet been made.

Conclusion

These preliminary results demonstrate that it is possible to produce a stable highly ionized plasma isolated from the walls of a toroidal tube. Hydrogen gas has been maintained in a state of virtually complete ionization with a particle density lying between 10^{13} and 10^{14} per cm.^{3}, for times of milliseconds. The mean energy of the ions in the plasma is certainly of the order of 300 eV., and there are many indications that the electron temperature is of the same order. The containment time and the high electrical conductivity are both adequate for the detailed study of magnetohydrodynamical processes.

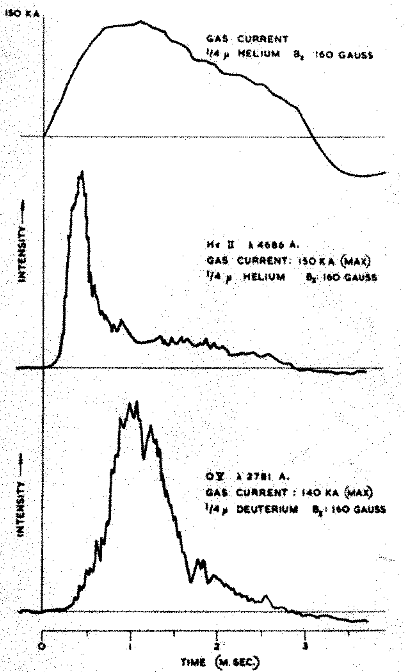

Fig. 5. The two lower traces are photomultiplier records of the intensity variation of two selected spark lines during the current pulse

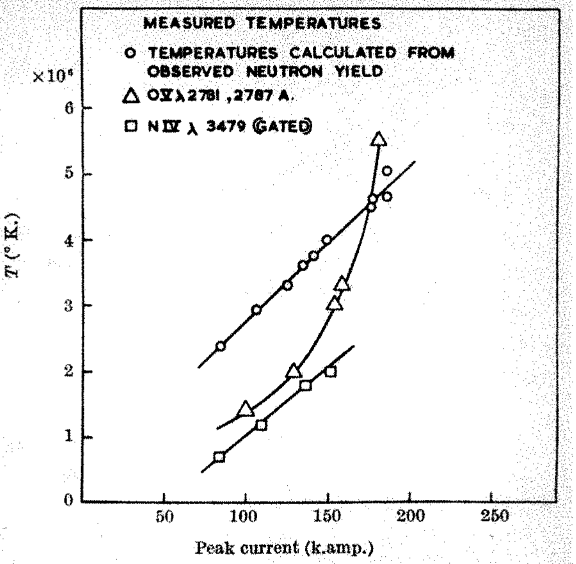

Fig. 6. Ion temperature as a function of peak current determined from the Doppler broadening of (O V) and (N IV). Conditions: initial gas pressure, 0·13 × 10^{-3} mm. deuterium and 5 per cent nitrogen; B_z = 160 gauss. The temperature of the deuterium gas, estimated from the observed neutron yield, is shown for comparison

To identify a thermonuclear process it is necessary to show that random collisions in the gas between deuterium ions are responsible for the nuclear reactions. In principle, this can be done by calculating the velocity distribution of the reacting deuterium ions from an exact determination of both the energy and direction of emission of the neutrons. The neutron flux so far obtained is insufficient to attain the desired accuracy of measurement.

Investigations leading up to the present results have been constantly encouraged and supported by Sir John Cockcroft and the late Lord Cherwell. The theoretical investigations have been directed by Dr. W. B. Thompson, of the Theoretical Physics Division.

A major part of the engineering design and construction of ZETA was done by the Metropolitan-Vickers Electrical Co., Ltd.

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CO-OPERATIVE PHENOMENA IN HOT PLASMAS

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THE interesting results described by Thonemann and his co-workers in the preceding article provide not only an important step forward in the controlled release of thermonuclear energy, but also a challenging problem in the dynamics of fully ionized gases or plasmas. The spectroscopic line profiles and the neutron counts provide incontrovertible evidence for the acceleration of the positive ions. However, theory would seem to indicate that electron–ion collisions are inadequate to explain the observed rate of heating, and some unknown mechanism would appear to be involved.

The rate at which the positive-ion temperature increases, as a result of electron–ion collisions, has been given elsewhere[1]. It has been suggested, both in Great Britain and in the United States, that this process might be inadequate to explain the rate at which positive ions gain energy in certain electrical discharges. A relatively simple procedure, due to Stix[2], may be used to set an upper limit to the rate at which positive ions are heated by electron–ion collisions. In this method the rate of heating is made a maximum by setting the electron temperature equal to three times the ion temperature, T_i, and setting the electron density equal to a constant, n_e, corresponding to complete ionization and concentration within the discharge channel of all the gas initially present in the tube. On this basis (with $\ln\Lambda$ set equal to 15, see ref. 1) T_i is given by the relation

$$T_i^{3/2} = 1{\cdot}71 \times 10^{-2}\, n_e t \qquad (1)$$

where T_i is in degrees **K.**, n_e in electrons per cm.^{3}, and t in seconds.

To determine the density in the ZETA experiments, we compute the radius, r_d, of the discharge channel on the assumption that the flux of the axial magnetic field, B_z, is held constant in the gas during the contraction, and that the field, B_θ, due to the current equals the compressed axial field at the boundary of the discharge. As a result of the high temperatures achieved in ZETA, appreciable leakage of axial flux out of the discharge does not appear to be possible. Neglect of the finite gas pressure decreases the computed channel radius, increases n_e and again makes the rate of increase of T_i a maximum. On these assumptions, values of r_d have been computed for two currents, and an initial B_z of 160 gauss, and are listed in the second column of Table 1.

Table 1

I (amp.)	r_d(cm.)	n_e (cm.$^{-3}$)	T_i (°K.)	t(theor.)	t(obs.)
126,000	16	$8{\cdot}6 \times 10^{13}$	$3{\cdot}3 \times 10^{6}$	$4{\cdot}0 \times 10^{-3}$	$1{\cdot}0 \times 10^{-3}$
140,000	14	$1{\cdot}1 \times 10^{14}$	$2{\cdot}5 \times 10^{6}$	$2{\cdot}0 \times 10^{-3}$	$1{\cdot}0 \times 10^{-3}$

These values of r_d are consistent with those cited by the Harwell group. The values of n_e in the third column correspond to complete ionization of all the deuterium initially present in the torus, at a pressure of 1/8 μ, and its concentration in the current channel. The value of T_i for the lower current in column 4 is taken from Table 1 in the article by Thonemann *et al.*, and is based on the neutron yield. The value of T_i at the higher current is the temperature obtained from the Doppler width of the O V triplet, as shown in Fig. 6 of the Harwell article. The ion temperature obtained from the neutron yield under this condition is about 50 per cent greater, but no information is available on the time at which the neutrons appear in this case. In the fifth column are given the values of the time, in seconds, required for the positive ions to reach this temperature, computed from equation 1.

For comparison, the final column lists the observed times, in seconds, at which the positive-ion energies reach the values corresponding to the fourth column. For the lesser current, this is the time at which the neutron yield reaches half its peak value as shown in Fig. 4 of the paper from Harwell. For the greater value of current, t(obs.) is set equal to the time at which the O V radiation reaches its peak intensity, as shown in Fig. 5 of the Harwell paper. The simplifications made have tended to reduce t(theor.), and the correct value may be about an order of magnitude greater than given in Table 1. Thus the discrepancy seems real. There does not appear to be any simple model, based on a quiescent plasma, which is consistent with the observed rapid heating of the positive ions.

Following a suggestion by the Harwell group as to the importance of non-thermal heating processes, Stix[2] in 1956 arrived at conclusions similar to the above from experimental results obtained at Project Matterhorn. A discharge was produced in helium gas in a stainless-steel race-track tube of 10 cm. diameter and 240 cm. axial length, with an initial pressure of 0·63μ and an externally produced axial field of 19,000 gauss. The magnetic field was arranged so that intersection of the outer lines of force with material walls restricted the discharge to a channel of 5 cm. diameter. A loop voltage of 300 V. was applied around an iron transformer threading the race-track, and a maximum current of 8,000 amp. observed; since this current produces only a minor perturbation in the magnetic field, there was no pinching of the discharge. Time-resolved spectroscopic profiles of the He II line, λ 4686, indicated that the kinetic temperature of these ions increased to $1{\cdot}2 \times 10^6$ degrees K. in $1{\cdot}5 \times 10^{-4}$ sec., as compared to a theoretical maximum value of $0{\cdot}8 \times 10^6$ degrees in this same time-interval.

It has been known since the work by Langmuir[3] that electrons in a conventional gas discharge approach a Maxwellian distribution much more rapidly than can be explained by inter-particle collisions. Recent research by Gabor and his collaborators[4] has shown that oscillations generated in the plasma sheath are responsible for much of this effect, but the detailed mechanism is still unexplained. Possibly the high ion energies observed in ZETA represent a phenomenon related to Langmuir's paradox. To analyse the possible processes involved, such as oscillations, shocks, hydromagnetic turbulences, etc., it would be helpful to obtain information on the extent to which the positive-ion velocities are thermalized, that is, on how nearly the distribution function is isotropic and Maxwellian. Evidently detailed experimental investigations of these co-operative effects in hot plasmas will be of great interest in basic physics.

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A STABILIZED HIGH-CURRENT TOROIDAL DISCHARGE PRODUCING HIGH TEMPERATURES

By Dr. N. L. ALLEN, Dr. T. E. ALLIBONE, F.R.S., D. R. CHICK, R. F. HEMMINGS, T. P. HUGHES, Dr. S. KAUFMAN, B. S. LILEY, J. G. MACK, Dr. H. T. MILES, Dr. R. M. PAYNE, J. E. READ, Dr. A. A. WARE, J. A. WESSON and R. V. WILLIAMS

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SUCCESS in stabilizing a pinched toroidal discharge was first achieved in the apparatus known as ZETA at the Atomic Energy Research Establishment[1]. The stabilization was produced by applying a toroidal magnetic field (B_z) to a gas discharge combined with a metal-walled tube. A discharge similarly stabilized has been obtained in this Laboratory in a smaller apparatus, known as SCEPTRE III.

The discharge tube of SCEPTRE III was an aluminium torus having an internal diameter of 30 cm. and a mean torus diameter of 115 cm. A 4-ton iron core linked the torus with a primary winding of eight turns, wound close to the torus to keep the leakage inductance to a minimum. A condenser bank of 150 μF. charged to voltages up to 30 kV. was discharged through the primary by means of a spark-gap switch. A toroidal magnetic field of up to 1,000 gauss was produced within the torus.

Fig. 1 shows a plot of the peak gas current against applied magnetic field for discharges in deuterium at $3{\cdot}8 \times 10^{-4}$ mm. mercury pressure, the range of currents measured being from 20 to 200 k.amp. Typical

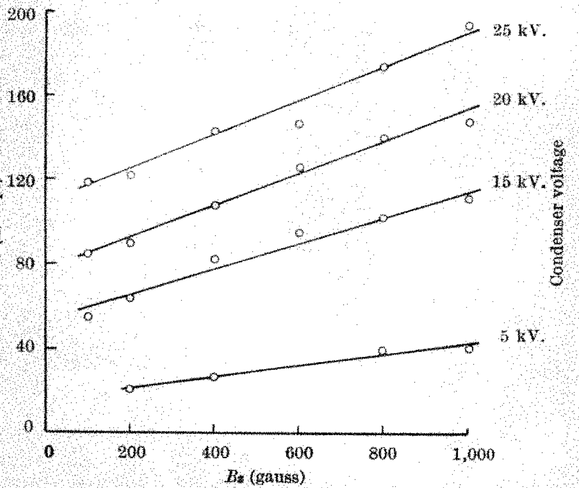

Fig. 1. Current/magnetic field; deuterium, $3{\cdot}8 \times 10^{-4}$ mm. mercury

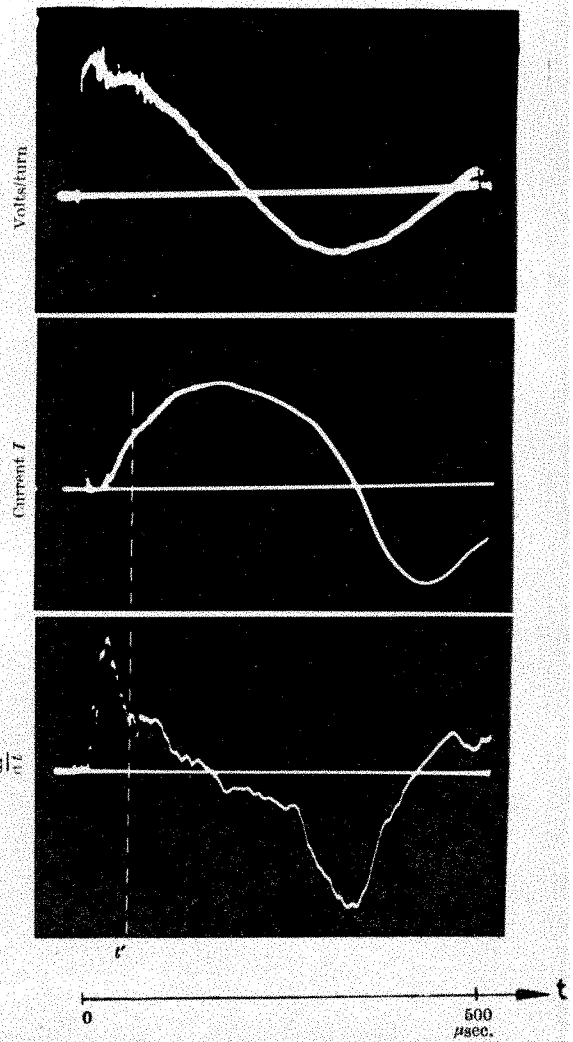

Fig. 2. Deuterium, $3{\cdot}8 \times 10^{-4}$ mm. mercury; condenser voltage, 20 kV.; turns ratio, 8 : 1; magnetic field, 1,000 gauss

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PHYSICS Dept.

Table 1

Pressure (10^{-3} mm. mercury)	Condenser voltage (kV.)	No. of primary turns	B_z (gauss)	Total neutron yield per pulse	Temperature from neutron yield (10^6 °K.)	Temperature from Doppler broadening (10^6 °K.)	Theoretical temperature (10^6 °K.)
1·9	15	16	300	8×10^3	2·7		2·3
1·9	20	16	500	5×10^4	3·3		2·9
1·9	25	16	500	10^5	3·5		3·4
0·9	20	16	200	—		3·2	3·9
3·7	20	16	200	$1 \cdot 2 \times 10^3$	2·0	2·5	2·2
1·2	25	16	300	—	—	3·8	4·1
0·5	11	8	300	—	—	2·6	2·3

oscillograms of the voltage (V) measured around the torus, the gas current (I) and rate of change of current (dI/dt) are shown in Fig. 2. The marked change of (dI/dt) at t' occurs at that current for which the magnetic field at the wall (B_θ) due to the gas current is equal to the applied B_z field. Theory shows that when these fields are equal, the discharge leaves the walls and constricts, and a sudden change of effective inductance will occur because energy must be supplied to compress the gas and the B_z flux. The change of (dI/dt) at this point confirms this theory. A corresponding change occurs at the same current value when I is decreasing. This is consistent with an expanding discharge reaching the wall at this time. Measurements of inductance at peak gas current derived from the ratio $\left(\frac{dV}{dt}\Big/\frac{d^2I}{dt^2}\right)$ indicate that between 0·55 and 0·9 of the applied B_z flux is trapped by the constricting discharge.

Spectroscopic observations show the presence of a considerable amount of impurity in the discharge (oxygen, carbon, copper and aluminium). These impurities are thought to be produced by the arcing which occurs between the gaps which must be left in the metal walls of the torus. Ion temperatures have been measured by observing the Doppler broadening of the quadruply ionized oxygen lines by means of a Hilger medium quartz spectrograph. The line profiles obtained after allowing for instrumental broadening (by Voigt profiles) were found to be Gaussian down to 1/20 of their peak intensity: this is the experimental limit of observation. At 6×10^{-4} mm. mercury pressure, 15 kV. condenser voltage, and B_z 300 gauss, the line-breadth for the (O V) lines at 2781 A. was 0·97 ± 0·1 A., which with an instrumental width of 0·3 A. corresponds to a temperature of $2 \cdot 6 \times 10^6$ degree K. No temperature measurements have been derived when operating at less than 11 kV. condenser voltage because of the faintness of the impurity lines. Above this voltage the temperature has been found to decrease somewhat with increased voltage. This disappointing result must be due to radiation and other losses from the discharge increasing more than proportionately with voltage, caused by increased impurity; more arcing does occur at higher voltages.

To reduce the amount of impurity in the gas, experiments were carried out with a greater number of primary turns and hence a lower gradient for a given input energy. Since the impedance of the discharge channel is still predominantly inductive, the peak currents for a given input energy are only slightly reduced. Preliminary measurements with a 16-turn primary have yielded ion temperatures in the range $2 \cdot 5 \times 10^6$ to $3 \cdot 8 \times 10^6$ °K., the temperature increasing with condenser voltage up to 25 kV. With deuterium in the torus, neutron emission has been detected over the range of pressures 9×10^{-4} to 7×10^{-3} mm. mercury, a maximum occurring at about 2×10^{-3} mm. mercury, when the magnetic field is about 500 gauss. Table 1 gives some preliminary results for the total number of neutrons per pulse, and in some of the cases the corresponding measured ion temperatures. The temperatures in column 6 of Table 1 are calculated from the neutron yield, assuming a constant density within a discharge channel one-third the diameter of the tube and having a constant temperature for a period of 400 μsec.

Because of the impurities in the discharge, it emits sufficient light to be photographed. Fig. 3 shows a streak photograph of the discharge. The discharge is viewed at one point of the torus simultaneously through a slit window on top of the tube and on the side of the tube. Fig. 3a shows a print from a colour photograph which records both red and blue light,

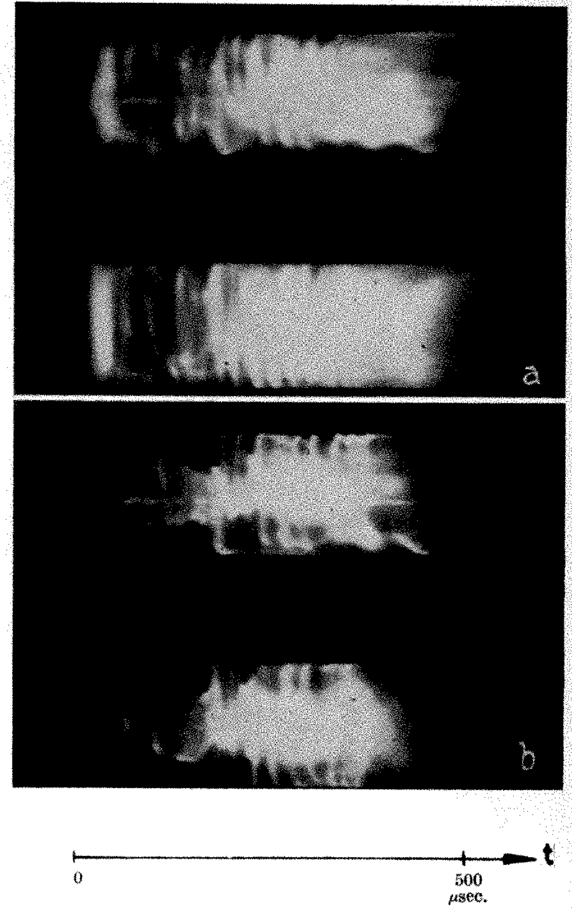

Fig. 3. Streak photograph of the discharge: (a) without filter; (b) with blue filter. Deuterium, $1 \cdot 2 \times 10^{-3}$ mm. mercury; current, 55 k.amp.; turns ratio, 8 : 1; magnetic field, 320 gauss

and Fig. 3*b* a print taken through a blue filter. The main discharge channel is blue and sharp-edged; its diameter decreases as the current increases and becomes unstable after about 300 μsec. when a/b reaches about 0·5, where a and b are the discharge and internal tube radii. The applied B_z was too small in this case to maintain stability throughout the whole pulse time. Superimposed on this channel are bars of light stretching across the whole tube which are mainly red at first, but later become white. These bars have been shown to travel around the torus with velocities of the order 2×10^6 cm. sec.$^{-1}$, and are believed to be due to shock waves produced by the intermittent arcing occurring at the gaps.

The observed results are consistent with the discharge being stabilized, due to the applied toroidal magnetic field being trapped by the constricting discharge. The theoretical conditions for such stability have been studied by Shrafranov[2], Tayler[3] and Rosenbluth[4]. Further properties of a discharge stabilized in this manner have been studied theoretically by Liley, of this Laboratory, in work not yet published. In particular, if the toroidal discharge is produced by discharging a condenser bank through a primary closely coupled with the gas current, the temperature reached at peak current is relatively independent of a/b within the range $1 > \frac{a}{b} > \frac{1}{3}$ and is given in degrees K. by:

$$T = 3 \times 10^7 \times J^{3/5}/(\gamma p b^4 E_0)^{2/5}$$

where J is the energy stored in the condensers in joules per cm. of the discharge tube-length, p the initial pressure of deuterium in microns, and E_0 the initial applied electric field in volts cm.$^{-1}$, γ is a factor near unity associated with skin effect, and b is in cm. This result has been obtained assuming that the gas kinetic pressure is small compared with the magnetic pressure, that the radial heat conductivity is sufficient to maintain uniform temperature across the discharge channel, and that the energy exchange time between positive ions and electrons is small compared with the period of the condenser discharge. Ohmic heating due to currents in both the z and θ directions is taken into account, as is also the effect of adiabatic compression as the discharge contracts. Radiation and other heat losses are neglected.

The temperatures calculated from the above formula are given in column 8 of Table 1; considering the simplifying assumptions which were made, these values agree reasonably well with the experimental observations.

We wish to thank Sir George Thomson for his advice and encouragement throughout this work, and to acknowledge the invaluable assistance received from colleagues at the Associated Electrical Industries, and in particular Mr. J. N. Barnett and Dr. S. E. Hunt; and the stimulus and help resulting from close collaboration with our fellow scientists at the Atomic Energy Research Establishment, Harwell.

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MAGNETIC MEASUREMENT OF PLASMA CONFINEMENT IN A PARTIALLY STABILIZED LINEAR PINCH

By Drs. L. C. BURKHARDT, R. H. LOVBERG and J. A. PHILLIPS

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THE distribution of currents in a linear pinched discharge in deuterium has been measured by the use of small magnetic probes inserted into the plasma[1]. This report of work performed in mid-1956 describes the current distribution in a discharge which compresses a longitudinal magnetic field originally set up in the tube by an external coil. The stabilizing properties of an included longitudinal field have been discussed theoretically elsewhere.

The discharge tube was of the Columbus[2] design with an inside diameter of 6·8 cm. and an electrode spacing of 30 cm. Energy was stored in a capacitor bank of 75 μF. at 10 kV. The connecting circuit, consisting of ten ignitrons and coaxial cables in parallel, had an inductance of 0·12 μH., which allowed a peak current in the discharge of approximately $1{\cdot}5 \times 10^5$ amp.

The magnetic probes consisted of 44-turn coils of No. 40 wire on 1-mm. diameter forms. These were encapsulated in slotted hypodermic tubes which provided electrostatic shielding, and these in turn were surrounded by quartz jackets for insulation from the plasma. The coil output was integrated by

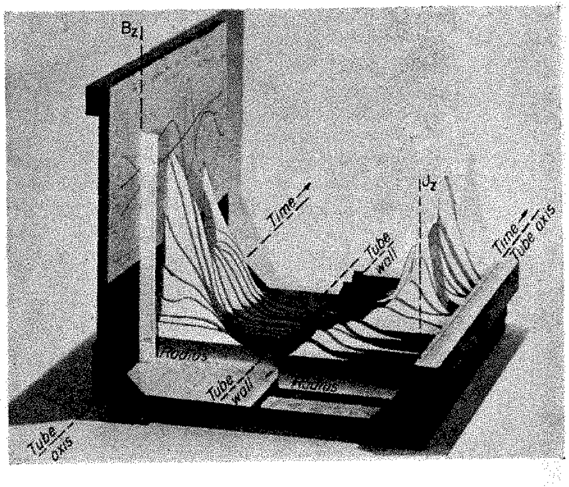

Fig. 1. B_z magnetic field and axial current density (J_z) distributions as a function of time. Initial conditions: B_z = 1,000 gauss; deuterium pressure, 600μ; V, 10 kV.

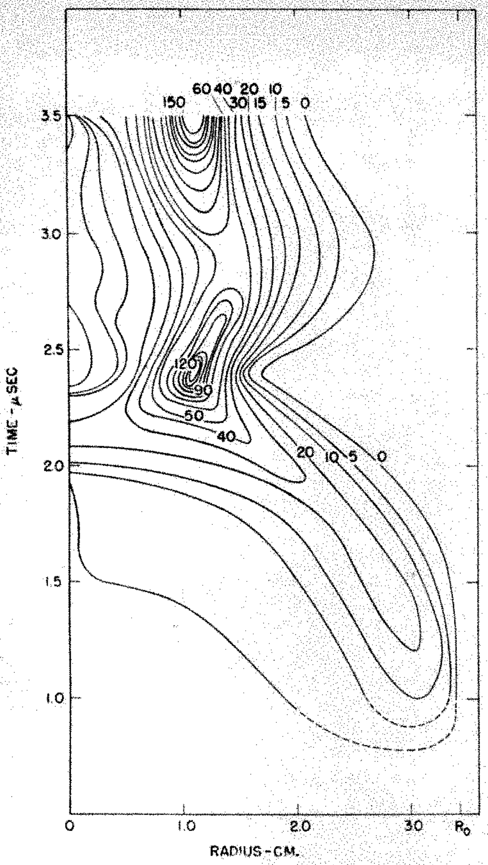

Fig. 2. Contour plot of axial J_z current density as a function of time. Same conditions as in Fig. 1

an RC network and displayed on an oscilloscope the sweep of which was triggered by the initial derivative of discharge current.

Plots of the B_θ and B_z fields were made by firing the tube and photographing the traces from the appropriately oriented probe at each of a family of equally spaced radial intervals. These traces of $B(t)$ for different radii were used for constructing curves of $B(r)$ for separate times. Differentiation of these traces then yielded distributions for j_θ and j_z. The requirement for good reproducibility of traces from shot to shot was well met up to approximately three microseconds, when the discharge, not completely stabilized by the 1,000-gauss B_z, went into a kink instability and became turbulent, filling the tube.

The experimental results for a discharge in deuterium at 600μ with 1,000-gauss B_z applied initially are shown in Figs. 1, 2 and 3. The discharge is seen to be compressed to approximately one third the tube radius and to oscillate about a mean value. The B_z field is compressed within the main current sheath.

If B_z and B_θ are known throughout the tube, and if one assumes the pinch to be in an equilibrium state, the plasma pressure may be calculated from the equation: $\mathbf{j} \times \mathbf{B} = \nabla p$.

In this case, the pinch was not entirely in equilibrium, as evidenced by a tendency to 'bounce' slightly at maximum compression. However, pressure balance calculations were made at times when the sheath acceleration was zero, where the above equation also applies.

Fig. 4 shows a plot of $B_z(r)$, $B_\theta(r)$ and $p(r)$ at 2·5 μsec. after firing the discharge. The pressure corresponds to a kinetic temperature of approximately 10 eV. if all the gas is assumed to have been swept in with the current sheath. In later stages in the discharge the maximum temperature before breakup was about 40 eV.

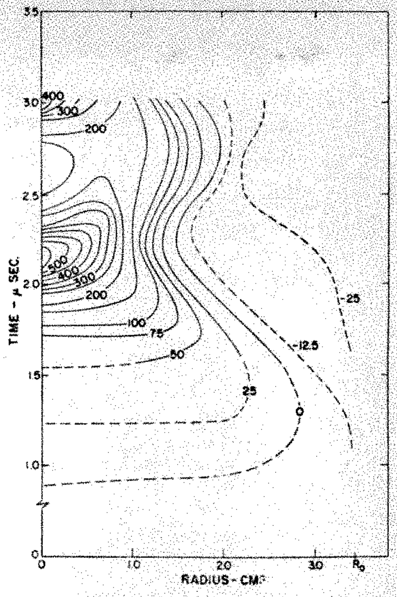

Fig. 3. Contour plot of B_z magnetic field as a function of time. Same conditions as in Fig. 1

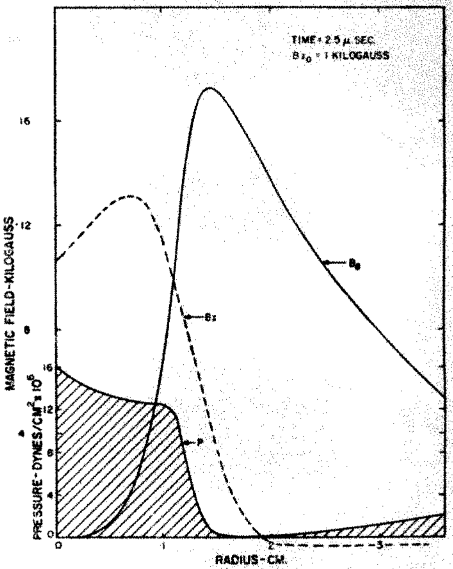

Fig. 4. B_θ and B_z magnetic fields plotted as a function of radius at 2·5 μsec. under conditions of Fig. 1. The radial material pressure as calculated from pressure balance considerations is also shown

We wish to acknowledge the encouragement of J. L. Tuck during this work. L. Fretwell assisted generously in the taking of results. We also acknowledge the pioneer (1954) work of J. W. Mather in the use of magnetic probes.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

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[2] Burkhardt, L. C., Dunaway, R. E., Mather, J. W., Phillips, J. A., Sawyer, G. A., Stratton, T. F., Stovall, E. J., and Tuck, J. L., *J. App. Phys.*, **28**, 519 (1957).

NEUTRON PRODUCTION IN A HIGH-POWER PINCH APPARATUS

By DRS. D. C. HAGERMAN and J. W. MATHER
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IN the work on fusion power devices, several investigators[1-5] have studied the neutrons produced by forming a pinch in deuterium. This communication reports on those neutrons coming from the Los Alamos Scientific Laboratory device known as Columbus II (July 1957). In view of the fast rate of growth of instability amplitudes in the pinch, Columbus II was designed as a high-powered machine in which the current reached its maximum value in as short a time as possible.

The Columbus II main condenser bank (shown in Fig. 1) consists of twenty-five 0·8 μF., 100-kV. low-inductance condensers on the periphery of a circle 14 ft. in diameter. The transmission line which connects the condensers to the centrally located discharge tube consists of two circular copper sheets separated by a ½ in. polyethylene insulator. This bank is switched by a graded vacuum spark gap (Hagerman, D., unpublished work), which is placed above the discharge tube. The condenser bank is charged by a Marx generator in 90 μsec. The inductance external to the discharge tube is 0·035 μH., which implies that under short-circuit conditions at 100 kV. the maximum current capability is 2·5 million amp. Typical operation is at 60 kV. with a gas current of 1 million amp. and a rise-time of 2 μsec. In addition to the main high-voltage bank, a second low-voltage bank (60 μF., 20 kV.) was available which could be used to form a partially stabilized pinch in the discharge tube before application of the high-voltage bank. The reason for this two-stage operation was the hope that the low-power pinch could be adiabatically compressed by the high-power bank beyond the region of stability to a high transient temperature. Axial magnetic fields up to 10 kilogauss were provided by an auxiliary low-voltage condenser bank. Ceramic discharge tubes (30 cm. long, 10 cm. in diameter) of sillimanite were found to allow operation up to 55–60 kV. An interesting difficulty has up to date prevented all effective use of the machine above 60 kV. The pinch phenomena can be identified by characteristic voltage or, in the case of extremely low inductance supply such as this one, current fluctuations observed during the discharge cycle. These are found to disappear at voltages above 55 kV. as do the neutrons.

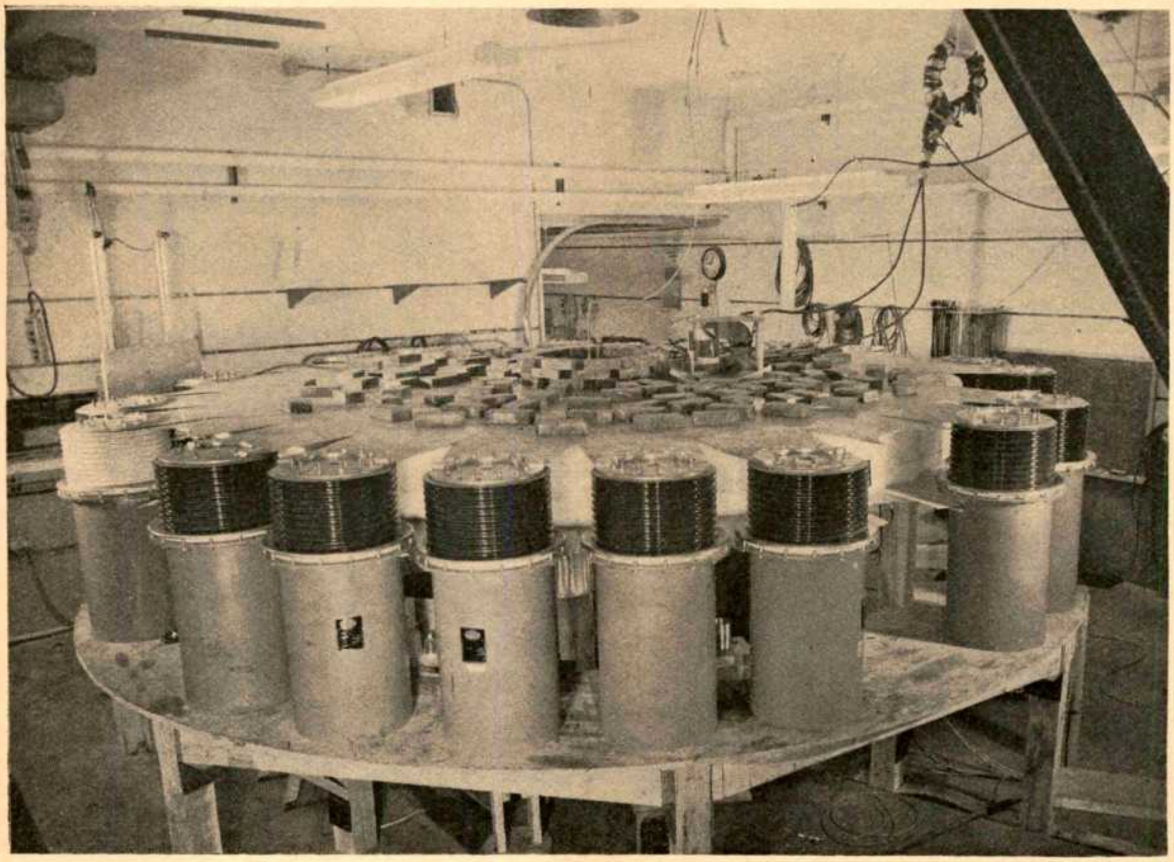

Fig. 1. General view of the apparatus

Table 1. COMPILATION OF TYPICAL DATA CHARACTERIZING NEUTRON OBSERVATIONS FROM LINEAR PINCHED DISCHARGES. (UNREPORTED DATA REPRESENTED BY BLANK SPACES)

	Electrical parameters			Neutron parameters								
								Neutron dependence on:				
Reference	V_0 (kV.)	$I_{max.}$ (k.amp.)	Rise-time (μsec.)	Pulse duration (μsec.)	Occurrence No. of bounces	Max. yield per pulse	Anisotropy in neutron energy (MeV.)	B_z field	Contamination	D_2 pressure	I or V	Neutron distribution
a 1	40	400	~8	~1·0	2	4×10^7			Strong. Vanish with 0·01 per cent H_2, A, Xe		Increase by 20 from 220 to 450 k.amp.	Uniform
b 2	35	~300	2·0	~0·3	2, 3, 4	10^7–10^8	~0·3	Strong. Decreased by factor 50 for 50 gauss	Strong. Decreased by factor of 50 for 8μ of A.	Peak at 200μ	Increase by 20 from 15 to 30 kV.	Uniform axial plates
c 3	15	250	5·0	0·1	2, 3	10^7–10^8	~0·26	Strong. Vanish with 100 gauss	Strong. Vanish with 0·2 per cent N_2. Decrease to ¼ for 5 per cent He	Peak at 125μ	Increase by 50 from 14 to 17 kV.	Linear increase from anode to cathode
d 4	10	300	5·0	~0·5	3	10^8		Weak. Decrease by factor 10 for 1,000 gauss	Vanish with 5 per cent N_2			
e 5 Columbus II	23	200	6½	~1·0	1, 2, 3							
f Preheaters alone	15	250	6	~0·1–0·3	1, 2	2×10^7		Strong. Decrease by factor 6 for 23 gauss				
g Main bank alone	50	800	2·0	~1·5	1	3×10^8	0·17	Weak. Decrease to ½ for 125 gauss	Weak. Decrease according to $(1-f)^2$ for He up to 50 per cent	Increase by 2·3 from 70 to 200μ of D_2	Increase by 2 from 40 to 50 kV.	Non-linear 0–5 cm. at anode. Uniform 5 cm. to cathode
h Preheater and main bank	50	~800	2·0	~1·0	1	7×10^7		Weak. Decrease to ⅓ for 90 gauss				

(*a*) *Low-voltage* (*preheater*) *bank alone.* Neutrons were produced in short bursts (0·1–0·3 μsec. long) occurring approximately at the time of the first and second contraction of the pinch. The maximum yield of neutrons was 2×10^7; the yield decreased by a factor of 6 by the addition of a 23-gauss axial magnetic field, which suggests that these neutrons may be produced by some instability mechanism. (One form of instability mechanism is discussed in ref. 3.)

(*b*) *High-voltage bank alone.* Fig. 2 shows d*i*/d*t* and *i* for 50-kV. operation. The neutrons appear shortly after the first contraction, as indicated by the small dip in the current. Fig. 3 shows typical neutron pulses with and without an axial (B_z) magnetic field. With no B_z field a short (0·3 μsec.) neutron burst with little or no tail was observed. A small B_z field lowers the relative height of the initial burst of neutrons and enhances the number of neutrons appearing in the tail of the neutron pulse. Neutron-pulse durations of up to 1·5 μsec. were observed with B_z fields as small as 200 gauss. The total yield of neutrons was rather insensitive to the axial magnetic field, dropping by only 55 per cent when the field was changed from 0 to 125 gauss. The maximum yield observed for zero B_z field was 3×10^8 neutrons. The dependence of the neutron yield on pressure and helium contamination showed: (1) that the yield was proportional to the pressure, increasing by a factor of 2·3 between 70 and 200μ; (2) the fraction f of the helium contamination lowered the yield according to the expression $(1-f)^2$ (these results were obtained with a B_z field of 200 gauss). Fig. 4 shows the axial neutron energy distribution from nuclear

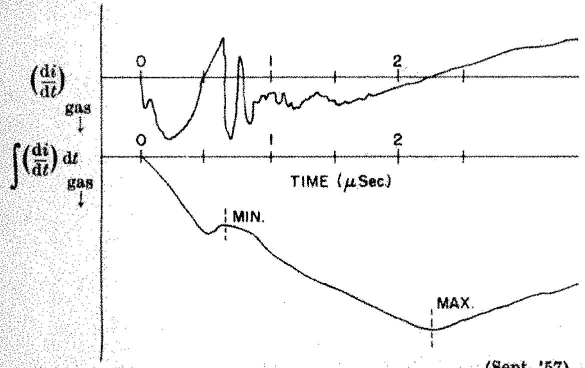

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Fig. 2. Gas current and $(di/dt)_{gas}$ vs. time

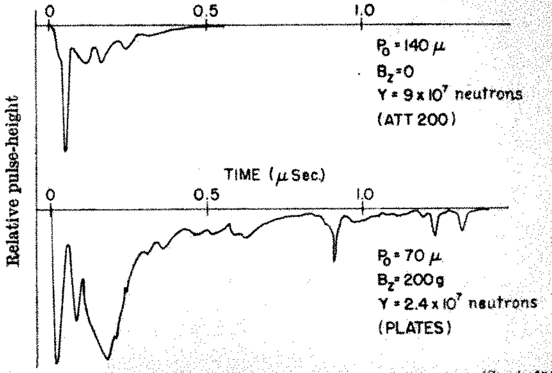

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Fig. 3. Typical neutron pulse shapes

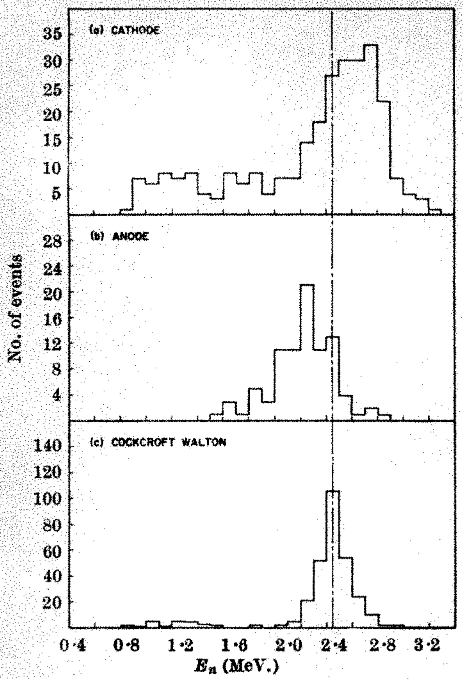

Fig. 4. (*a*) and (*b*) show the axial neutron energy distribution; (*c*) a range-energy calibration using a Cockcroft–Walton machine

plates situated behind the cathode and anode. The observed energy shift of approximately 0·17 MeV. corresponds to a 20-keV. deuteron colliding with a deuteron at rest, or to a group of interacting deuterons travelling toward the cathode with a velocity of 7×10^7 cm./sec. Plates were also exposed radially at three positions along the discharge; the results are compatible with a uniform neutron distribution from the cathode to within 5 cm. of the anode, beyond which the yield is lower. All the plate exposures were made with a 200-gauss B_z field and 50-kV. bank voltage.

(*c*) *Operation of banks in combination.* These results are preliminary. (1) Time-sequence operation was achieved; however, timing had little effect on neutron yield if the fast bank was timed prior to the development of instabilities in the first-stage pinch. (2) Neutron pulse widths were approximately 1 μsec. (3) Neutron yields were approximately 10^7/pulse. (4) A 90-gauss axial magnetic field reduced the yield by a factor of 3. (5) Neutron yield increased by a factor of 2 in going from 40 to 50 kV. on the high-voltage bank. In Table 1 the above results are compared with those reported by other laboratories.

The dependence of neutron yield (row *g*, Table 1) on applied magnetic field, helium contamination, gas pressure and voltage, as well as the long neutron pulse-duration, suggests a mechanism of neutron production different from the usual instability process. However, it is clear from the anisotropy in the neutron energy spectrum at 200-gauss axial magnetic field that directed motion of the reacting deuteron system exists. This anisotropy is smaller than that reported (row *b*, *c*, Table 1) for instability neutrons without axial magnetic field, even though the applied electric field in Columbus II is appreciably larger.

We are indebted to J. L. Tuck and J. A. Phillips for many helpful discussions concerning this experiment. Thanks are also due to L. Rosen and the nuclear plate group for their generous assistance, to J. H. Coon for the provision of D–D calibration neutrons, to L. Neher for assistance in fast-scintillation techniques, and to A. H. Williams and Glen Livermore for their technical assistance throughout.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

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NEW CONFINEMENT PHENOMENA AND NEUTRON PRODUCTION IN A LINEAR STABILIZED PINCH

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A LINEAR discharge device[1], designated Columbus *S*–4, has been constructed to test the effect of increased tube diameter and inter-electrode spacing on the properties of a B_z-stabilized pinched discharge. The apparatus utilizes the same capacitor bank as that employed in the magnetic-probe experiments (75 μF., 20 kV.) with the external inductance reduced to 0·075 μH. The discharge tube is a cylinder of porcelain ('Mullite') of inside diameter 5·0 in. and 24 in. spacing between electrodes. A close-fitting cylindrical return conductor of 1/16 in. stainless steel provides negligible delay in the 2-msec. rise of the longitudinal (B_z) field which is set up by an external solenoid and capacitor bank. Provision has been made for radial insertion of a magnetic probe halfway between the electrodes.

From the time of its initial operation, this tube has exhibited properties qualitatively different from those observed in previous experiments. Initial observations of optical spectra from the discharge were made with a monochromator of approximately 1 A. resolution which looked along the tube axis. After the tube had been operated for about one hundred discharges, it became impossible to detect the spectra of the common impurities such as silicon and oxygen until the peak of the second half-cycle of discharge current. The photomultiplier gain was set an order of magnitude higher than the value adequate for use

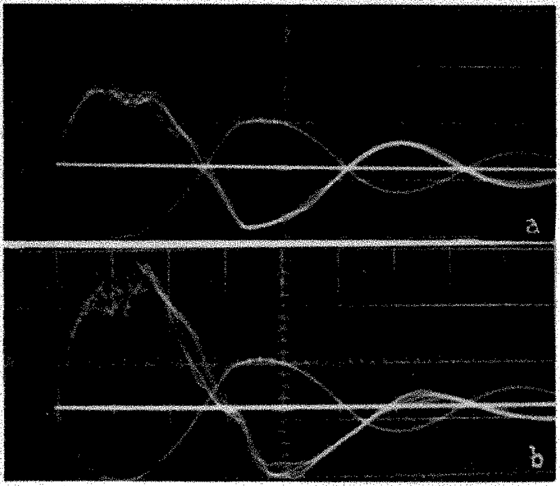

Fig. 1 (a) Four superimposed traces of $B_\theta(t)$ for a radius of 6·4 cm. (tube-wall radius). The capacitor bank current is shown in opposite polarity. Sweep: 5 μsec./cm. (b) B_θ traces for $r = 4 \cdot 4$ cm.

on previous systems. The H_β line, under these conditions, appeared with considerable amplitude during the initial discharge current rise, dropped to an almost undetectable amplitude near the first current maximum, and remained faint until the second current maximum, when it again became prominent. The rise in gas pressure after each shot was less than 5 per cent. Operating conditions for the above observations were:

Condenser voltage = $1 \cdot 5 \times 10^4$ V.
B_z = 1,750 gauss
Deuterium pressure = 40μ mercury
$I_{\text{max.}}$ = $2 \cdot 5 \times 10^5$ amp.
Time to first current peak = 6 μsec.

Magnetic-probe measurements of the B_θ and B_z fields were made under these conditions, and for times extending through three half-cycles of the bank current. While the shot-to-shot reproducibility of the probe traces became imperfect after 3 μsec., due to an apparent small-amplitude flutter of the plasma column, the spread in the trace amplitudes was still sufficiently small to allow the plotting of meaningful field distributions and the calculation of approximate plasma pressures. Figs. 1a and 1b are B_θ records for radii of 6·4 cm. (the tube wall) and 4·4 cm. respectively. Four traces are superimposed in each picture, and the capacitor bank current is also displayed in opposite polarity. The sweep-speed is 5 μsec. per cm. An unexpected effect is seen to manifest itself after a time of 3 μsec. While before this time the amplitudes display the $1/r$ dependence characteristic of all current being within 4·4 cm. radius, this dependence breaks down at later times in the half cycle; in particular, the amplitude ratio between the two sets of traces at 10 μsec. exceeds a factor of two. This implies the existence of a sheath of negative current just inside the tube wall. The same conclusion can be drawn by comparing the B_θ amplitudes at the zero of input current; no net current flows inside the tube, since B_θ at 6·4 cm. is zero; yet about 5×10^4 amp. is flowing inside 4·4 cm. radius. A circulation of current is evidently taking place inside the tube. Later in the cycle it is seen that when the central core current has dropped to zero, the entire bank current is flowing in the outer sheath; this proceeds to pinch, and the above process is repeated. It is noteworthy that contaminant spectra appear only at the compression of this second sheath; wall materials have apparently collected in it during its relatively long existence at the wall.

A pressure-balance calculation has been done using the B_z and B_θ amplitudes at 6 μsec. after the starting of current, that is, at the current maximum. The plasma pressure at the tube axis and at this time appears to be about 12 atmospheres; if the plasma is assumed to be uncontaminated and pinched to the same radius as the longitudinal current, the temperature should be in excess of 300 eV.

Since a temperature as high as this, together with the assumed central density, should result in an easily detectable neutron yield, namely, of the order of 100/c.c.-μsec., a series of counter experiments was performed. A plastic scintillation counter was found to give pulses centred at the current maximum, and tests with paraffin interposed between the counter and discharge tube established the radiation to be neutrons. The yield was found to be too small to activate a silver foil counter to significantly greater than a background count, and it was concluded from the known counter calibration that the total yield was fewer than 10^5 per discharge. The numbers of counts observed in the plastic scintillators made it apparent that some of the discharges yielded more than 10^3 neutrons. At the time of writing, the number has not been accurately fixed. Fig. 2 shows the output of the scintillation counter for several successive discharges, along with a trace of the condenser current. In this instance, the condenser voltage had been raised to 17·5 kV.

Runs were made to measure relative neutron yield as a function of bank voltage, B_z, deuterium pressure, and contaminant fraction in the gas. The yield over the half-cycle was obtained by integrating the photomultiplier anode current for this time. Ten shots were taken at each condition of the system. In Figs. 3, 4, 5 and 6 the relative yield for each discharge is plotted as a small dot, while the mean values are horizontal bars.

It must be remarked that most of the data plotted in the above figures were taken at conditions more favourable for neutron production than those used for the magnetic-field measurements. However, counts were observed in significant numbers at 15-kV. bank voltage and 1,750-gauss B_z; typically, one observed the order of 10 counts per discharge in a 5 in. × 5 in. cylindrical plastic scintillator placed

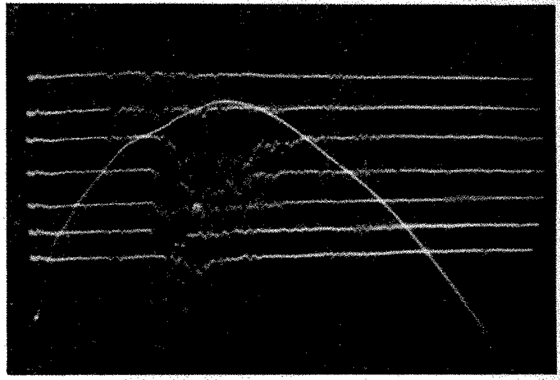

Fig. 2. Traces of plastic scintillator output vs. time; sweep, 2 μsec./cm. Capacitor bank current is superimposed

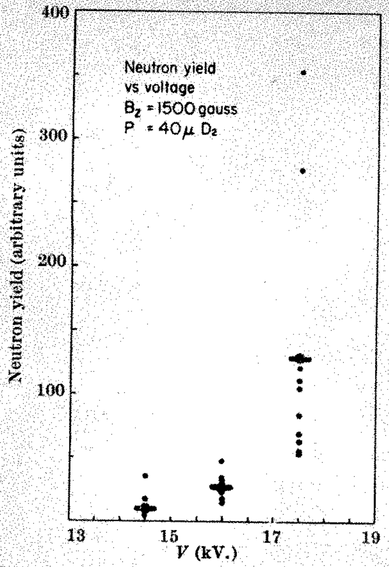

Fig. 3. Neutron yield vs. capacitor bank voltage. The small dots represent yields for individual discharges; ten discharges were measured at each value of *V*. The bars are mean values for the ten points

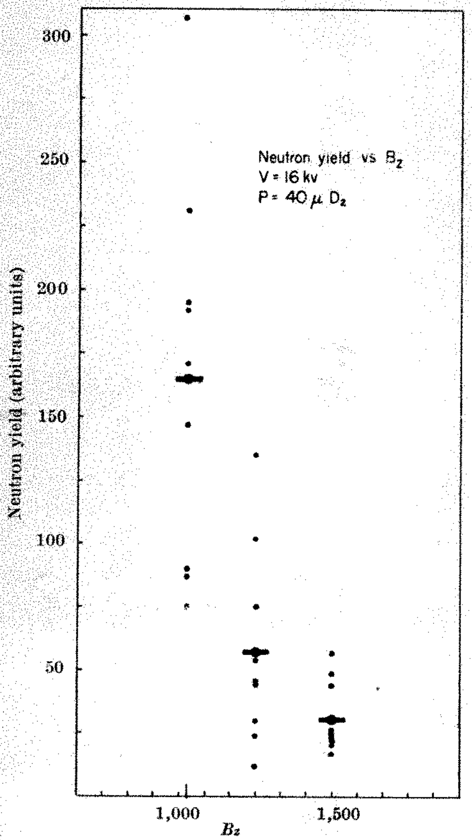

Fig. 4. Neutrons vs. B_z

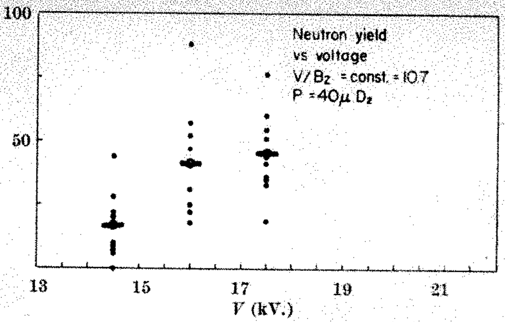

Fig. 5. Neutrons vs. *V* for V/B_z held constant at 10·7

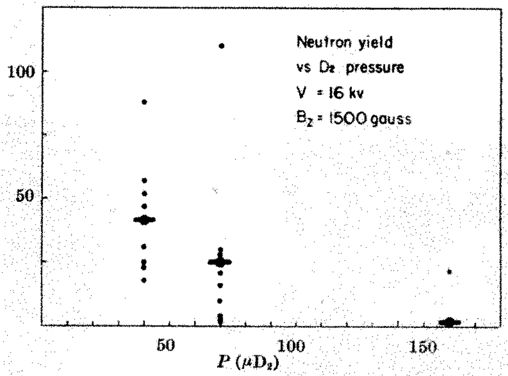

Fig. 6. Neutrons vs. deuterium pressure

8 in. from the centre of the tube. At this condition, as in Fig. 2, the neutrons are produced in a time interval 4 μsec. wide, centred near the current maximum.

While the pinch configuration for the case of the measured field distribution (15-kV. bank voltage, 1,750 gauss B_z) is clearly stable against break up by kinking, and the 16 kV., 1,500-gauss condition also appeared stable in this sense from initial probe surveys, it is not established that the runs which involve higher ratios of bank voltage to B_z are stable. One must, therefore, allow the possibility that the neutron output in the lowest B_z and highest bank voltage cases results from some acceleration mechanism associated with instability. Even in the configuration of which B_θ traces are shown, the fluttering of the fields near maximum current may represent strong local field inhomogeneities which could provide a particle-accelerating mechanism. It is clear, however, that the variations of yield with *V* and B_z are consistent with a thermonuclear origin of the neutrons, since the plasma compression and current density are sensitive to variation of these parameters.

The lower limit of gas pressure was set by the inability of the tube to break down at less than 40μ.

A contaminant of 5 per cent air in the deuterium reduced the neutron output to less than a tenth of its normal value.

Work is progressing on the problem of determining pinch stability for the conditions where it is now uncertain. An effort will also be made to measure the degree of energy isotropy of the neutrons, since anisotropic energy distribution has in the past identified the neutron yield from several devices as being non-thermonuclear[2].

We wish to thank J. L. Tuck and J. A. Phillips for helpful discussions during the course of this work. We also acknowledge the contribution of H. Dreicer in predicting theoretically the entrapment of wall impurities by a plasma sheath.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

[1] Burkhardt, L. C., Dunaway, R. E., Mather, J. W., Phillips, J. A., Sawyer, G. A., Stratton, T. F., Stovall, jun., E. J., and Tuck, J. L., *J. App. Phys.*, **28**, 519 (1957).

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NEUTRONS FROM A STABILIZED TOROIDAL PINCH

By Drs. J. HONSAKER, H. KARR, J. OSHER, J. A. PHILLIPS
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HYDROMAGNETIC calculations on idealized models of the pinch have indicated that stability might be attained by a combination of a central axial magnetic field and conducting walls, provided that certain restrictions on compression and $8\pi p/B^2$ (p is plasma pressure) are obeyed[1-5]. The problem is actually more complicated than these simple models suggest, especially when the finite thickness of the boundary layer between external magnetic confining field B_θ and internal magnetic stabilizing field B_z is taken into account.

Experiments at Los Alamos on straight tubes[6] using magnetic probes have measured substantial plasma pressure confinement with appreciable stability by these means. It proved unexpectedly difficult to do as well in toroidal geometry, due in part to the technical difficulty of inducing high-voltage gradients and also to the presence of unavoidable gradients in electric and magnetic fields across the discharge tube cross-section. After a progression of machines extending over several years, Perhapsatron S–3 began to show (middle 1957), by magnetic probe measurements[7], more symmetrical detachment of the current channel from the walls. This apparatus is shown in Fig. 1.

Fig. 2 shows a magnetic pressure measurement with plasma pressure (nkT) determination made in Perhapsatron S–3 at two stages in the current wave $t = 4$ μsec., $2\cdot0 \times 10^5$ amp., and $t = 6$ μsec., $2\cdot3 \times 10^5$ amp. Such curves show penetration of the B_θ magnetic field towards the pinch axis with some increased confining current density along the axis and little current outside the pinch. We evaluate nkT by substitution in the pressure balance equation :

$$\left[nkT + \frac{B^2}{8\pi}\right]_{r_1}^{r_2} = -\frac{1}{4\pi}\int_{r_1}^{r_2}\left(\frac{B_\theta^2}{r} + \frac{B_z^2}{r}\right)dr + C$$

where $B^2 = B_\theta^2$, r and R are the radii of curvature of B_θ and B_z respectively, and C is a constant evaluated at some position at which nkT is known. The calculations of nkT are not precise, since (1) the radii of curvature of the magnetic field lines are assumed from symmetry and (2) uncertainties of the position of the discharge axis seriously affect the integration in its vicinity. The pressures are consistent with appreciable average temperatures greater than 125 eV. Also the cooling effect of impurity influx from the walls is suggested by the lower pressures at 6 μsec., compared with those indicated at 4 μsec. This is paralleled by the rise in impurity spectral line inten-

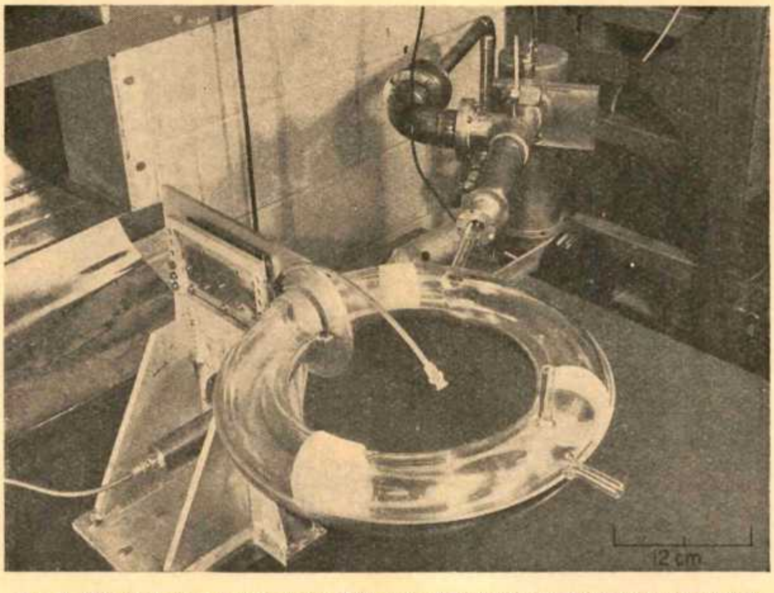

Fig. 1. The glass torus (minor radius 2·65 cm.) of Perhapsatron S-3 is shown supported in the lower half of the copper primary (major radius 16·2 cm.). The condenser is 225 μF. (44,500 joules at 20 kV.) with a total connected inductance of 0·08 μH. at the torus feed-point

sities emitted from the discharge, up to this time quite faint (Fig. 3*f*). It was also observed that the small magnetic probe, diameter 1·7 mm., when extended into the discharge, caused the impurity lines to appear earlier. This suggests that the temperature would be higher and the current sheath thinner when the probe was absent.

A large liquid scintillator (43 cm. diameter, 50 cm. high) showed neutron emission (December 17, 1957) of 10^4 per discharge. Substitution of a quartz ('Vycor') torus for the 'Pyrex' glass one raised the average output to 2×10^5 neutrons per discharge. Addition of a laminated iron core improved the coupling in the early stages of the current cycle before it saturated, and gave a further small increase. Neutron yields up to 10^6 per discharge have been observed.

Neutron intensity versus time as detected by a proton recoil scintillation counter shows a burst of duration approximately 2 µsec. starting at about 3·0 µsec. after gas breakdown, with successive smaller bursts superimposed on a tail of duration 10–15 µsec. (Fig. 3*c*). It seems definite that some neutron emission continues through the discharge current zero and occasionally up to and beyond the second current maximum (~30 µsec.). A pulse of neutrons is at times associated with the second current zero ~60 µsec. This may have interesting implications. There is a well-defined optimum B_z, with no yield at zero B_z (Fig. 4). The yield rises with diminishing deuterium pressure, and the lower limit in this direction is determined by failure to obtain gas breakdown (Fig. 4) even with radio-frequency pre-excitation. The yield is sensitive to contaminants and to the quality of the base vacuum pressure. 5 per cent nitrogen reduces the yield by a factor of 2 (Fig. 5). Yields are variable at fixed operating conditions by a factor of about 3.

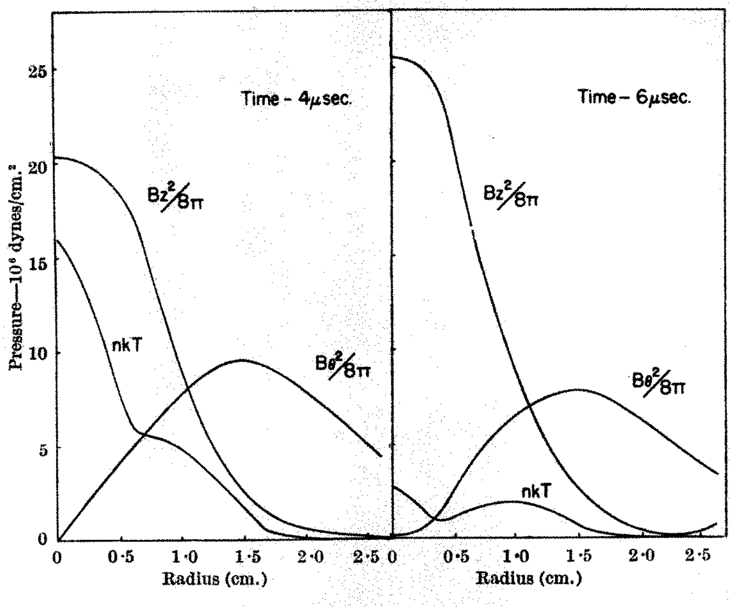

Fig. 2. Magnetic field pressure distributions as a function of radius at $t = 4$ µsec. and 6 µsec. The material pressure (*nkT*) distributions calculated from pressure balance considerations are also shown

X-rays appear in a sharp burst, duration approximately 1 µsec., about 0·9 µsec. after gas breakdown, which is before the time of neutron emission. Little or no X-ray yield is observed under the conditions of maximum neutron yield. The X-ray intensity increases with deuterium pressure, whereas the neutron intensity increases with decreasing pressure. At high pressures (400µ), X-ray energies as high as 0·9 MeV. have been measured with 12 kV. primary voltage and 5,000 gauss B_{z_0}.

A spectrogram taken during three complete discharges at 11 A. per mm. dispersion over range 3000–6600 A. shows a strong continuum throughout, with a few lines greatly broadened ~30 A. tentatively identified as Si II, Si III.

One of the central features of the design of Perhapsatron *S*–3 is the thinness (0·3 cm.) of the glass walls of the torus and its close fit to the metal primary, based on the unequivocal predictions by theory of the bad effect of B_z external to the pinch on stability. This has made the glass torus very fragile and easily broken by strains transmitted to it from the heavy primary under electromagnetic forces. The neutron yield rises between 14 and 15 kV. primary voltage, with higher voltages limited by failure of the glass torus. A precision alumina porcelain torus when delivered is expected to reduce these difficulties, with the possible added advantage that alumina is known from other experiments to be superior to quartz in the contaminants it supplies to the discharge.

A temperature of 600 eV. (compression 9) would be consistent with the observed yield of neutrons, and the pressure balance equations would support this. Magnetic probes indicate that the pinch undulates as a whole with an amplitude of about 2 mm. The diminution in neutron yield after the initial burst is a matter for concern and finds an explanation in terms of cooling by the influx of impurities (~3·6 µsec.). The observed sensitivity to impurities is supporting evidence for a thermonuclear reaction but has been misleading in the past—

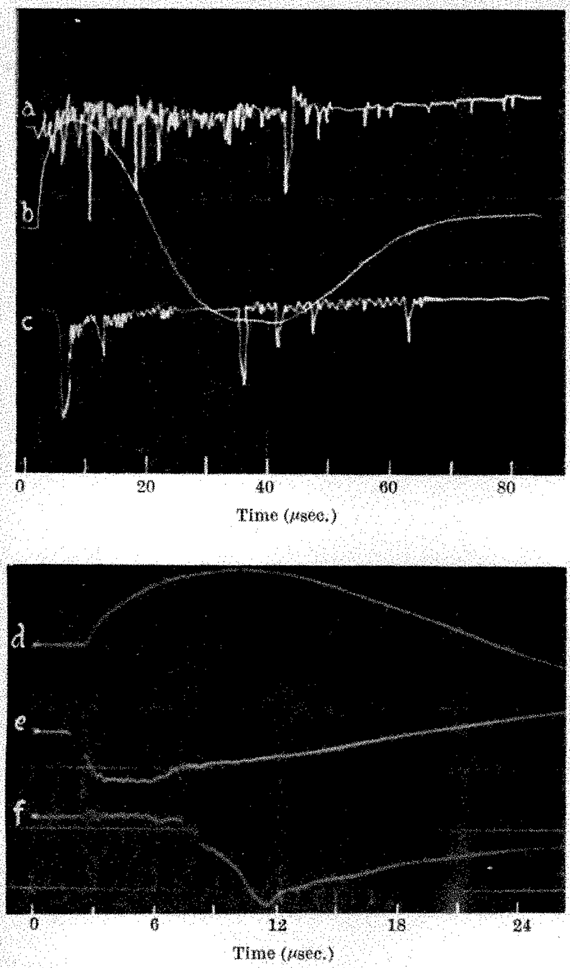

Fig. 3. Multiple-beam oscilloscope traces as a function of time of: *a*, neutron capture γ-rays from a cadmium-loaded liquid scintillator; capture half-life ~ 30 μsec.; *b* and *d*, gas current; *c*, proton recoils from a fast scintillator; *e*, secondary voltage; *f*, intensity of silicon line, 4128 A.

witness the great sensitivity of instability neutrons to impurities[8–10].

We think it fairly safe to say that at any rate the fringe of thermonuclear temperatures of approximately 500 eV. is being approached. The principal anxiety arises from the fact that it is precisely at this point that conditions are ideal for simulation of a thermonuclear reaction by a Fermi mechanism[11]. Reflexion of deuterons from magnetic disturbances travelling at the Alfvén speed $\sqrt{B^2/4\pi p}$, give deuterons in the 12-keV. energy-range after very few reflexions, yet a small fraction of the gas, 0·6 per cent with this energy, equals the thermonuclear yield of a plasma at 600 eV. Nor is it easy to distinguish the two experimentally. Refined nuclear emulsion techniques could do it, but would require several thousand discharges to accumulate enough intensity at the present output-level of Perhapsatron *S*–3. Comparison of yields with DD and DT gas fillings can also be used, but requires more reproducibility than prevails at present.

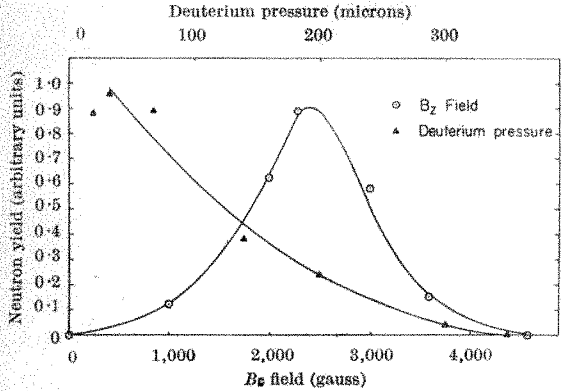

Fig. 4. Neutron yield versus initial longitudinal B_z magnetic field and deuterium gas pressure. The experimental points are averages of several runs with variations of a factor 3 in neutron yield

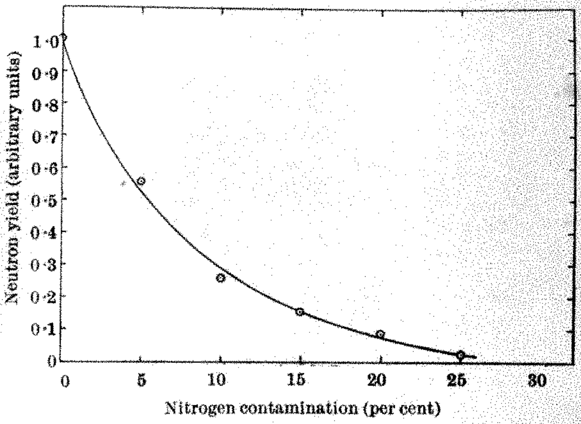

Fig. 5. Neutron yield versus percentage nitrogen contaminant (mean of several runs)

We acknowledge with pleasure the co-operation of L. Burkhardt and R. Lovberg for scientific contributions to the experiment, of R. Dike for engineering design, of A. Schofield for electrical design, of A. Roensch for inspired precision glass-blowing with difficult materials, and of J. M. B. Kellogg for co-operation in the division.

We are indebted to the Atomic Energy Research Establishment, Harwell, for assistance in handling this paper for publication simultaneously with the ZETA experiments (which, incidentally, preceded this work by several months).

This work was performed under the auspices of U.S. Atomic Energy Commission.

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OBITUARIES

Prof. M. A. Catalán

Miguel Antonio Catalán was born at Saragossa in Spain on October 9, 1894, and died at Madrid on November 11, after a brief and unexpected illness, at the age of sixty-three.

Following graduation at the University of Saragossa, Catalán received his Ph.D. degree with honours at Madrid in 1917 and started research work on spectroscopy in the laboratory for advanced studies of the Department of Physics. With a Spanish fellowship, he studied in England under Prof. Alfred Fowler's direction in 1920–21. During this stay at the Imperial College of Science and Technology, Catalán made his most important contribution to spectroscopy with the discovery of multiplets in the arc spectrum of manganese. For the first time, the spectrum of a complex atom could be interpreted, giving experimental support to the quantum theory of those atoms. Catalán's discovery was the beginning of a novel approach to the study of atomic spectra, and all laboratory spectroscopists began to study many other complex spectra, looking for multiplets as Catalán did in Mn I.

In 1923 he was awarded a Rockefeller Fellowship, at the suggestion of Prof. A. Sommerfeld, and worked with him during 1923–24. Back in Spain, Catalán continued his work on atomic spectra, and in 1930 was promoted head of the Atomic Spectroscopy Section at the Rockefeller Institute of Madrid. Many students from Spain and abroad worked under his direction, and in 1934 he became full professor in the University of Madrid. During the following years, a large number of important papers on analyses of atomic spectra were published by Catalán and his students; thus, very soon his school was well known and appreciated all over the world. Invited by the American Philosophical Society, he worked in the United States during 1947–48 and again in 1950 and 1951. In 1950 he was appointed chief of the Department of Spectroscopy in the newly created Institute of Optics, Madrid; and in 1952 he was elected to the Joint Commission for Spectroscopy of the International Council of Scientific Unions. His important contributions to the field of atomic spectroscopy were also rewarded in Spain when he was elected member of the Real Academia de Ciencias in 1955. At the invitation of South American universities, Catalán lectured in Argentina and Venezuela in 1956 and 1957. Up to the date of his illness, he was still very active and productive; thus his death surprised and shocked all his friends.

Prof. Catalán was not only an eminent spectroscopist; he was also a great teacher and he enjoyed lecturing to students or to any type of audience. Teaching was really his hobby. He had the rare ability of making simple and understandable the most difficult subjects, and he liked these outside activities so much that, apart from his lectures at the University, he always instructed groups of high-school students.

Catalán was friendly and helpful to everyone. He was liked and admired by all who knew him, and he will be remembered with affection by his many friends and colleagues. R. Velasco

Prof. Louis Pillemer

Louis Pillemer, well known to many immunologists in Great Britain, died unexpectedly on August 31, 1957, at the age of forty-nine years.

Born in South Africa, Pillemer spent all but the first year of his life in the United States. He took a B.S. degree at Duke University in 1932, went to Western Reserve University in 1935 and took his Ph.D. there in 1938. In 1944 Pillemer worked at the Army Medical School in Washington. When he returned to Western Reserve University he became, in quick succession, associate professor of immunochemistry (1946) and professor of biochemistry (1950) without teaching duties at the Institute of Pathology.

His association with W. A. Perlzweig at Duke University, with E. E. Ecker, who was his chief at Western Reserve University for many years, and with E. J. Cohn at Harvard, undoubtedly influenced his experimental approach and orientation, but the direction and drive of his endeavours flowed from his own stormy and original personality and from the intuitive faculties of his mind. When one came to know him intimately, one realized the uncompromisingly high standards of values which guided his scientific decisions and the tremendous emotional strain caused by the demands he so pitilessly made on himself.

Pillemer's experimental work ranged from studies of protein specificity[1] and complement[2] to clinical biochemistry[3] and to the purification of toxins and toxoids[4].

Pillemer made contributions of fundamental significance in several directions, but his choice of research projects was usually strongly weighted by their potential practical value. Purification studies were aimed at an improved combined vaccine of diphtheria–tetanus–pertussis; the later development of a pertussis vaccine by ultrasonic disintegration of the microbes followed by absorption of the protective antigen on human red cell stroma continued this endeavour[5].

During recent years he abandoned other lines of research to turn his attention again to complement; soon 'Properdin' was discovered by him and his small band of enthusiastic and able colleagues and assistants. 'Properdin', acting with components of complement and magnesium ions, was shown to be part of the constitutive defence mechanisms of the mammalian organism and to mediate the destruction of certain micro-organisms and abnormal red cells[6]. By the time of Pillemer's death, it was clear that the discovery of 'Properdin' represented an important milestone in the study of the non-induced defence mechanisms against infection.

Pillemer felt that the highest award a scientist could gain was respect of his colleagues for his work—he certainly gained this award.

Our sympathy goes to his family. He leaves a wife, who as Jean Burrell[7] was among his collaborators, and four sons. Bernhard Cinader

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NEWS and VIEWS

Hydraulics Research :
Sir Claude Inglis, C.I.E., F.R.S.

Sir Claude Inglis is retiring from the post of director of the Hydraulics Research Organization of the Department of Scientific and Industrial Research. According to "Who's Who", Sir Claude was born in 1883 ; those who are familiar with him and with his work will read this statement with some incredulity, for it implies that at the date of his appointment as the first director of the Organization he was already some sixty-three years of age. Although so many fundamental contributions to the subject of hydraulic scale models had been made by British engineers (notably Osborne Reynolds and A. H. Gibson), facilities for such investigations, especially in the field of loose-boundary hydraulics, then lagged far behind those established in many places abroad. Happily, the situation is now different, and this is very largely due to Sir Claude's quiet but effective persistence, his infinite patience and his capacity for continuous hard work ; all combined with his specialized knowledge and the experience of his earlier directorship of the Indian Waterways Experiment Station at Poona. The Department of Scientific and Industrial Research now has a magnificent Hydraulics Research Station at Wallingford (a site chosen by Inglis), which includes a main experimental hall with a floor area of 60,000 sq. ft. Before joining the Department, Sir Claude had comparatively little experience of tidal models ; nevertheless, he has since directed several notable tidal model investigations of considerable complexity. A remarkable feature of his directorship has been his enthusiasm for the development of new measuring devices, the design of novel tide- and wave-making machinery and the exploitation of radioactive isotopes as an aid in tracing the movement of sand and silt. At the same time, he has maintained his interest in the basic mechanics of the regime of channels and the meandering of rivers.

Mr. Fergus H. Allen

Mr. Fergus H. Allen, who has been appointed to succeed Sir Claude Inglis as director of the Hydraulics Research Station at Wallingford, has earned widespread respect and confidence during tenure of the office of assistant director. The site of the Station was only acquired in 1949, and the design and construction of buildings and equipment there have clearly demanded strenuous efforts by all concerned and not least by Mr. Allen, who has shared the responsibility for many of the investigations undertaken both at the Station itself and on other premises, and has at the same time shouldered many of the administrative duties. Mr. Allen has visited hydraulics research laboratories abroad and has been the author or co-author of several publications, including "The Regimen of the Thames Estuary as affected by Currents, Salinities and River Flow", a paper which aroused considerable discussion when it was read by Inglis and Allen at the Institution of Civil Engineers in May 1957. At meetings of the Hydraulics Research Board of the Department of Scientific and Industrial Research and at conferences held by bodies such as the International Association for Hydraulic Research and the Permanent International Association of Navigation Congresses, Mr. Allen has made a very favourable impression by his grasp of the subjects under discussion and by his capacity for lucid exposition. The Hydraulics Research Station may look forward with confidence to continuing progress under his direction.

Irrigation Research Station, Griffith :
Mr. E. R. Hoare

Mr. E. R. Hoare has been appointed as officer-in-charge of the Commonwealth Scientific and Industrial Research Organization, Irrigation Research Station, Griffith, New South Wales. Mr. Hoare comes from the United Kingdom Institute of Agricultural Engineering, Silsoe, Bedfordshire. He has been in charge of the Horticultural Engineering Department, which has made important contributions to research on plant cultivation. He graduated in mechanical and electrical engineering at the University of London in 1934. For eleven years he was research engineer and physicist with the General Post Office. He undertook important services for the Armed Forces during the War, including the synchronization of all radar stations on the east coast of Britain, and the design and installation of D-day cross-channel communications.

Mr. Hoare has applied his experience as a radio and electrical engineer to the study of the basic requirements of the growing plant. In this work he and his team of research workers have developed many original and sensitive electronic instruments for assessing such factors as the respiration of plants and their sensitivity to light and heat. Among the projects successfully developed by the Horticultural Engineering Department under his guidance have been the study of the uptake of water in plants both in glasshouse and open ground cultivation ; cultivation and tractor problems ; plant-culture under glass with special reference to heat requirements ; crop- and pest-spraying problems ; study of light, radiant energy and radioactivity in relation to plant growth.

Giovanni Alfonso Borelli (1608–79)

Mathematician, astronomer, physicist and physiologist, Giovanni Alfonso Borelli was the son of a soldier and was born at Naples 350 years ago on January 28, 1608. A pupil of Galileo, he became professor of mathematics at Messina in 1649 and seven years later, at the invitation of Ferdinand II, Duke of Tuscany, went to Pisa. There he met Malpighi, whom he taught mathematics and physics and from whom he acquired an interest in physiology. Borelli looked upon locomotion, respiration and digestion as mechanical processes, describing digestion as the result of a mechanical trituration of the food within the stomach. He taught, erroneously, that contracting muscle increases in bulk due to fermentation in muscle, and believed that the nerve supplying the muscle discharged a fluid, *succus nerveus*—his substitute for Galen's 'animal spirits'. His neurogenic theory of the heart beat, revived by J. J. C. Legallois in 1812, held the field against the myogenic theory until modern times. Borelli's "De motu animalium", an enormous work in two volumes, was published posthumously in 1680–81. His pseudonymous letter, "Del movimento della cometa apparsa il mese di decembre 1664" (1665), contains the first suggestion of a parabolic path, and his "Theorica mediceorum planetarum ex causis physicis deducta" (1666) deals with the influence of attraction on the satellites of Jupiter. In 1679 he invented a diving apparatus capable of altering the specific gravity of the diver. Borelli returned to Messina in 1668 and in 1674 retired to Rome, where he lived under the protection of Queen Christina of Sweden. A morose, obstinate and quarrelsome man, he died of pleurisy on December 31, 1679.

The Commonwealth Trans-Antarctic Expedition

THE trans-Antarctic survey party led by Dr. Vivian Fuchs reached the South Pole on January 20, where they were met by Sir Edmund Hillary and Rear-Admiral G. Dufek, commander of the American naval base at the Pole. The expedition, which consists of Dr. Fuchs and his team of eleven men, four 'Snocats' and a 'Weasel', with two dog teams and sledges, left Shackleton Base for South Ice on the Weddell Sea on November 24 and started from South Ice for the Pole on December 21. Throughout the journey the expedition has conducted a programme of scientific observations including seismic soundings every thirty miles, gravimetric readings every fifteen miles and meteorological observations every three hours, in connexion with the International Geophysical Year. It is reported that Dr. Fuchs proposes to continue his journey across the Antarctic continent to Scott Base on the Ross Sea using the depots of food and fuel established by Sir Edmund Hillary's earlier supporting party.

Tenth Anniversary of British Ocean Weather Ships

IN August 1957 British ocean weather ships completed ten years of service in the North Atlantic. The first, *Weather Observer*, arrived at station 'Juliett' (53° 50′ N., 18° 40′ W.) on August 5, 1947, and transmitted her first observation to the Central Forecast Office, Dunstable, on that day, thereby inaugurating the active participation of the United Kingdom in the North Atlantic Station Agreement. The record of the ten years work is summarized by Comdr. C. E. N. Frankcom, marine superintendent of the Meteorological Office, in an article in the issue of the *Meteorological Magazine* of October 1957. Besides the usual surface observations, regular upper air ascents with radio-sonde and radar-wind balloons have been made, a difficult task in the high winds so often encountered at the ocean weather stations.

In addition to performing their meteorological work, the four ships have provided navigational assistance to aircraft, carried out oceanographic research, and been used for researches by other institutions, for example, in seismological work by the University of Cambridge. Ten of the marine staff have served throughout the decade and one meteorologist for six years. The ships employed, converted "Flower"-class naval corvettes, are showing wear after their war and ocean-station work and one of them is to be replaced by a larger "Castle"-class frigate now being converted for its new duties. The new vessel, which may be followed by others of the same type, will be much more roomy and comfortable.

U.S. National Astronomical Observatory

THE National Science Foundation has entered into a contract with the Association of Universities for Research in Astronomy, Inc., for the construction, operation and maintenance of a U.S. national astronomical observatory. The Association, which has its principal office in Phoenix, Arizona, comprises the following Universities: California, Chicago, Harvard, Indiana, Michigan, Ohio State and Wisconsin. These Universities joined together to constitute a management group for the new observatory, because they have had experience in operating large observatories and have big programmes of research and graduate instruction in astronomy. As the project develops, it is expected that other universities and individuals will join the Association. The Board of Directors of the newly formed corporation consists of a scientific and an administrative representative of each of the seven participating universities, as follows: *California:* Dr. C. D. Shane, director, Lick Observatory; Mr. J. M. Miller, assistant vice-president, business affairs; *Chicago:* Dr. G. P. Kuiper, director, Yerkes Observatory; Mr. W. B. Harrell, vice-president, business affairs; *Harvard:* Dr. D. H. Menzel, director, Harvard College Observatory; Mr. Edward Reynolds, administrative vice-president; *Indiana:* Dr. F. K. Edmondson, chairman, Department of Astronomy; Mr. J. A. Franklin, vice-president and treasurer; *Michigan:* Dr. R. R. McMath, director, McMath–Hulbert Observatory; Mr. G. L. Lee, jun., controller; *Ohio State:* Dr. P. C. Keenan, professor of astronomy; Mr. C. F. Miller, controller; *Wisconsin:* Dr. A. E. Whitford, director, Washburn Observatory; Mr. A. W. Peterson, vice-president. The corporation appointed Dr. McMath president, Dr. Edmonson as vice-president, and Mr. J. M. Miller as secretary.

The new observatory, when completed, will be open for research to all qualified astronomers. Under the terms of the contract, it is hoped to equip the Observatory initially with a 36-in. and an 80-in. telescope. The National Science Foundation's appropriation for the fiscal year 1958 includes an item of 3·1 million dollars for construction of an optical observatory on a site which is to be selected as a result of extensive tests. The Foundation earlier awarded grants totalling approximately 800,000 dollars to the University of Michigan to support studies leading to the establishment of such an observatory (see *Nature*, 178, 837; 1956). After extensive studies under the direction of Dr. Aden B. Meinel, executive secretary of the Foundation's advisory panel for the observatory, the choice of site was narrowed to five locations: Kitt Peak (6,875 ft.), 40 miles south-west of Tucson, Arizona; Summit Mountain (7,500 ft.), 11 miles south of Williams; Chevalon Butte (6,950 ft.), 40 miles south of Winslow; the Hualapai Mountains (7,350 ft.), 13 miles south of Kingman; and Junipero Serra (5,800 ft.), 21 miles west of King City, California. A special committee, under the chairmanship of Dr. C. D. Shane, director of Lick Observatory, recently spent some time in Arizona reviewing the situation. As a result, site studies will be continued at Kitt Peak and Hualapai and at a new location on Mormon Mountain (8,440 ft.), 35 miles south of Flagstaff, but discontinued elsewhere because recent work has shown that the other sites are unsuitable. Temperature and wind velocity will continue to be measured and seeing conditions tested at the three remaining sites. Studies are expected to be completed by about June 30, 1958.

British Group for Computation and Automatic Control

THE British Conference on Automation and Computation is being organized in three sections, as follows: (*A*) the British Group for the Engineering Applications of Automation; (*B*) the British Group for Computation and Automatic Control; and (*C*) the

British Group for the Sociological and Economic Aspects of Automation Techniques (*Nature*, 179, 948; 1957). At a meeting held on December 20, Group *B*, the British Group for Computation and Automatic Control, was formally constituted, comprising as its members twenty-three professional and learned institutes and societies with interests in these fields.

The objects of the Group are to foster the development and applications of automatic controls, computing and data-processing equipment and programming techniques; to afford a common meeting ground for the adhering organizations; to maintain liaison with other Groups of the British Conference on Automation and Computation and with corresponding national committees of other countries; and to encourage and co-ordinate the presentation at international conferences of British papers on subjects falling within the purview of the Group. Mr. T. E. Goldup (president of the Institution of Electrical Engineers) was elected chairman of the Group, with Messrs. J. F. Coales (Society of Instrument Technology) and E. M. Renals (Institute of Cost and Works Accountants) as vice-chairmen. Mr. J. D. Green (Institute of Chartered Accountants in England and Wales) was elected honorary treasurer, and Mr. W. Bamford (Institution of Electrical Engineers) honorary secretary, and the offer of the Institution of Electrical Engineers to provide secretarial services for the Group was accepted. The chairman, the honorary secretary and one vice-chairman (Mr. E. M. Renals) were chosen to act as the representatives of the Group on the general committee of the British Conference on Automation and Computation, which will also comprise representatives of the two remaining Groups now in process of formation. The constitution of the Group provides for the election of additional member societies: those interested should communicate with the honorary secretary of the Group, at the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

Transparent Magnetic Oxides

The work going on in Prof. L. Néel's laboratory in Grenoble on ferrimagnetism in rare earth iron garnets has recently been extended in the Bell Telephone Laboratories by an investigation of their optical resonance behaviour carried out by J. F. Dillon, jun., using single crystals grown by J. W. Nielsen. These materials are remarkable in that some of them are transparent. Consequently, their Faraday rotation can be conveniently investigated, and it is found that it amounts to several degrees per mil of thickness, so that domains within the crystals can be made clearly visible, enabling the domain structure to be studied over a wide range of temperature and field conditions. Yttrium iron garnet has been most completely studied so far. It has a Curie temperature of 545° K. and a spontaneous magnetization, at 0° K. and infinite field, of 4·96 Bohr magnetons per molecule, which is close to the theoretical value of 5·0. This magnetization results from super-exchange interactions through the O^{2-} ions between Fe^{3+} ions in crystallographically different positions in the cubic lattice. The fact that yttrium iron garnet contains magnetic ions with but a single valence is of great interest, and X-ray and neutron-diffraction studies have shown that, unlike the ferrites, interactions between identical magnetic ions wholly occupying two different crystallographic sites are responsible for ferrimagnetism in the garnet structure.

Systematics and Biology of Ungulates

About sixty zoologists from Belgium, Denmark, France, Germany, Great Britain, Holland, Italy, Russia, Switzerland and the United States, attended a three-day colloquium in Paris on the "Systematics and Biology of the Ungulates" during October 23–26. The colloquium was arranged by the Comité de Direction et d'Administration of the journal *Mammalia* and the (Benelux) Société pour l'étude et la protection des mammifères, under the presidency of Prof. E. Bourdelle, with Prof. Roger Heim as président d'honneur, and Dr. Jean Dorst as secretary-general. After a reception at the Parc zoologique de Vincennes on the evening of October 23, the following three days were fully occupied in the presentation and discussion of some thirty papers embracing many aspects of the subject from classification and conservation to blood groups, placental structure, animal behaviour, and the biology of particular species. The text of these papers, together with some others the authors of which were unable to be present at the colloquium, will be published in full in *Mammalia*. The members of the colloquium agreed, as was plain from the speeches at the concluding dinner where they were the guests of the management of *Mammalia*, that the meeting was most valuable and stimulating not only in its formal business but equally in the opportunity it gave to zoologists working on the Mammalia for informal discussion and exchange of ideas. It is greatly to be hoped that organizations in other countries will follow the example set by their colleagues of France, and will arrange similar international meetings for the benefit of zoologists interested in the study of the Mammalia.

Cytological Techniques and the Apical Meristem

The reactivity of the shoot apical meristem as ascertained by cytological and other techniques, in particular by French observers led by Plantefol and Buvat, has been discussed by Wardlaw (*New Phytol.*, 56, 221; 1957). The French school places great emphasis on the initial or meristematic ring as the active region of the apical meristem, particularly in the inception of leaf primordia and phyllotaxis. The conclusion reached in the paper under consideration is that the cytological investigations now being so vigorously pursued by the French workers and their adherents are to be welcomed as contributing new facts about the distribution of nuclear and cytoplasmic proteins in different regions of the apex; and it should be recognized that the theories and ideas which have been expounded, whether or not they are validated by further work, have given a new impetus and direction to the study of the shoot apex. The results that have so far accrued from this approach, however, tend to forfeit some of their value and objectivity, partly because of the *a priori* complete acceptance and, indeed, over-emphasis, on the part of the protagonists and their followers, of the validity of the underlying theory of phyllotaxis and apical organization, with a consequential tendency for the observations to be somewhat selective in character, and partly because the new observations have not been related to the well-substantiated body of evidence on apical ontogeny, organization and reactivity that has accrued from experimental and other investigations. Lastly, in considering the views of the French workers and criticisms of these views, it is well to bear in mind how very little is yet known about the physiology and biochemistry of the apex.

College

New facts, however, can be sought and they may decide the controversial issues.

Peaceful Uses of Atomic Energy

A MAJOR symposium on the peaceful uses of atomic energy will be held in Sydney during June 2–6. The symposium is being sponsored by representatives of the universities, professional institutes, industrial firms, power authorities, Commonwealth and State departments and the Australian Atomic Energy Commission. The symposium will be a forum for the discussion of technical and scientific aspects of the peaceful uses of atomic energy. Papers will be presented by overseas scientists as well as many Australian contributors. Particular attention will be given to the part atomic energy can play in the development of Australia. There will be several public lectures and a special atomic energy exhibition, to show developments in uranium mining, research into nuclear power and the industrial uses of radioactive isotopes. Further information can be obtained from the Symposium General Secretary, A.A.E.C. Research Establishment, Private Mail Bag, Sutherland, New South Wales, Australia.

University News: London

DR. F. G. FOSTER, lecturer in statistics in the London School of Economics and Political Science, has been appointed to the University readership in statistical computing tenable at that School.

Manchester

THE board of Unilever has given to the Manchester College of Science and Technology £21,000 under a seven-year deed of covenant. Out of this, £2,000 is to be allocated to the staff college, the balance to be divided equally between the Chemistry and Chemical Engineering Departments.

Announcements

A DISCUSSION on "Experimental Results with the ZETA Apparatus on Controlled Thermonuclear Reactions" will be opened by Sir John Cockcroft in the rooms of the Royal Society on February 5 at 3 p.m.

MR. JOHN BUNYAN, Leverhulme Research Fellow, St. Mary's Hospital Medical School, Paddington, has been elected president of the Royal Microscopical Society; he will hold office for two years.

THE Medal of the New York Academy of Medicine has been awarded to Dr. Alphonse R. Dochez for his distinguished service in medicine. After graduation from the Johns Hopkins Medical School, Dr. Dochez was appointed to the staff of the Rockefeller Institute, where, with Gillespie, he established the biological classification of pneumococci into specific types. During the First World War, Dr. Dochez worked on the serological differentiation of hæmolytic streptococci causing respiratory diseases, and later devoted some years to virus studies of the common cold.

MR. LEWIS T. WRIGHT, general secretary of the Amalgamated Weavers' Association, has been appointed to the Council for Scientific and Industrial Research in succession to Mr. W. L. Heywood, who has been appointed a member of the Restrictive Practices Court. Mr. Wright is chairman of both the Production and Scientific Advisory Committees of the Trades Union Congress and is also chairman of the British Productivity Council.

DR. M. E. FOSS has been appointed head of the Department of Chemistry and Metallurgy, Coventry Technical College, in succession to Dr. H. C. Smith, who has been relieved of that office in order to take up the full-time post of vice-principal of the College, of which he has been deputy-principal for the past five years. Dr. Foss, who is vice-chairman of the Bristol Section of the Royal Institute of Chemistry, was senior lecturer in organic chemistry at Gloucester Technical College where he had been on the staff for six years. Prior to that he was lecturer in biochemistry at Guy's Hospital Medical School.

THE sixty-third annual congress of the South-Eastern Union of Scientific Societies will be held in Reading, meeting in the University of Reading, during April 9–11. The president-elect is Prof. H. L. Hawkins. Further information can be obtained from the hon. local secretary, Mrs. A. Hasker, Clarence Lodge, 93 London Road, Reading.

THE Metal Physics Committee of the Institute of Metals is organizing a one-day symposium on "Metallurgical Aspects of Semi-Conductors", to be held on February 25 at the College of Technology, Gosta Green, Birmingham. Further information can be obtained from the Secretary, Institute of Metals, 17 Belgrave Square, London, S.W.1.

THE annual general meeting of Aslib (Scottish Branch) will be held on February 7 in the Scottish Central Library, Lawnmarket, Edinburgh. The chairman will be Dr. W. M. Cumming, and there will be lectures on "United States Information Services to Industry in the United Kingdom" by Miss Margaret Haferd, and "Scientific Information in the Modern World" by Dr. J. C. Malloch. In the afternoon there will be a symposium on "Librarians Here and There".

THE second Australian Conference in Radiation Biology will be held at the Cancer Institute, Melbourne, Australia, during December 15–19. Papers on relevant subjects are invited, and titles and a 250-word abstract should be in the hands of the convener by July 31. Further information can be obtained from Dr. J. H. Martin, Physics Department, Cancer Institute Board, 483 Lt. Lonsdale Street, Melbourne, Victoria, Australia.

THE Ministry of Agriculture, Fisheries and Food is offering the following scholarships for rural workers, or to the sons and daughters of rural workers, of seventeen years of age or more: twenty senior scholarships tenable at universities or colleges, for degree or diploma courses in an agricultural subject or in veterinary science; and thirty junior scholarships, with six extensions for existing holders, tenable at farm institutes for one-year courses in agriculture, horticulture, dairying or poultry husbandry.

Further details and application forms (to be completed by February 28) may be obtained from the Secretary, Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W.1, or from education offices of County Councils.

THE International Council of Scientific Unions Secretariat has removed to a new address at Paleis Noordeine, The Hague, Netherlands.

ERRATUM. In the communication entitled "Antimitotic Activity of 5-Tertiary Butyl Benzimidazolone" in *Nature* of December 21, p. 1428, from paragraph 3 onwards, for "5-tertiary benzyl benzimidazolone" read "5-tertiary butyl benzimidazolone".

NEWER PREPARATIVE METHODS IN ORGANIC CHEMISTRY

A SYMPOSIUM was held jointly by the Chemical Society and the Fine Chemicals Group of the Society of Chemical Industry on "Newer Preparative Methods in Organic Chemistry" at the Chemistry Department, University College, London, on November 7. The meeting took the form of two sessions in the afternoon at each of which three papers were read; the reading of papers was followed by a dinner in the evening, also at University College. The afternoon meetings were attended by nearly 400 chemists and the evening dinner by 116. Papers were read on "Dehydrogenation with Manganese Dioxide" by Dr. R. M. Evans, "Amine Oxidations" by Prof. H. B. Henbest, "Organic Oxidations with Hexavalent Chromium" by Dr. R. Slack, "Mixed Anhydrides as Synthetical Reagents" by Prof. G. W. Kenner, "Some Reactions between Metal Carbonyls and Acetylenic Compounds" by Dr. M. C. Whiting and "Some Applications of Metal Carbonyls in Organic Chemistry" by Dr. P. O. Lenel.

The meeting was opened by Prof. E. L. Hirst, who mentioned that this was the first joint meeting between the Chemical Society and the Fine Chemicals Group and expressed his hope that it would be a successful one. Dr. B. A. Hems took the chair at the first session and Prof. E. R. H. Jones presided over the second.

The purpose of the meeting was to discuss the applications of some reagents that have recently come into prominence in preparative chemistry and of which the scope and details of experimental methods may not yet be widely known. The authors of the papers had themselves had extensive personal experience of these reagents and could point to the theoretical and practical significance of various methods of using them.

Dehydrogenation by manganese dioxide was discussed by Dr. Evans. When this reagent is used for dehydrogenation the method of preparation and the physical form of the oxide appear to have a considerable effect on its reactivity. One form, prepared under strongly alkaline conditions, appears to be the best for dehydrogenating unsaturated primary or secondary alcohols to $\alpha:\beta$-unsaturated aldehydes or ketones, whereas an acidic form appears to be better for dehydrogenating unsaturated ketones, at least in the sterol group. Dr. Evans pointed out that manganese dioxide brought about many other oxidizing reactions under more vigorous conditions, but that selectivity was then lost. The most useful applications of this reagent lay with specially active forms of the oxide used in mild conditions on polyene or polyenyne alcohols that were difficult to oxidize to the corresponding aldehydes or ketones by other methods.

The dehydrogenation of amines to give unsaturated compounds was discovered many years ago but has received very little application in general preparative chemistry. It is to be expected that the work that Prof. Henbest and his colleagues are doing on the subject will bring this potentially useful reaction to the notice of a wider audience.

He mentioned in his paper that tertiary amines are generally regarded as being chemically rather unreactive, but pointed out that this is not so. Dehydrogenation with mercuric acetate under mild conditions in dilute acetic acid gives enamines. Sometimes in a heterocyclic ring system complete dehydrogenation to the aromatic ring will take place, but often partial dehydrogenation can also occur. He compared this with the action of manganese dioxide on tertiary amines, where again enamines are formed under mild conditions, but this is often accompanied or followed by oxidative cleavage of the double bond to give amides. Diethylaniline gives a mixture of ethylvinyl aniline and ethylformanilide.

The third of the oxidizing agents discussed, chromic oxide, is, of course, widely used for a variety of purposes. It may be applied to both dehydrogenations and oxidations by a diversity of methods the theoretical and practical significance of which is not yet thoroughly understood. Differences undoubtedly exist about the effectiveness with which these different techniques can be used on different substrates, and although it is probable that a common theoretical background exists, it is nevertheless true that much has yet to be learnt about the best method to be used on any particular type of substance. Dr. Slack pointed out that oxidations with chromic oxide in acetic acid were often not stoichiometric, that chromic oxide could still remain, even in the presence of unoxidized substrate, because its oxidizing action was inhibited by the presence of lower valency forms of chromium. He added that one function of the sulphuric acid, sometimes added to these reactions, is to overcome this inhibition. He compared the uses of chromic oxide as its pyridine complex or tertiary butyl ester and finally pointed to the existence of some other hexa- and penta-valent chromium complexes such as acetyl chromic acids or complex salts derived from trichloro oxo-chromium (V) that had not yet been investigated by organic chemists but might repay some attention.

These three papers composed the first session of the meeting and were followed by three on condensation reagents.

Mixed anhydrides have come very much into prominence during the past few years for condensations involving carboxyl groups where, because of the delicacy of either the starting materials or the final product, mild reaction conditions are required.

Another advantage that mixed anhydrides have is that one of the partners is usually derived from a small and relatively cheap molecule, and their use avoids the wasteful regeneration of a molecule of the larger and perhaps much less accessible acid. Prof. Kenner pointed out that in a mixed anhydride a cleavage reaction could theoretically take either of two directions and he discussed the relative activities of various groups showing that the attack of a nucleophilic reagent was determined by the relative electrophilic character of the two parts of the anhydride. This, however, was not the only factor affecting reaction; the pK of the acids taking part, steric hindrance and the co-ordination number at the electrophilic centres also played a part in determining which of the two reaction products would predominate. Mixed anhydrides derived from chloroformic ester, phosphoric and sulphuric acids or their esters had shown themselves to be extremely useful in the synthesis of peptides and nucleosides.

The last two papers were on metal carbonyls. Frequently to-day, new preparative methods involve the use of reagents that a few years ago were considered too difficult or too dangerous to handle because of the risks of explosion, fire or toxicity. The hazards of using acetylene under pressure and the toxicity of carbonyls frequently cause these reagents to be avoided and it is hoped that these papers, in which safe methods of handling were discussed by the authors, may alleviate some of these fears.

Dr. Whiting stressed the usefulness of nickel carbonyl in reacting with acetylenes having a terminal triple bond to give α-substituted acrylic acids, a type of compound otherwise rather inaccessible. These reactions are carried out in acetic acid at moderate temperature, with excess carbonyl which is not difficult to handle provided that its transfer from vessel to vessel is carried out under conditions involving only a very slight degree of exposure to air, and provided that excess is removed from the reaction mixture by co-distillation with ether. The distillate is immediately disposed of and leaves a reaction mixture that can safely be handled in the usual way. Even so, both he and Dr. Lenel pointed out that although these substances could be handled safely they still had to be treated with considerable respect. Dr. Whiting also went at some length into the mechanisms of these reactions. He was followed by Dr. Lenel, who dealt mostly with the industrial applications of carbonyls in reaction with acetylenes to give unsaturated acids, or with olefines to give saturated acids. Cobalt carbonyl catalyses the important reaction of carbon monoxide and hydrogen with olefines to give aldehydes which can then be reduced to alcohols by hydrogenation. The industrial preparation of alcohols and acids by these reactions is now carried out on a very large scale involving many thousands of tons of product per annum, though the reactions necessitate fairly high temperatures and pressures. Several other carbonyls of transitional elements are known, though they have not yet achieved prominence in an industrial sense; they are of profound interest to the inorganic and theoretical chemist because their constitutions throw new light on electronic structures.

This was, as Prof. Hirst pointed out, the first joint meeting of the Chemical Society and the Fine Chemicals Group of the Society of Chemical Industry, and it is very much to be hoped that it will be followed by others. The members of the Fine Chemicals Group are predominantly interested in the preparation of complex chemicals in a high degree of purity: perfumes, photographic sensitizers, drugs, vitamins and hormones, for example. These processes often involve twelve to twenty stages that, if they are to be carried out efficiently, demand the use of the most up-to-date knowledge and techniques available. This Group, of all the special groups in the Society of Chemical Industry, is the one that has the strongest kinship with the Chemical Society. With the rapidly increasing activity in industrial chemistry of all kinds and the rapid extension of industrial technical staffs, joint meetings of this kind can be a valuable aid to progress. A closer relationship between the members of the two Societies can be of great benefit to both.

INTERACTION IN IONIC SOLUTIONS

THE Faraday Society held a general discussion on "Interaction in Ionic Solutions" at Oxford during September 17–19. The meeting was held in the University Laboratory of Physiology, and more than 180 members and visitors stayed in Balliol College, where the guest-night dinner was held. The president of the Society, Mr. R. P. Bell, in opening the discussion, reminded those present that a general discussion on "Electrolyte Solutions" had been held thirty years ago in Oxford. In fact, the president's first published contribution to the subject was presented at that meeting in 1927 in a joint paper with Sir Harold Hartley. Among others present, who had attended and contributed to the earlier discussion, was Prof. H. S. Harned (Yale), who delivered the Spiers Memorial Lecture on "Some Recent Experimental Studies of Diffusion in Liquid Systems". Prof. Harned gave an account of the elegant experimental techniques for the precision measurement of diffusion in electrolytes which have been recently developed at Yale, and indicated some of the many possible directions of further advance. The accurate determination of activity coefficients by diffusion measurements is a remarkable achievement.

The first paper to be discussed was that by Prof. H. Falkenhagen and Dr. G. Kelbg (Rostock), which dealt with the extension of the limiting-law equations. Dr. M. Eigen (Göttingen) directed attention to the information that can be obtained about the intimate details of short-range interaction in bi-bivalent electrolytes by the observations of relaxation effects in sound-absorption spectra. Dr. S. Levine and Mr. H. E. Wrigley (Manchester) reported a calculation of the interaction of two univalent ions at small separations, and considered the relevance of the macroscopic dielectric constant of the solvent in this situation. In discussion, Prof. L. Onsager (Yale) directed attention to some recent mathematical advances which might help in the electrolyte problem, while Prof. H. S. Frank (Pittsburgh) seized the opportunity to express heretical views about the Debye–Hückel theory. A paper by Prof. T. F. Young, Mr. Y. C. Wu and Dr. A. A. Krawetz (Chicago) reported some measurements of the heat effects due to interactions between ions of like charge when pairs of univalent electrolytes with an anion or cation in common are mixed.

There followed a major section devoted to the presentation and discussion of papers dealing with the incomplete-dissociation model as a way of handling short-range ion–ion interactions. Prof. C. W. Davies (Aberystwyth) surveyed the present position in an introductory paper. Prof. E. A. Guggenheim (Reading) considered the ion distribution in dilute aqueous solutions of single binary electrolytes, and concluded that although the Debye–Hückel approximation is invalid for bi-bivalent sulphates in water, the model (complete ionization to rigid spherical ions) is satisfactory if, following N. Bjerrum, ions of opposite charge approaching more closely than 10–14 A. are treated as associated. Dr. O. Redlich and Dr. G. C. Hood (Shell Development Co., California) presented the results of Raman and nuclear magnetic-resonance investigations of the dissociation of strong acids (including nitric, perchloric and sulphuric acids). The agreement between the results is very satisfactory. Mr. W. D. Bale, Mr. E. W. Davies, Mr. D. B. Morgans and Dr. C. B. Monk (Aberystwyth) reported on the study of various ion association equilibria by spectrophotometry. Mr. W. G. Davies, Mr. R. J. Otter and Dr. J. E. Prue (Reading) reported precise spectrophotometric results for copper sulphate solutions, and discussed the significance of the dissociation constants obtained from cryoscopic, conductimetric and spectrophotometric measurements. Dr. G. H. Nancollas (Glasgow) gave an account of attempts to obtain and interpret heat and entropy changes for ion association reactions. In the discussion of this section there was general agreement about the validity and usefulness of the incomplete dissociation model for higher-valent electrolytes, but there was some dissension, particularly between Prof. Davies and Dr. Prue, about the relation of the numerical values of the dissociation constants to the choice of a distance of closest approach of free ions.

A section on ion-solvent interaction was introduced by Prof. H. S. Frank and Dr. Wen-Yang Wen (Pittsburgh), who discussed the several ways in which they consider ions affect the structure of water. Dr. O. T. Samoilov (Moscow) had submitted a paper on "A New Approach to the Study of Hydration of Ions", but was unfortunately absent. Dr. S. R. Gupta, Dr. G. J. Hills (Imperial College) and Dr. D. J. G. Ives (Birkbeck College) considered that their recent very precise measurements of activity coefficients of aqueous hydrochloric acid solutions over a temperature-range provide evidence for changes in heat capacity which can be interpreted in terms of changing ion-solvent interactions. A theoretical paper by Dr. A. D. Buckingham (Oxford) led to the conclusion that the ion-quadrupole term is significant in the interaction between the ion and solvent molecule, and that the dielectric-saturation effect is unimportant outside the first hydration sphere.

Few real advances or firm conclusions were discernible in the ion-solvent interaction section. However, there is considerable evidence for the existence of the proton as a tetrahydrate in water. It is entirely reasonable that a hydroxonium ion forms strong hydrogen bonds with three neighbouring water molecules and Dr. K. N. Bascombe and Mr. R. P. Bell (Oxford) showed that the variation of Hammett acidity functions with concentration in concentrated strong acids can be satisfactorily interpreted with such a model. Their general conclusion was supported by Dr. Th. Ackermann's (Hamburg) study of the heat capacity and infra-red absorption spectra of aqueous acid and alkali solutions. Further support was provided by the X-ray diffraction studies of aqueous electrolyte solutions by Mr. C. L. van Panthaleon van Eck, Mr. H. Mendel and Mr. W. Boog (Royal Dutch Shell, Amsterdam). This method shows considerable promise as a direct way of exploring the solvation problem; present results suggest that water molecules in water and potassium and calcium ions are octahedrally surrounded by six water molecules.

Dr. P. A. H. Wyatt (Sheffield) considered the interpretation of acidity functions in concentrated acids. Dr. M. Kaminsky (Marburg) discussed the relationship between the dependence on temperature of viscosity of aqueous solutions and the ion-solvent interaction. A paper on the dependence on concentration of the surface potentials of a number of electrolyte solutions by Dr. J. E. B. Randles (Birmingham) suggested that the interpretation of the results is too complex to lead to reliable evidence about ion hydration. Mr. M. Smith and Dr. M. C. R. Symons (Southampton) presented a study and interpretation of the effects of changes of solvent, added electrolyte and temperature on the first electronic absorption band of the iodide ion.

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REORGANIZATION OF THE METEOROLOGICAL OFFICE

In 1955, the Secretary of State for Air appointed a Committee under Lord Brabazon to review the organization of the Meteorological Office. This Committee took evidence from users, both inside and outside Government service, of the services provided by the Meteorological Office, and from members of the Office staff. The main features of the Committee's report, which will not be published, were given to the House of Commons in June by the Minister for Air.

The Committee agreed that the Air Ministry should continue to be responsible for the Meteorological Office, and expressed the opinions that the standing of the Office as a scientific institution is high and that users have considerable confidence in the services provided for them. In considering possible lines of advance the Committee singled out the development of numerical methods of forecasting as one of the most important, welcomed the forthcoming installation of an electronic computer in the Office, and suggested there was a possibility of achieving greater precision in local forecasting by a closer study of weather characteristics and by the use of the radar-echo method of observing cloud and precipitation.

As regards internal arrangement, the Committee recommended that the Office should be reorganized into three 'prongs' dealing, respectively, with forecasting and services, research, and administration. This reorganization was put into force in July 1957. Its recommendations also led to a regrading of the senior posts whereby the post of Director has been raised to that of Director-General, the forecasting and services 'prong' is placed under the Director of Services and research under the Director of Research, each of the two latter posts being in the grade of chief scientific officer. The administrative 'prong' now under an assistant secretary has been enlarged to make the Office more self-contained in administrative matters.

Several new posts in the grade of senior principal scientific officer have also been created, and the number of the highest posts available to members of the experimental officer class will also be increased. These measures will improve the career prospects, a matter on which the Brabazon Committee expressed considerable concern, for all classes of the staff. The need for improvement was especially evident in the scientific officer class, to which it had been difficult to attract recruits of sufficiently high ability.

On the Services side the new posts include a senior principal scientific officer to control 'Techniques and

Training' with the special task of ensuring close contact between research and forecasting.

Another new post in the same grade, responsible direct to the Director-General, has been established to co-ordinate the increasingly large volume of work in international meteorological relationships.

In considering research the Brabazon Committee paid tribute to the work of the Meteorological Research Committee which, established in 1942, has had an outstanding success. The Director-General expressed in his article the gratitude of the Office to the many outside scientists who have devoted so much time to that Committee's work.

The re-organization is particularly striking on the research side, which for the first time in the history of the Office can now be said to be fully developed. The Director of Research, whose regrading has already been mentioned, will have under him a deputy-director especially responsible for research in physical meteorology. The assistant directorates of research, all at the senior principal scientific level and increased in number by two, will be respectively responsible for controlling research in dynamical meteorology—primarily in numerical forecasting—in synoptic meteorology, special operational investigations, climatological research, atmospheric physics, and instrument development. The post of head of the Meteorological Research Flight, one of the world's primary units of upper air research, has been raised to senior principal scientific officer.

The system of general supervision of the work of the Office by the Meteorological Committee has been changed. The Brabazon Committee reported that the previous Meteorological Committee, which was a large body representative of Government departments using the services of the Office, of the Royal Societies of London and Edinburgh, and the universities, had ceased to perform any very useful function. The Committee recommended the formation in its place of an advisory committee from outside Government service. The Secretary of State accepted this advice and has established a new Meteorological Committee consisting of an independent chairman, two scientists and two laymen. One of the scientists is to be the chairman of the Meteorological Research Committee and the other is to be appointed in consultation with the President of the Royal Society. The Committee will keep under review the progress, efficiency, broad policy and scale of effort and cost of the Office and ensure the maintenance of adequate contacts between the Office and users of its services. The chairman is Lord Hurcomb and the members are Sir Austin Anderson, Sir David Brunt, Sir Charles Normand and Colonel Stopford Sackville. The Meteorological Office Advisory Council for Scotland remains unchanged.

The Brabazon Committee welcomed the decision already taken to bring together the headquarter units of the Office, now situated in central London, Harrow and Dunstable, into a single group of new buildings at Bracknell. The benefits of the reorganization will be fully felt when the new buildings, of which the planning is now well advanced, come to be occupied.

ROTHAMSTED EXPERIMENTAL STATION

THE agricultural production of the British Isles, while high for the available area of land, is still capable of great expansion. Sociological considerations apart, increases in production will, to a great degree, depend on the work of agricultural research stations. Among these stations, Rothamsted is pre-eminent in the breadth of studies carried out. Its activities are, of course, not confined to the British Isles but are gradually reaching out to many parts of the world, and the Station regularly participates in work on agricultural problems of great importance to the Commonwealth.

It is impossible in the compass of a short article to do justice to, or to present a really fair picture of, the great variety of pure and applied studies being made at such a station. The following account merely mentions some lines of investigation which struck the writer as being of particular interest and which may stimulate the reader to study the report* itself.

In the Physics Department studies continue on the microclimate in crops of wheat and potatoes. In particular, data have been obtained on the condensation and evaporation regimes and a special recording anemometer has been developed for measuring low wind-speeds within the foliage. Further important fundamental studies have been on the surface physics of clays and the mechanism of soil structure-formation. The latter subject is reviewed in a special article at the end of the report.

The Chemistry Department reports a large and varied programme of work. Experiments on the placement of fertilizers have continued, and the effects of different nitrogenous fertilizers, including formalized casein, have been studied on a wide range of crops. Work on the loss of nitrate by denitrification has shown that such loss is insignificant if the moisture content of the soil is less than 60–70 per cent of water-holding capacity. Studies on phosphate uptake using fertilizers labelled with phosphorus-32 show that the radiation effects of the active isotope are generally negligible.

The Pedology Department, in close collaboration with the Soil Survey, has continued to investigate the nature of soil parent materials derived from both igneous and sedimentary rocks. Important information on the formation of aggregates and the location of exchangeable cations is being obtained by calorimetric methods. Among other projects, work is continuing on water-absorption and potassium fixation by clay minerals and on the nature of the leaf extracts which affect constituents of soil profiles.

The Soil Microbiology Department is mainly concerned with the biological interactions in soil which encourage or control the growth of micro-organisms. The micro-population of the rhizosphere is, of course, specially important since it may influence the availability of nutrients and may include pathogens. A group of bacteria resistant to certain antibiotics has been found to be abundant in the root surroundings but rare elsewhere in the soil. Other important studies include the decomposition of herbicides and insecticides in the soil and the processes of root-hair infection by nodule organisms.

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*Report of the Rothamsted Experimental Station for 1956. Pp. 280. (Harpenden: Rothamsted Experimental Station, 1957.) 10s.

Investigations in the Botany Department have shown that the higher yields of improved strains of barley and beet are not due to higher net assimilation-rates or greater leaf area but to a more effective translocation of the products of photosynthesis. It appears that the efficiency of photosynthesis cannot be significantly increased by breeding. Ecological studies of weeds have cast doubt on the efficacy of temporary leys as a means of eradicating wild oats.

The emphasis of the work of the Biochemistry Department is on the nature of enzyme action. The enzyme from bracken that destroys vitamin B has been prepared in a stable form, and its action has been studied by improved methods. Studies of tobacco mosaic virus have shown that the whole virus is not essential for infectivity, but that a low level of infectivity is associated with fragments of it. Some parts of the enzymic processes by which viruses lose their infectivity on storage in the laboratory have been examined as a preliminary to studying the mechanism of attack on susceptible hosts.

Members of the Plant Pathology Department are also studying the tobacco mosaic virus and have shown that infectivity may reside in the nucleic acid fraction and antigenic specificity in the protein. Five viruses infecting leguminous plants were identified and five more in cereals and grasses. This raises the very interesting question as to whether the beneficial effects of ploughing-up and re-seeding old leys may be partly due to the elimination of virus-infected grasses and clovers. Important work continues on sugar-beet virus and, on the mycological side of the Department, on potato blight.

The Nematology Department has paid particular attention to bud and foliar nematodes. Work is continuing, in association with the Biochemistry Department, on the hatching factors given out by potato roots, and preliminary studies have been made of the factors affecting hatching of eggs from cysts of beet eelworm and on the movement and activity of larvæ in soil.

The Insecticides Department is working on the persistence and fate of insecticides in the soil. The factors influencing the toxicity of insecticides are also receiving attention. Toxicity is, for example, influenced by temperature, and the effect of change of temperature on speed of action differs for the different insecticides. Further work has been done on the mode of action of the organo-phosphorus insecticides. It is known that they affect choline esterase, and a comprehensive study of this enzyme as it occurs in insects is being made. The effect of plant protection chemicals on beneficial insects have been further investigated and techniques devised for the diagnosis of poisoning in bees.

The Entomology Department has carried out regular surveys of Rothamsted and Woburn farms for pest insects which will be of the greatest value to those carrying out experiments in these areas. Investigations have been started of the influence of climatic factors on insects: in the field on the effect of microclimate on growth, and in the laboratory on the relation between fat metabolism and temperature. Work on the wheat bulb-fly has continued, with special attention being paid to the reaction of the larvæ to plant exudates.

In the Bee Department a very important advance has been made in the study of European foul brood. *Streptococcus pluton*, an organism suspected of causing the disease, has been isolated in pure culture, and it has been found that this organism and *Bacillus eurydice* have both to be present in a larva to cause the disease. Di-*n*-decyldimethylammonium bromide promises to be an effective control. Further studies have been made of the nature of 'queen substance'. It has been found that 'queen substance' received in regurgitated food from other workers is sufficient to inhibit development of the ovaries in the absence of a queen. It has also been shown that mammalian hormones such as androsterone, as well as extracts from queen ants, inhibit ovary development.

In the Statistics Department the electronic computor is now fully occupied, and an interesting application is the analysis of some of the very long-term experiments at Rothamsted. A useful account of the computor and its capabilities is given at the end of the report. Nation-wide surveys of fertilizer practice and cattle diseases are in progress.

Progress reports are also given by the Field Experimental Section, the farms at Rothamsted and Woburn, the Soil Survey of England and Wales and the advisor in tropical soils. The report closes with the review articles on soil structure and the electronic computor referred to above. R. M. S. PERRIN

ASTRONOMY AT THE CAPE OF GOOD HOPE

THE Report of Her Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for 1956[*] appears under seven headings. In the first of these, "Buildings and Grounds", reference is made to the amount of maintenance work that has been carried out, with the result that the general condition of the buildings and grounds is now very satisfactory. A new building has been erected to house the Lyot heliograph, and the new 65-h.p. fire pump, mentioned in the report for 1955, was installed in January—fortunately in time to prevent large grass fires in February and March in adjoining properties from spreading into the Observatory grounds.

Under "Instruments", accounts are given of the work carried out with the reversible transit circle, the Victoria telescope, the astrographic telescope, the 18-in. reflector, the photoheliograph, and the new d.c. amplifier (No. 6) for the astrographic photometer, which was started in 1955. The first visual observations made with the 18-in. reflector showed that a number of minor modifications were necessary, and when the report was compiled it was hoped that the instrument would be brought into routine use during the first half of 1957. A third Brown recording potentiometer has been purchased for use with the instrument.

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[*] Report of Her Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for the year 1956. Pp. 11. (Cape of Good Hope: The Observatory, 1957.)

"Observations and Reductions" includes the routine work with the reversible transit circle, with which a total of 11,801 transits were observed during the period under review, and 530 observations were also made of the Sun, Moon, the planets and Ceres and Vesta. Of the other nine sections of this programme, reference may be made to "Proper Motions", for the determination of which 68 plates were taken with the astrographic refractor. Owing to the poor condition of the axes of the telescope, which made precise guiding of long exposures very difficult, this programme was not stressed during 1956. After the renewal of the main bearings early in 1957 every effort will be made to complete this programme as quickly as possible. Among matters of interest in "The Radcliffe Section" special mention may be made of the work of Dr. D. S. Evans, who obtained measurable spectra of five regions, in *NGC* 253, using the Newtonian spectrograph. It was possible to identify the nearer edge of this extragalactic nebula and to trace out its spiral arm system, and the spectrograms show that the system is rotating with the arms trailing. It may also be mentioned that a start has been made with the production of an atlas of southern extragalactic nebulæ: this atlas will consist of enlarged prints from selected plates, each plate being accompanied by a short description.

One disconcerting feature is mentioned under "Personal Establishment", which may not, however, be confined in its implications to the southern hemisphere. Only one Observatory officer of those recruited since the War remains on the staff, most of the others having resigned at one time or another to take up more remunerative employment. H.M. Astronomer, Dr. R. H. Stoy, adds the following comment: "This once again emphasizes the many representations that have been made to the Admiralty that the conditions and prospects at present offered are completely unattractive to potential recruits".

Under "Miscellaneous", reference is made to the regular meetings of the Cape Centre of the Astronomical Society of South Africa, and on the second and fourth Saturday evenings of each month members of the Centre have been in attendance, when the weather is fine, to show members of the public celestial objects through the 6-in. telescope. These meetings have been well attended and greatly appreciated by the public.

LINNÆUS

THE Swedish Linnean Society this year celebrated its fortieth anniversary. There are twenty or so Linnean Societies (that of London being the oldest); but the Svenska Linné-Sällskapets differs from the rest in being concerned solely with Linnæus.

The Årsskrift for 1956–57 (Vols. 39–40. Pp. 198+24. Uppsala: Almqvist and Wiksells Boktrykeri *AB.*, 1957) is admirably produced. It is surprising how, year after year, a considerable volume is issued throwing further light on aspects of Linnæus's life, writings, associations and period, and this, of necessity, with little reference to the mass of material at Burlington House in London. (Incidentally, this material still needs a good deal of sorting by someone thoroughly competent in Swedish and Latin—and able to read Linnæus's writing—such as Dr. A. Hj. Uggla, secretary and editor of the Swedish Society, who has given such valuable service in this connexion.) The first paper in the present volume is "Linnæus and Cornwall" by Spencer Savage. Its title might lead one to think that Linnæus had contrived to visit the county during his short time in England in 1736, but it refers to his interest in Cornish mineralogy. W. Borlase, vicar of Ludgvan, well known for his "The Natural History of Cornwall", was asked by his friend, John Andrew, then studying medicine at Leyden, to send a "little box" of various ores and mundics apparently to gratify the curiosity of Boerhaave. The minerals sent were shown to Linnæus who, in the opinion of Boerhaave, "understands the nature of all kinds of mettals the best of any one in the World". Gronovius undertook their naming and sent a list following Linnæus's nomenclature. A further collection was forwarded, and, with their names, Gronovius sent a copy of a report he had received from Linnæus on the liquefaction of copper. (A third set of minerals was sent, after Linnæus had left Leyden, but no copy of this was found in Borlase's papers at Penzance and Truro.)

A. J. Boerman writes about Linnæus's candidature for his medical doctorate. To save both time and money, many Swedish medical students took their degree at the University of Harderwijk previous to hearing Boerhaave's lectures at Leyden. Before presenting and defending his thesis Linnæus had to show that his general medical knowledge was of the standing expected of a doctor. It is known that he had written his thesis before leaving Sweden; but the day after arriving at Harderwijk he had to prepare a manuscript for his Candidatus Medicinae. The text of what appears to be a fair copy of the Latin original (Linnean Society, London) is given and its English translation. There is certainly much still to be learned about Linnæus's activities in Holland.

The remaining eight principal papers are in Swedish. Carl-Axel Torin writes on Linnæus as 'rusthållare' in the horseguards. At that time landlords, as part of their tenure, had to procure and maintain a number of soldiers for the standing army, and provide them with a small plot of land. The archives of the regiment show that when Linnæus acquired Hammarby in 1758 he was responsible for four dragoons and their horses. During the Seven Years War two of these dragoons lost their lives and Linnæus had much difficulty in replacing them.

A long contribution by Gunnel Hazelius-Berg and Sigurd Wallin deals with Linnæus's wardrobe at Hammarby, with much contemporary allusion. It is amusing to find that the three-cornered hat, covered with pale green silk with a rose-coloured band, so often figured as his Dutch doctor's hat, is simply one of the kind received by the successful candidates for the medical doctorate at Upsala.

Nils Sylvén gives a catalogue of the plants of Linnæus's native parish, collating his data with those given by Linnæus, and Assar M. Lindberg, recording the tradition that three ecclesiastical families in Småland—Lindelius, Tiliander and Linnæus—took their names from a large lime tree at Jonsboda, shows that both Linnæus's father, and Tiliander, the father's uncle, so derived their names, but not Lindelius. The tree disappeared about 1823, but its site is still pointed out. Olaf Svanberg writes on "Pan Svecicus". Linnæus, in his Dalecarian journey in 1734, noticed how horses avoided certain plants. This prompted a study of which plants were eaten by various domestic animals, and twenty years later he formed a team of about thirty students to make observations; in 1749 he published a list of 600 species ("Pan Svecicus"). Prof. Svanberg has carried out an investigation on similar lines, and has established that lymphadenosis, a disease among cattle in one district of Sweden, is caused by calves eating *Ranunculus acris* which is now left standing in the fields.

Hugh Osvald discusses Linnæus's 'hay-seed'. During practically the whole of the eighteenth century Swedish agriculturists suggested the introduction of foreign plants as a means of improving fodder. Linnæus stated that a Swedish plant, *Medicago falcata*, would serve this purpose; but, in spite of his prestige, his suggestion was not generally accepted. Recently this plant has been crossed with other species of the same genus with the object of producing a fodder suitable to Swedish conditions.

A. Hj. Uggla publishes a series of letters from the younger Linnæus to Abraham Bäck, his father's most intimate friend, written in 1778, the year after his death. They contain the son's answers to questions put while Bäck was writing his commemorative address for the Academy of Science. They are of great value in throwing light on Linnæus's character and ideas and also give an impression of the difficulties the son had in following his father as professor, without his standing.

A number of smaller papers on points concerning Linnæus and the Society add to the picture of lively interest.

There is an English summary of the principal contents. A most valuable supplement is an index to the content of the forty volumes of the yearbook, which contains a wealth of information that will prove invaluable when a reasoned account of Linnæus as a scientist, his influence on the development of ideas, and his personality is attempted.

J. RAMSBOTTOM

APPLIED PROBABILITY

"APPLIED Probability" is an exceedingly valuable collection of papers badly mistitled*. In no sense could the first three contributions (by Lévy, Doob and Feller) be regarded as essays in *applied* mathematics. Thus, Lévy's paper, ostensibly about Brownian motion, studies an abstraction of that phenomenon involving $(2p + 1)$-dimensional 'time', which would not be appropriate for the description of the physicists' Brownian motion even when $p = 0$. This comment is not intended to be uncomplimentary; rather the reverse. The reviewer only regrets that many who would find interest and even inspiration in this book will leave it unopened because of its unfortunate title.

To return to Lévy's paper, a fascinating and apparently very difficult problem is suggested by the series of papers by Lévy, of which this was the first to be written (though not the first to appear). Let E_n be real n-dimensional Euclidean space (or Hilbert space, when we write $n = \infty$), and let $d(x,y)$ denote the distance between the points x and y in E_n ($\| x-y \|$, if $n = \infty$). Then it is known that a Gaussian random function $f(x)$ can be constructed in such a way that

$$\mathcal{E}\,(f(x) - f(y)) = 0\,; \quad \operatorname{var}\,(f(x) - f(y)) = d(x,y)$$

If A is a set of points in E_n, and if the values of $f(x)$ for x in A are given, then Lévy writes $\mathcal{E}\,(\ldots \mid A)$ and $\operatorname{var}\,(\ldots \mid A)$ for the corresponding conditional means and variances of various random quantities. In particular, if S_t is the surface of a sphere centred at the origin in E_n and of radius t, and if K_t is the region outside S_t, Lévy considers the quantities

$$\operatorname{var}(f(0) \mid K_t) = c_n t \text{ and } \operatorname{var}(f(0) \mid S_t) = c_n' t$$

which plainly depend on t in the manner indicated and on the dimensionality n. When n increases, c_n and c_n' both decrease, and it is asserted that

$$\lim_{n\to\infty} c_n = c_\infty = 0\,; \ \lim_{n\to\infty} c_n' = c_\infty' = 1 - 2^{-1/2}$$

Now $f(x)$, as a random variable having a finite variance, can be identified modulo a suitable equivalence with a point in the Hilbert space of random variables having a finite expected square; thus, in the case $n = \infty$, we can think of $f(.)$ as mapping one Hilbert space into another in such a way that

$$\| f(x) - f(y) \| = \sqrt{\| x-y \|}$$

The existence of such square-root mappings is well known and some of their surprising properties have been studied[1]. One of the results of Lévy which has been noted above suggests that the following geometrical relation ought to hold for square-root mappings of the kind just described: $f(0)$ lies in the closed linear variety spanned by $f(K_t)$. If this could be proved directly, much insight would be gained into the studies Lévy has made of such many-parameter 'Brownian motions'.

The papers by Doob and Feller may both be regarded as contributions to generalized potential theory. Doob's paper summarizes results which have already been reported by him in detail elsewhere[2] and which are concerned with solutions to abstract problems of the Dirichlet type directed by the following key idea: the boundary is to be approached in such a way that the instantaneous motion at any point is controlled by the harmonic measure. There is a slight link with Lévy's paper in that in some simple concrete situations the trajectories will be those of one-parameter Brownian motion. Doob's paper is again one of a long series; the latest has just appeared in the Russian probability journal *Teoriya Veroyatnostei*. Feller might be said to be writing about generalized discrete harmonic functions; specifically he studies the solutions to the equations

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* Applied Probability. (Vol. 7 of Proceedings of Symposia in Applied Mathematics of the American Mathematical Society.) Pp. v+104. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 37*s.* 6*d.*

$$x_i = \sum_{j=1}^{\infty} p_{ij} x_j \quad (i = 1,2, \ldots) \qquad (1)$$

where the coefficients p_{ij} are non-negative and sum (over the suffix j) to unity for each separate i. Such *stochastic matrices* (p_{ij}) are of immense importance in modern probability theory. The structure of the set of natural solutions to the associated equations

$$y_j = \sum_{i=1}^{\infty} y_i p_{ij} \quad (j = 1,2, \ldots)$$

(that is, the solutions such that $\Sigma \mid y_i \mid < \infty$) is relatively simple and has been known for some time, but the structure of the set of natural (in this case, bounded) solutions to (1) is exceedingly intricate and is just now being unravelled by Blackwell[3] and Feller. Feller studies among other things the extremal solutions to (1) and their relation to the various possible 'escape routes' for systems the stochastic motion of which is governed Markov-chainwise by the matrix (p_{ij}). It has been customary in the past to speak of the system's escape to 'infinity' if the (Cesàro) limits of the n-step transition probabilities do not total j-wise to unity. This use of language should imply that the set of states (1, 2, 3, . . .) has been compactified by the addition of a single 'point at infinity'. The main content of Feller's work shows how much more fruitful it is to adopt a more discriminating compactification, so that (so far as possible) distinct escape routes shall be provided with distinct destinations on the boundary. Feller's boundary is constructed in terms of maximal ideals in the lattice of non-negative solutions to (1). Vast new perspectives in the theory of Markov chains and processes are opened up by this work, which is a summary of a longer paper already published elsewhere[4].

The papers by Hopf and Batchelor at last make contact with the real world, the subject-matter of both being the statistical theory of turbulence. Hopf discusses this with the aid of the characteristic functional, a technique introduced by himself in turbulence theory and independently and in other contexts by Le Cam, Bochner and others. Batchelor's object is to point out that a mathematical model of turbulence is inadequate if it leads to a spectrum analytic near zero wave-number, the essential non-analyticity being associated with requirements imposed by the Navier–Stokes equation.

Münch writes on stochastic processes in astronomy. Consider, for example, an infinite galaxy containing a uniform distribution of emissive material and superpose on this a Poisson distribution of absorbing clouds all having the transmission factor q $(0 < q < 1)$. Then with suitable units the intensity observed in a particular direction will be

$$U = u_0 + qu_1 + q^2u_2 + q^3u_3 + \ldots \qquad (2)$$

where the u's are independent random variables having the distribution $\exp(-u)\,du$ $(0 < u < \infty)$. Write $F(V) = \text{prob } (U \leqslant V)$. One of the simpler problems discussed by Münch is the determination of $F(V)$. One simple method of procedure would be as follows: if $s > 0$ then the Laplace transform $\varphi(s)$ of the distribution of U will be

$$\varphi(s) = \mathcal{E}\{\exp(-sU)\} = \prod_{r=0}^{\infty} (1 + q^r s)^{-1}$$

$$= \sum_{m=0}^{\infty} A_m (1 + q^m s)^{-1}$$

say. Now

$$\varphi(s) = \varphi(qs)/(1 + s)$$

and on manipulating the partial fractions we easily find that

$$A_m = -q^m (1 - q^m)^{-1} A_{m-1} \quad (m = 1, 2, 3, \ldots)$$

so that

$$F(V) = C \sum_{m=0}^{\infty} (-)^m \left(\prod_{n=1}^{m} q^n/(1 - q^n) \right) (1 - \exp(-V/q^m)$$

where C is a normalizing constant. When a finite galaxy is considered, or when the transmission factor q is allowed to be a random variable, the problem is more difficult.

In the next paper Kac surveys equilibrium problems in statistical physics, and problems concerning the approach to equilibrium. In Part 1 he discusses the Ising model, the spherical model and the problem of the imperfect gas. In Part 2 he summarizes his "Foundations of Kinetic Theory" (ref. 5). There is much to interest the analyst in these apparently 'applied' papers.

Ulam's and Koopman's contributions are apparently less mathematical in content, being largely written in prose. Koopman discusses the foundations of probability theory in relation to quantum theory; Ulam reports on a number of studies he has made with John Pasta of mathematical 'models' rather different from those commonly discussed in physics but which, he thinks (and the reviewer agrees), may be found useful in the future. For example, consider the lattice of points with integer co-ordinates in n dimensions $(1 \leqslant n \leqslant 3)$, and assign to each lattice-point mass one or mass zero, with equal probability, the assignments to be made independently. Now rub out the construction lines (the lattice), think of the array of masses as lying in E_n and let them attract according to the law of the inverse square. It is stated that the resultant force can be well defined for all $t \geqslant 0$, and that the motion for all $t \geqslant 0$ can be studied if collisions are handled by assuming coalescence and conservation of mass and momentum. When $n = 1$, the author asserts that (i) the masses appearing in the course of time are unbounded, (ii) some particles will always remain single, (iii) the asymptotic density remains constant, and (iv) arbitrarily large 'holes' will appear in the system. The mathematics of the problem is vastly more difficult when $n = 2$ or 3, and here the author and his collaborator had to resort to Monte Carlo techniques. The results quoted are very instructive, and one looks forward to reading a more detailed account of this work. One is reminded of the balance between diffusion and accretion which is sometimes indicated (for example, by Jeans[6]) as a mechanism for stellar evolution. A detailed handling of this astronomical problem would undoubtedly raise questions of the kind considered here.

D. G. KENDALL

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USE OF FARADAIC RECTIFICATION FOR THE STUDY OF RAPID ELECTRODE PROCESSES

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SEVERAL workers[1,2] have observed a small change in mean potential when an electrode is polarized by a sinusoidal alternating current. This phenomenon, which has been aptly termed faradaic rectification[2], is caused by the non-linearity of electrode processes as regards the variations of their rates with potential. Theoretical treatments have been given by Doss and Agarwal[3,4] and Oldham[2] for an electrode in contact with a solution containing a simple redox couple. The former workers considered only the case in which the concentrations and diffusion coefficients of the reactants are equal and found that the mean potential change for constant alternating component of potential approached a limiting value as the frequency increased. This limiting value was proportional to $1 - 2\alpha$, where α is the transfer coefficient of the forward process of the electrode reaction. Oldham, however, found that the potential change approached zero for all values of α as the frequency increased. Some time ago we had occasion to consider the same system. For the redox reaction

$$O + n\varepsilon \rightleftharpoons R$$

in the most general case ($C_o \neq C_r$, $D_o \neq D_r$) it was found that the potential change ψ is given by

$$\Psi_{(V \ll RT/nF)} = V^2 \frac{nF}{RT}\left[\frac{2\alpha - 1}{4} + \left(\frac{(1-\alpha)D_o^{1/2}C_o - \alpha D_r^{1/2}C_r}{2D_r^{1/2}C_r + 2D_o^{1/2}C_o}\right)\left(\frac{Zk_e + 2^{1/2}Z^2k_e^2}{2^{1/2} + 2Zk_e + 2^{1/2}Z^2k_e^2}\right)\right] \quad (1)$$

where $Z = \dfrac{D_r^{1/2}C_r + D_o^{1/2}C_o}{C_r\omega^{1/2}D_r^{1/2}D_o^{1/2}}$

In (1) C_o and C_r are the concentrations of O and R, respectively, in the bulk of the solution. D_o and D_r are the diffusion coefficients of the two reactants. V is the amplitude of the (almost) sinusoidal component of the interfacial potential and ω is the angular frequency. The rate constant at equilibrium of the forward process of the reaction (the reduction of O) is denoted by k_e.

Equation (1) applies equally well to a liquid metal electrode when R is dispersed throughout the metallic phase. It is only valid for values of V much smaller than RT/nF, and hence, in any accurate test of (1), ψ is likely to be quite small. If $C_o = C_r$ and $D_o = D_r$, (1) reduces to an equation derived earlier by Doss and Agarwal[4].

The corresponding expression for ψ in the case of an electrode reaction in which the concentration of R at the electrode surface remains constant (for example, $Hg_2^{2+} + 2\varepsilon \rightleftharpoons 2Hg$) is obtained from (1) by letting $C_o/C_r \rightarrow 0$. One then obtains

$$\Psi_{(V \ll RT/nF)} = \frac{V^2nF}{4RT}\left[2\alpha - 1 - \frac{2\alpha\,(2^{1/2}k_e^2 + k_e\omega^{1/2}D_o^{1/2})}{2^{1/2}k_e^2 + 2k_e\omega^{1/2}D_o^{1/2} + 2^{1/2}\omega D_o}\right] \quad (2)$$

For both types of reaction ψ tends towards the limiting value $(2\alpha - 1)V^2nF/4RT$ as ω increases, thus making possible a direct determination of the transfer coefficient if V is known. Further, by studying the variation of ψ with frequency, k_e can also be determined, if the diffusion coefficients which appear in the appropriate equation are known.

The validity of (1) has been tested by studying the variation with frequency of the amplitude of the low-frequency alternating current (the faradaic rectification or F–R current) which has to be supplied to a mercury-drop electrode to keep its mean potential constant, when it is polarized by an amplitude-modulated radio-frequency current. Square wave modulation (225 c./s.) has been used, and the F–R current has been measured with a 225 c./s. square wave polarograph[5] using the basic circuit shown in Fig. 1. Frequencies between 100 kc./s. and 6·4 Mc./s. have generally been used.

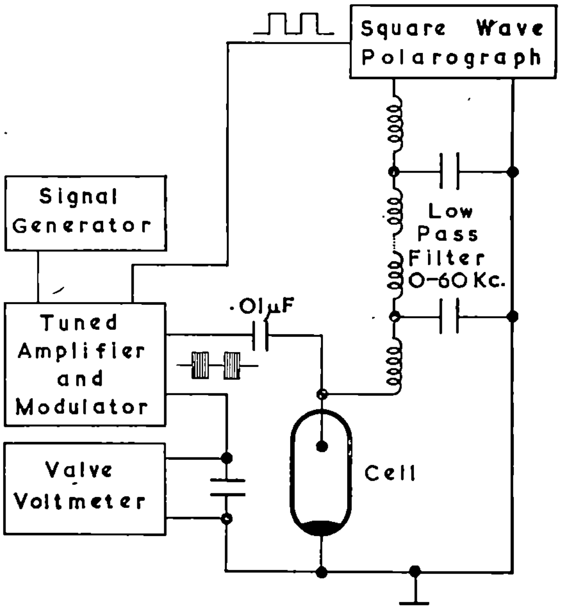

Fig. 1. Basic circuit for measurement of faradaic-rectification current

In all cases in which the kinetics have been such that the reaction at the highest frequency was almost entirely kinetically controlled, the amplitude of the F–R current for constant C_o, C_r and V has approached a limiting value, showing that ψ must also have a finite limiting value. As predicted by theory, this

Table 1. Approximate Values of α and k_0

Medium	Temp. (°C.)	Reaction	α	k_0 (cm. sec.$^{-1}$)
0·5 *M* K_2SO_4	22	$Cd^{2+} + 2\varepsilon \rightleftharpoons Cd(Hg)$	0·08	0·08
		$Tl^+ + \varepsilon \rightleftharpoons Tl(Hg)$	0·68	3·1
		$Pb^{2+} + 2\varepsilon \rightleftharpoons Pb(Hg)$	0·60	3·3
1 *M* $NaClO_4$ (*p*H 2)*	22	$Cd^{2+} + 2\varepsilon \rightleftharpoons Cd(Hg)$	0·07	2·3
		$Tl^+ + \varepsilon \rightleftharpoons Tl(Hg)$	0·69	1·2
		$Pb^{2+} + 2\varepsilon \rightleftharpoons Pb(Hg)$	0·81	0·8
1 *M* KNO_3 (*p*H 2)*	22	$Cd^{2+} + 2\varepsilon \rightleftharpoons Cd(Hg)$	0·15	6·3
		$Tl^+ + \varepsilon \rightleftharpoons Tl(Hg)$	0·8	0·3
		$Pb^{2+} + 2\varepsilon \rightleftharpoons Pb(Hg)$	0·94	0·2
1 *M* KCl (*p*H 2)*	22	$Cd^{2+} + 2\varepsilon \rightleftharpoons Cd(Hg)$	0·78	2·9
		$Tl^+ + \varepsilon \rightleftharpoons Tl(Hg)$	0·9	0·15
Ternary eutectic $LiNO_3$ $NaNO_3$ KNO_3 + 0·02 mole per cent KCl	156	$Pb^{2+} + 2\varepsilon \rightleftharpoons Pb(Hg)$	0·83	1·4
		$Cd^{2+} + 2\varepsilon \rightleftharpoons Cd(Hg)$	0·60	0·53

* *p*H adjusted by addition of perchloric acid.

value is independent of C_o and C_r and its sign is governed by the sign of $1 - 2\alpha$.

The kinetics of various rapid electrode reactions have been investigated by studying the dependence of the *F–R* current on ω and on the concentration ratio C_o/C_r, using values of C_o and C_r smaller than $\frac{2}{n^2} \times 10^{-4}$ *M* and values of *V* smaller than 5 mV. Some approximate values of α and of k_0, the rate constant of the forward process of the reaction when the rate constants of the forward and reverse processes are equal, are given in Table 1. For the reduction of cadmium ion in 0·5 *M* sulphate solution the values of α and k_0 are in fair agreement with values deduced from data given by Gerischer[6]. For the reduction of the same ion in molar potassium nitrate solution, k_0 is about ten times larger than a rate constant (approximately equal to k_0) reported by Randles and Somerton[7]. In no other cases has it been possible to compare the present results with results obtained by other workers. Table 1 shows that in some cases α is surprisingly small ($\sim 0{\cdot}07$) and in others it is unusually large ($\sim 0{\cdot}9$). In such instances the main rate-controlling step in the reduction of the ion may possibly be a chemical process. For example, slow dehydration of the ion prior to its transfer to the electrode may be responsible for values close to zero, while slow formation of a soluble intermetallic compound between the metal and mercury could lead to an apparent value of α close to unity. However, it is not easy to see why the latter process should tend to become the rate-determining process in the case of chloride solutions, and it seems more likely that the large values of α in some way are connected with the reduction of complex ions.

The faradaic rectification method appears to be a powerful method for the study of very rapid electrode processes. It is free from errors associated with the resistance of the solution such as occur when conventional methods[8] are employed. Also, if C_0 and C_r are small the interfacial impedance at radio-frequencies is controlled by the double-layer capacity, and, provided that this capacity is an aperiodic quantity, errors connected with its low impedance do not arise. To avoid systematic errors, small corrections must be applied to allow for the effect of the slight non-linearity of the double-layer capacity, and for the effect of changes with frequency in the distribution of the polarizing current over the electrode surface. At the present time, uncertainties in the magnitude of the latter correction and in the value of D_0 are often the major sources of error in the determination of α and k_0.

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CONSTITUTION OF THE FIBRILLAR AND NON-FIBRILLAR COMPONENTS OF THE WALLS OF *VALONIA VENTRICOSA*

By Prof. R. D. PRESTON, F.R.S., and J. CRONSHAW

Department of Botany, University of Leeds

THE microfibrils of *Valonia* cellulose, first observed in 1948[1], have long been known to occur as flattened ribbons averaging some 200 A. in width, and perhaps half as thick[2], with the flattened faces lying more or less parallel to the wall surface. Within these microfibrils the planes of 6·1 A. spacing lie parallel to these flattened faces and therefore in turn to the surface of the wall[3]. It is now known that native celluloses in general take the same form, though the width and the thickness are usually less than those found in *Valonia* cellulose.

Various lines of evidence, however, have suggested that the microfibrils of *Valonia* cellulose type are unique in possessing an extraordinarily high degree of crystallinity. Thus the X-ray diagram of the untreated *Valonia* wall, and the electron diffraction diagram as observed in the electron microscope, suggest that the crystallites of this cellulose are about as broad as the microfibrils themselves[3,4]; the cellulose is soluble only with extreme difficulty in cuprammonium and a positive reaction with iodine and sulphuric acid or with chlorzinc iodide is always difficult to obtain and often lacking[5]; the wall does not swell in 72 per cent sulphuric acid[2] and the microfibrils are scarcely affected by acid of that strength. It has, however, always appeared to be a

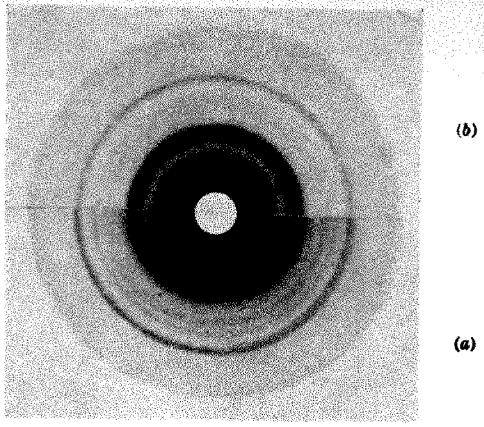

Fig. 1. X-ray powder diagrams of *Valonia* cellulose and cotton cellulose. Copper $K\alpha$ radiation collimated to a beam 0·5 mm. in diameter. Specimen-film distance, 3 cm. (*a*) a pellet of purified *Valonia* cellulose; (*b*) a pellet of purified cotton fibres

paradox that the percentage crystallinity as determined by the method of Hermans is no higher than 70 per cent[6] and therefore of the same order as that in the cellulose of many fibres in which the crystallinity is fairly low as judged by other methods.

Little is known, however, concerning the chemical constitution either of the microfibrils or of the whole wall of *Valonia*, and it is obviously essential to know something about this before the figure of 70 per cent can be made significant. During a recent investigation of the chemical constitution of celluloses from various sources[7] we have included but not reported upon *Valonia* cellulose. In this study the wall was fractionated, and the sugars in the hydrolysis products detected, by the methods of Jermyn and Isherwood[8]. In addition, the chemical extraction process described by Roelofsen and Houwink[9] was also used to obtain a preparation of the pure cellulose component. It was found that the cellulose component, observed in the electron microscope to consist entirely of microfibrils with little or no associated amorphous material, represents about 75 per cent of the wall dry weight. This therefore would seem to harmonize the results obtained by Hermans's method with the high crystallinity associated with other observations. On hydrolysis, this material yields glucose only, as shown by paper chromatography. The other wall material extracted by boiling water and by treatment with 4 *N* potassium hydroxide gave upon hydrolysis a mixture of galacturonic acid, galactose, glucose, arabinose and xylose. It is impossible to say at this time whether any of these extracted sugars were extracted from the microfibrils.

The X-ray diagram of a compacted pellet of the purified microfibrils is presented in Fig. 1*a* in comparison with a similar diagram of cotton cellulose produced under the same conditions (Fig. 1*b*). It will be clear that the prominent ring of 3·9 A. spacing (the fourth ring from the centre) is noticeably narrower than the corresponding ring in the cotton diagram. It is a little difficult to pronounce upon the relative thickness of the other rings, since the relative intensities differ, owing presumably to some trivial cause in, for example, the packing of the microfibrils. This, however, indicates without any doubt that the crystallites in *Valonia* cellulose are broader than are those in cotton, which itself is already known to be rather highly crystalline.

We suggest, therefore, that it is reasonable to consider the microfibrils of *Valonia* cellulose as very highly crystalline, consisting of a central core of crystalline cellulose measuring on an average about 200 A. × 100 A. and containing, therefore, something of the order of 600 molecular chains. These may be clothed, perhaps, in one or two layers of chain molecules the crystallinity of which is upset by the incorporation of chain compounds other than glucans; one such layer would then contain about 100 chains more randomly arranged than those of the central core.

Two further observations show that this central crystalline core does not, however, run uninterruptedly along the whole length of a microfibril, and that the microfibril is therefore heterogeneous along its length. First, treatment of the microfibrils with sulphuric acid of sufficient strength breaks down the microfibrils into shorter lengths. This supports an earlier observation[3] that when sulphuric acid begins to attack *Valonia* cellulose it does so at local regions along the microfibril. When the microfibril becomes broken through at these localities, further hydrolysis ceases. Secondly, whenever *Valonia* microfibrils are observed in an electron microscope after treatment—prolonged boiling in water is often sufficient—the effect illustrated in Fig. 2 is frequently observed. It appears that, at positions irregularly distributed along the length of a microfibril, pieces of the microfibril have been removed although the shadow produced by metal shadowing is continuous across the gap. These pieces must therefore have been removed in the electron microscope, and have presumably been so changed even by the mild treatment as to become more sensitive to bombardment by electrons. It would appear that there are regions of weakness irregularly distributed along the length of the microfibrils, in which, therefore, presumably the thickness of this central core is reduced or the crystallinity disturbed in some other way.

On the basis of the observations which indicate the presence of this solid central crystalline core, it is evident that the larger *Valonia* microfibrils are not merely aggregates of smaller microfibrils of the order of those found in, for example, wood cellulose. On the grounds of this and other evidence concerning cellulose in general, which will be published else-

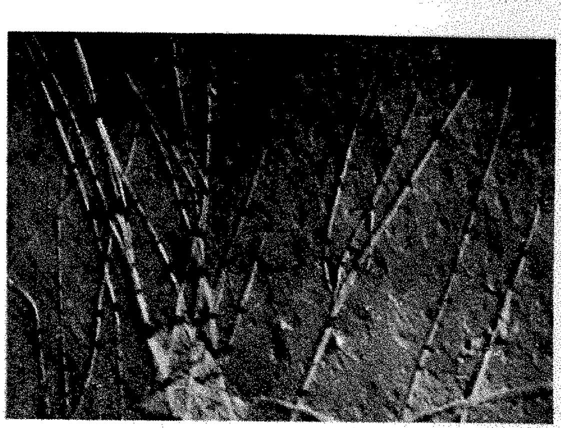

Fig. 2. Electron micrograph of *Valonia* cellulose after mild treatment with hydrochloric acid (× 24,000). Palladium–gold shadowed. Note the obvious breaks in the fibre across which the shadow is nevertheless continuous

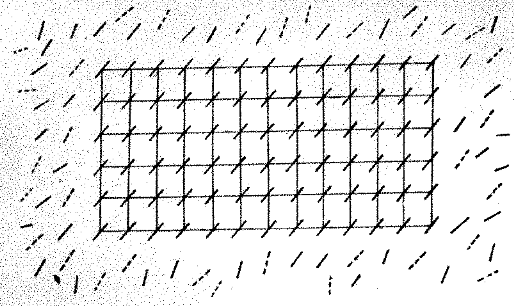

Fig. 3. Diagrammatic representation of the transverse section of a cellulose microfibril about 100 A. wide and about 50 A. thick. The solid strokes represent the planes of the glucose residues in the cellulose chain molecule and the broken strokes the planes of other sugars or sugar derivatives in non-cellulosic molecular chains. The area joined into a lattice represents the solid central core

where[10], it is suggested that the constitution of cellulose microfibrils in general is somewhat as illustrated in cross-section in Fig. 3. This figure refers to a microfibril some 100 A. wide ; an increase in the width of the microfibril would then occur chiefly by an increase in the width of the central crystalline core. This model differs from that presented by Frey-Wyssling[11] solely in the lack of 'internal' randomized molecular chains which are omitted for reasons which will be given elsewhere[10].

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INHIBITION OF CAROTENOID SYNTHESIS IN PHOTOSYNTHETIC BACTERIA

Specific Inhibition of Carotenoid Synthesis in a Photosynthetic Bacterium and its Physiological Consequences

We have suggested[1-3] that the carotenoid pigments characteristically associated with the photosynthetic apparatus perform an essential physiological function, by protecting the cell from the deleterious effects of chlorophyll-catalysed photooxidations. The hypothesis was initially formulated as a result of observations on the behaviour of a carotenoidless mutant of the photosynthetic bacterium *Rhodopseudomonas spheroides*. The mutant in question synthesizes almost normal quantities of bacteriochlorophyll, but the coloured carotenoids characteristic of the wild type are completely absent from its cells, their place being taken by a much more reduced colourless C_{40} polyene, phytoene. The mutant can grow photosynthetically under anaerobic conditions in the light ; but when photosynthetically grown cells are exposed simultaneously to light and air, they are rapidly killed and their bacteriochlorophyll is destroyed. The photosensitizing pigment is bacteriochlorophyll itself. Such photosensitivity is not manifested by the wild type, or by mutants in which the normal carotenoids have been replaced by other coloured carotenoids. The correlation between carotenoid deficiency and aerobic photosensitivity has since been demonstrated by Kandler and Schötz in a mutant of *Chlorella* with derangements of normal carotenoid synthesis[4].

Specific depletion of carotenoid pigments has been caused by gene mutation in the photosynthetic organisms so far studied. We have now found that specific depletion can be produced without a change of genotype in the photosynthetic bacterium *Rhodospirillum rubrum*, as a result of growth in the presence of diphenylamine. Under these conditions, cells of *R. rubrum* become almost devoid of coloured carotenoids, but maintain a normal content of bacteriochlorophyll. Exposed to light and air, such cells display the symptoms of photosensitivity (death and chlorophyll destruction) previously observed in the carotenoidless mutant of *Rhodopseudomonas spheroides*. In *Rhodospirillum rubrum*, carotenoid depletion is readily reversible. When the diphenylamine is removed, rapid carotenoid synthesis at the expense of accumulated endogenous precursors begins immediately. The restoration of coloured carotenoids is accompanied by a rapid diminution of the induced photosensitivity. This reversible physiological induction of photosensitivity, correlated with changes in carotenoid content, provides additional experimental support for our hypothesis concerning the function of carotenoid pigments in photosynthetic organisms.

Effects of diphenylamine on growth and pigment synthesis in Rhodospirillum rubrum. The inhibition of carotenoid synthesis by diphenylamine has been observed in many fungi and bacteria, and was first demonstrated in *R. rubrum* by Goodwin and Osman[5,6]. They reported, however, that the synthesis of bacteriochlorophyll was simultaneously suppressed, an observation which we have been wholly unable to confirm. Fig. 1 shows an experiment which illustrates the strikingly specific effect of diphenylamine on carotenoid synthesis. At the point indicated by an arrow, diphenylamine (final concentration : 7×10^{-5} *M*) was added to a culture of *R. rubrum* in the course of exponential photosynthetic growth under steady-state conditions of chlorophyll and carotenoid synthesis. The synthesis of coloured carotenoids ceased immediately, whereas both growth and chlorophyll synthesis continued, though at a lower rate. The parallelism of the curves for growth and chlorophyll synthesis shows that the differential rate of chlorophyll synthesis remained essentially unchanged. The extent to which the chlorophyll :

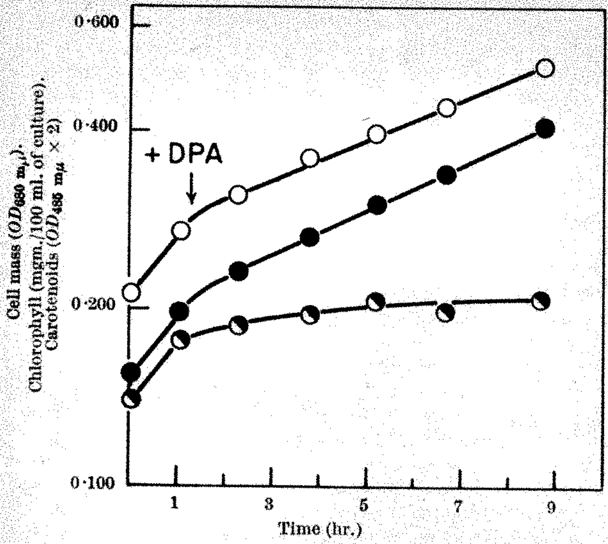

Fig. 1. Effect of diphenylamine (7×10^{-5} *M*) on growth and pigment synthesis by a culture of *Rhodospirillum rubrum*, developing exponentially in anaerobiosis and light. Pigments were measured in acetone–methanol extracts of the cells. Values for chlorophyll were calculated from the optical density of the extract at 775 mμ. Values for the coloured carotenoids are expressed in arbitrary terms, as the optical density of the extract at 485 mμ (the absorption maximum of the mixed carotenoids), corrected for light absorption at this wave-length by chlorophyll. ○—○, cell mass; ●—●, chlorophyll; ◐—◐, coloured carotenoids

carotenoid ratio can be modified by the cultivation of *R. rubrum* in the presence of diphenylamine is evident from the absorption spectra of normal and treated cells, grown photosynthetically under otherwise identical conditions (Fig. 2).

The suppression of normal carotenoid synthesis provoked by diphenylamine is accompanied by a massive intracellular accumulation of the more saturated polyenes, which are undetectable in normal cells. The major component is phytoene, accompanied by smaller quantities of phytofluene, ζ-carotene and neurosporene. Indications of this accumulation can be seen in the spectrum of the cells (Fig. 2). In treated cells, the bacteriochlorophyll peak at 375 mμ is much higher relative to the infra-red peak at 880 mμ than in normal cells. This is caused by the light-absorption of saturated polyenes in the near ultraviolet region. Quantitative analyses of the extracted polyenes, kindly performed for us by Dr. T. Nakayama, showed that the total polyene content of cells grown in the presence of diphenylamine is far higher than the content of carotenoid pigments in normal cells. In this respect as well, the findings of Goodwin and Osman[6], who detected only 'traces' of the more saturated polyenes in cells of *R. rubrum* grown with diphenylamine, could not be confirmed.

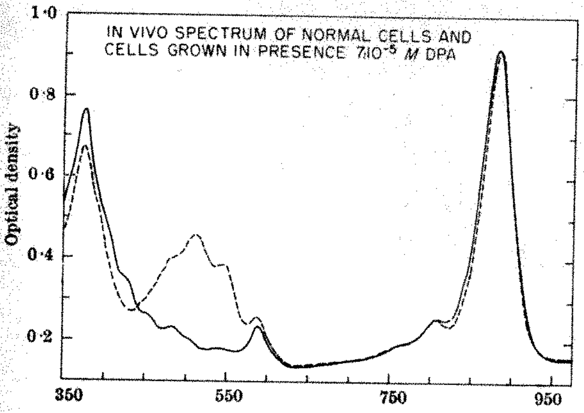

Fig. 2. The absorption spectra of two suspensions of *Rhodospirillum rubrum* grown anaerobically in the light and adjusted to the same optical density at 680 mμ before measurements were made. Spectra were determined through opal glass to reduce the effect of light-scattering. Dashed line: normal cells. Solid line, cells grown in the presence of 7×10^{-5} *M* diphenylamine

As discovered by Goodwin and Osman[6], an extensive and rapid synthesis of coloured carotenoids can occur when cells which have been grown in the presence of diphenylamine are washed and resuspended in buffer. This endogenous synthesis proceeds with equal rapidity under aerobic conditions in the dark and under anaerobic conditions in the light, but cannot occur under anaerobic conditions in the dark. It is presumably an energy-requiring process, for which energy can be supplied either by photophosphorylation in the light, or by oxidative phosphorylation in the dark. Since Goodwin and Osman could detect only traces of saturated polyenes in cells treated with diphenylamine, they assumed that the endogenous synthesis occurred at the expense of non-specific intracellular precursors. We have re-studied this question in collaboration with Mrs. Synnøve Jensen and Dr. T. Nakayama. The coloured carotenoids are in fact synthesized *exclusively* from the accumulated polyenes, through a succession of intermediates. These findings and their biochemical implications will be described elsewhere.

Induced photosensitization of Rhodospirillum rubrum. Representative results of two experiments which demonstrate the photosensitivity induced in *R. rubrum* by carotenoid depletion are given in Table 1. Cells harvested after growth in the presence of diphenylamine were washed and resuspended in chilled buffer. Aliquots of this suspension were added to aeration tubes, which were placed in a water-bath held at 30° C. and aerated with a mixture of 95 per cent nitrogen and 5 per cent carbon dioxide in the dark, to prevent any occurrence of endogenous carotenoid synthesis. At the start of experiments, the aeration mixture was changed to 95 per cent air and 5 per cent carbon dioxide. Illuminated tubes were exposed to a light intensity of approximately 1,000 foot-candles from incandescent lamps, and dark control tubes were completely shielded by a wrapping of aluminium foil. Samples were removed at intervals for determinations of viable count and chlorophyll content. As shown in Table 1, photo-killing is relatively rapid: in the presence of light and air, the viable count fell to less than 20 per cent of its original value within 2 hr. The viable counts of the dark

Table 1. PHOTO-KILLING AND CHLOROPHYLL DESTRUCTION IN BUFFERED SUSPENSIONS OF CELLS, DEPLETED OF COLOURED CAROTENOIDS BY GROWTH IN THE PRESENCE OF DIPHENYLAMINE

		Conditions of exposure		
		Air, light	Air, dark	Air, light, after 30 min. in air, dark
Exp. 1	Per cent survivors after 2 hr.	14	87·5	—
	Per cent chlorophyll after 23 hr.	39	106	
Exp. 2	Per cent survivors after 1·5 hr.	19·4	97	55·5
	Per cent chlorophyll after 23 hr.	75	100	92

controls also fell slightly, but this decline was comparatively negligible. The photo-destruction of chlorophyll is far slower than photo-killing, and much longer exposures are accordingly required for its accurate measurement. As shown in Table 1, the chlorophyll content of illuminated suspensions had declined markedly after 23 hr., whereas that of the dark controls was essentially unchanged. Comparable exposures to air and light cause no measurable death or chlorophyll destruction in normal cells.

Exp. 2 in Table 1 also illustrates the diminution of photosensitivity which occurs when cells are permitted to initiate endogenous synthesis of carotenoid pigments before exposure to light. In this experiment, an aliquot of the cell suspension was kept for 30 min. under aerobic conditions in the dark before exposure to light. The moment of light exposure was used as the zero time for measurements of viability and chlorophyll content on this tube. It can be seen that both death and chlorophyll destruction were much less rapid than in the suspension which was exposed to light and air without preceding maintenance under aerobic conditions in the dark. Desensitization was not complete; but the amount of endogenous carotenoid synthesis which had taken place at the time of light exposure was very limited. Complete restoration of the normal coloured carotenoids requires many hours.

Photo-inhibition of endogenous carotenoid synthesis. In *R. rubrum*, the photosensitivity which accompanies carotenoid depletion has one additional manifestation: inhibition of endogenous carotenoid synthesis. Fig. 3 shows the absorption spectra of acetone–methanol extracts prepared at successive intervals from two tubes of a buffered cell suspension incubated aerobically at 30° C. in the light and in the dark, respectively. Vigorous endogenous synthesis occurred in the suspension incubated in the dark, as evidenced by the increasing optical density of successive extracts in the region where light is absorbed by the carotenoid pigments. No detectable synthesis occurred in the suspension incubated in the light; in fact, the changes in the spectra of successive extracts suggest that the polyenes originally present may have been partly destroyed. A total photo-inhibition of endogenous carotenoid synthesis can be obtained only if the cells have been very thoroughly depleted of coloured carotenoids by preceding diphenylamine treatment. Once such depleted cells have initiated endogenous synthesis, the process can no longer be wholly arrested by light and air, although its rate may fall. The extent to which the rate is diminished by exposure to light and air is inversely related to the amount of synthesis which has already taken place at the time of exposure.

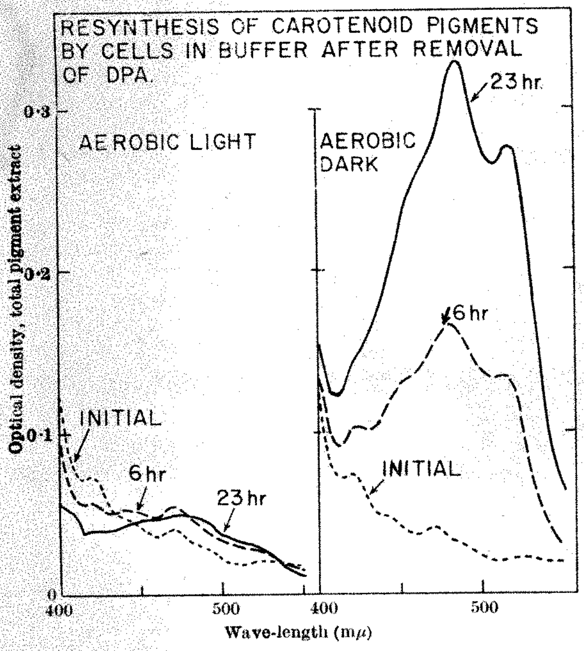

Fig. 3. The absorption spectra of acetone–methanol extracts prepared from two aliquots of a buffered suspension of cells which had been grown in the presence of diphenylamine. The suspensions were incubated aerobically at 30° C. in the light and in the dark, respectively, and samples were withdrawn after the times indicated for the preparation of extracts

The remarkable photosensitivity of endogenous carotenoid synthesis is intelligible in terms of cell structure. The normal photosynthetic pigment system of the purple bacteria is localized in macromolecular structures, variously termed 'chromatophores' or 'grana', which can be separated from other cellular components in extracts of the bacteria by differential centrifugation[7]. These bodies are the functional equivalents of plant chloroplasts, although they are much smaller and appear to be much simpler. By the fractionation of bacterial extracts, we have found that the polyenes which accumulate as a result of the diphenylamine treatment are almost exclusively associated with the chromatophores. This implies that the terminal steps of carotenoid synthesis, which take place at the expense of the saturated polyenes when diphenylamine is removed, occur in the chromatophores, where the saturated polyenes presumably fill the sites occupied by coloured carotenoids in normal cells. The substrates (and possibly also the enzymes) for endogenous carotenoid synthesis are therefore situated in the cell very close to the bacteriochlorophyll, and as a result are highly exposed to chlorophyll-catalysed photo-oxidation.

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Suppression of Carotenoid Synthesis and its Effect on the Activity of Photosynthetic Bacterial Chromatophores

STUDIES on the photochemical activities of the chromatophores[1] of the non-sulphur purple bacteria have demonstrated that these particles can carry out the light-dependent formation of adenosine triphosphate[2]. We have recently reported on the photochemical activities of highly purified chromato-

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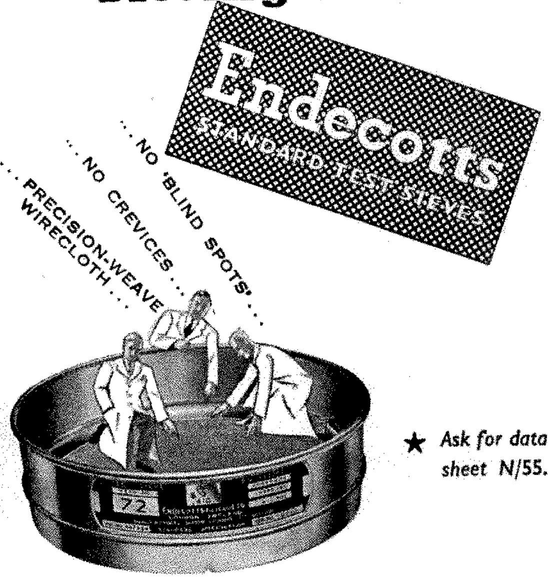
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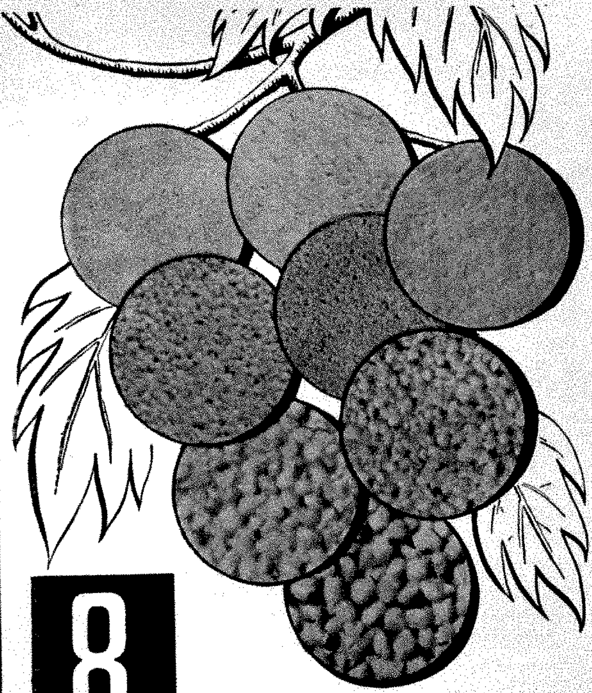

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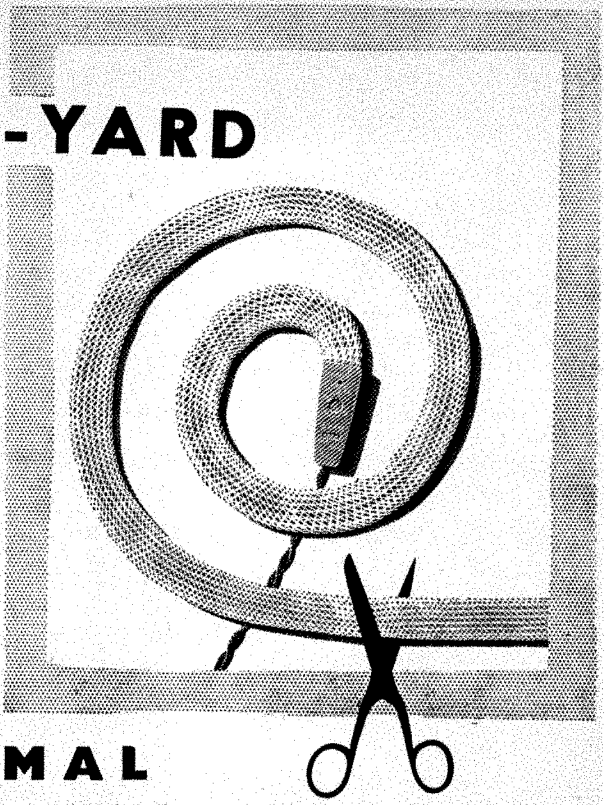

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phores of the photosynthetic sulphur bacterium, *Chromatium*[3]. The photochemically active particles of these obligate anaerobes produce adenosine triphosphate in the presence of light.

The function of carotenoids in photosynthesis has been an open question for many years. Evidence has been offered in some organisms for the direct participation of carotenoids in the capture and transfer of light energy[4]. Recent work has indicated that carotenoids are essential for the functioning of the 'Hill reaction' by isolated chloroplasts of higher plants[5]. Stanier[6] and co-workers have demonstrated in the non-sulphur purple photosynthetic bacteria that carotenoids protect the cell from photo-oxidations by bacteriochlorophyll. We have investigated the relationship of coloured carotenoids to photophosphorylation in *Chromatium*, by the study of suppression of carotenoid synthesis with diphenylamine.

Diphenylamine has been used for inhibiting the synthesis of coloured carotenoids in fungi, algæ and photosynthetic bacteria by Goodwin and his co-workers[7]. *Chromatium*, cultured and subcultured in the presence of diphenylamine, becomes a bright blue-green in colour and lacks any visible red carotenoids. The organisms grew readily in the presence of light with carbon dioxide as the only source of carbon, and there was no apparent effect on the total amount of bacteriochlorophyll produced. 'Carotenoidless' cells regain their coloured carotenoids in the absence of diphenylamine. Red 'Cellophane' filters were used between the light source and the cultures to reduce the destruction of diphenylamine by the shorter wave-lengths of light, and under these conditions the cells remained green during the growth period (3–4 days).

Chromatophores were isolated and concentrated as previously described[3] from both the normal and the diphenylamine-treated ('carotenoidless') bacteria, and the particles sedimenting at 144,000 *g* were washed with water before use in the following experiments. The absorption spectra of the chromatophores from both types of cells are shown in Fig. 1. As can be seen, the major coloured carotenoid peaks between 450 and 550 mμ have almost completely disappeared and there is at least one new peak at 420 mμ which probably represents a polyene precursor of the coloured carotenoids. It can be seen that the major near infra-red peak of bacteriochlorophyll is unaffected but there is a striking shift in the position of the various minor peaks. The normal chromatophores of our strain of *Chromatium* give an indication of absorption at 807, 825, 840 and 895 mμ (see Fig. 2). In the absence of coloured carotenoids (green chromatophores) the 807 peak remains unchanged and there is a peak at 830 and a shoulder at 885 mμ. Stanier shows a shift of the near infra-red peaks in his blue-green mutant of *Rhodopseudomonas spheroides* to a symmetrical band of the *R. rubrum* type. Duysens[8] has suggested that the various shapes of the multiple peaks of the bacteriochlorophyll absorption spectrum in different species may be due to a difference in the relationship of bacteriochlorophyll to various 'bearer molecules'. Stanier proposes that for his mutant of *R. spheroides* the shift is due to the substitution of the polyene precursors for the coloured carotenoids in the structural composition of the chromatophores. This hypothesis is extremely attractive for the diphenylamine-altered chromatophores of *Chromatium*, since similar shifts in the red spectrum are observed and the presence of precursors is indicated.

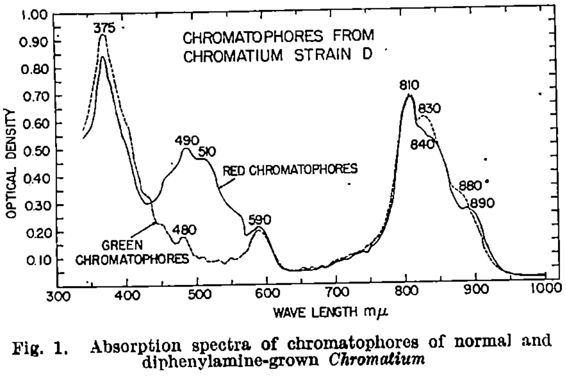

Fig. 1. Absorption spectra of chromatophores of normal and diphenylamine-grown *Chromatium*

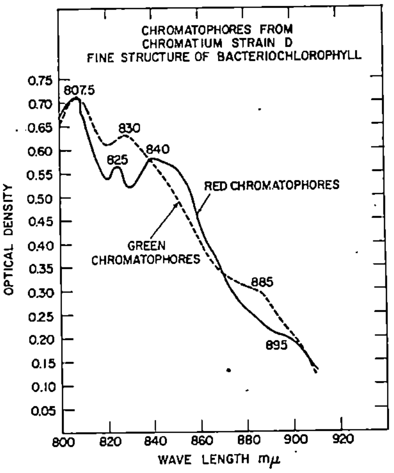

Fig. 2. Fine structure of bacteriochlorophyll absorption band for normal and diphenylamine-bleached chromatophores

Photosensitization of photophosphorylation. As previously reported, the chromatophores of *Chromatium* will make adenosine triphosphate in the presence of light and in the absence of oxygen at a rate up to 70 micromoles of phosphate esterified per mgm. bacteriochlorophyll per hour (ref. 3). Catalytic amounts

Table 1. PHOTOSENSITIVITY OF PHOTOPHOSPHORYLATION

Pre-treatment of chromatophores*		Type of chromatophore	
Illumination (min.)	Gas phase	'Carotenoid-less'	Normal
		Per cent activity†	
10 (light)	Air	0	63
10 (light)	Nitrogen	72	100
10 (darkness)	Air	100	100
30 (light)	Air	0	42
30 (light)	Nitrogen	82	88
30 (darkness)	Air	100	100
30 (darkness)	Nitrogen	100	100

* Pre-treatment of chromatophores and photophosphorylation measurements were carried out in an illuminated Warburg apparatus with 3,000 and 1,000 ft.-candles of light, respectively, at 20° C. The reaction mixtures of 3 ml. volume contained 0·1 *M* glucose, 0·02 *M* *tris* buffer at *p*H 7·8, 7·5 μmoles adenosine diphosphate at *p*H 7·8, 10 μmoles magnesium chloride, 25 μmoles orthophosphate, 0·3 ml. of supernatant from ruptured cells, 4 mgm. crude hexokinase (Sigma Chemical Co.), normal or 'carotenoidless' chromatophores containing 0·25 and 0·32 mgm. of bacteriochlorophyll, respectively. Chromous chloride was present in the centre well of the anaerobic flasks. After the various pre-treatments, the vessels were flushed with nitrogen in the dark, the vents were closed, adenosine diphosphate was tipped in, and photophosphorylation was initiated by turning on the lights. Disappearance of orthophosphate was determined (ref. 9) and used as a measure of photophosphorylation.

† Normal and 'carotenoidless' chromatophores esterified, respectively, 60 and 61 μmoles of phosphate per mgm. of bacteriochlorophyll per hour. This was used as the '100 per cent activity' figure.

of a reducing agent and a protein factor from the cellular supernatant are stimulatory but not required by the system. The effect of the absence of carotenoids on this type of system was tested as described in Table 1.

The observed diminution of coloured carotenoids has little or no effect on the ability of isolated chromatophores to carry out the light-dependent formation of adenosine triphosphate. However, activity is completely destroyed in the presence of both light and oxygen. This extends to an isolated system, the observation of Stanier that whole cells of a 'carotenoidless' mutant of *R. spheroides* are killed by light in the presence of oxygen.

According to French and Bishop[5], carotenoids are essential for the photochemical reduction of a dye by isolated chloroplasts, that is, for the 'Hill reaction'. However, coloured carotenoids do not appear to play any part in the production of high-energy phosphate by light as shown by adenosine triphosphate formation with green chromatophores. Therefore it is probable that the production of high-energy phosphate by the chromatophores precedes or is independent of the photochemically induced reduction of a dye.

This research was carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

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NATURAL OCCURRENCE OF THYMINE AND THREE METHYLATED ADENINE BASES IN SEVERAL RIBONUCLEIC ACIDS

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ALTHOUGH three naturally occurring bases in addition to adenine, guanine, cytosine and thymine have been isolated from deoxyribonucleic acid[1,2], the compound studied by Cohn, Davis and Allen[3] seems the only example so far of any additional bases naturally present in ribonucleic acid. During studies on the incorporation of unnatural bases, digests of ribonucleic acid from *Bacterium coli* were found to contain in small amount a compound with spectral and chromatographic characteristics which suggested that it was the riboside of thymine (ref. 4, and Smith, J. D., personal communication). We now have considerable evidence for the natural occurrence of thymine in ribonucleic acid prepared from two strains of *B. coli* and from *Aerobacter aerogenes* and in commercial yeast ribonucleic acid. From these sources we have isolated also three methylated derivatives of adenine: 2-methyladenine, 6-methylaminopurine and 6-dimethylaminopurine. We have found the last two compounds in the ribonucleic acid of rat liver microsomes. None of these compounds appears to be that described previously, which we believe we have noted in addition in ribonucleic acid from several sources. The natural occurrence of all four bases as nucleosides or nucleotides has been described previously, since thymine and 6-methylaminopurine occur in deoxyribonucleic acid[2,5], 2-methyladenine in the vitamin B_{12}-like Factor A[6], and 6-dimethylaminopurine in puromycin[7].

The ribonucleic acid of *B. coli* has been our main source of these four bases and their derivatives. About ten grams of growing bacteria[8] was collected by centrifugation, washed with saline, and extracted overnight with 60 per cent (v/v) ethanol – water at *p*H 4 and 20°. The residue was washed twice with 60 per cent ethanol – water, and once each with 90 per cent ethanol–water, ethanol, and acetone. After drying, it was extracted with 0·1 *M* sodium citrate for 1–2 hr. at *p*H 7·2 and 100° [9]. The sediment from high-speed centrifugation was discarded and the soluble nucleic acids precipitated three times from 60 per cent ethanol – water at *p*H 4. Two nucleic acid preparations were treated in addition by the Sevag procedure[10] to remove proteins. The final precipitate was hydrolysed overnight at 30° with 1 *N* potassium hydroxide to release the ribonucleoside 2′- and 3′-phosphates. After precipitation of the deoxyribonucleic acid by the addition of two volumes of ethanol plus perchloric and/or acetic acid to *p*H 4, the digest was centrifuged and the soluble nucleotides purified by paper chromatography using *iso*propanol–water (70 : 30, v/v) with ammonia vapour[11].

Early in this work the purified nucleotides were treated with prostatic phosphomonoesterase[12], and the four compounds discovered and studied as nucleosides. In paper chromatography using *iso*propanol/water with ammonia vapour, *n*-butanol/water (86 : 14, v/v) with ammonia vapour[13], and *n*-butanol/water/formic acid (77 : 13 : 10, v/v/v)[13], each of the four nucleosides showed the same mobility as the corresponding known riboside, which we synthesized by the incubation of the known base with inosine and a nucleoside phosphorylase prepared from *B. coli*[14]. On paper electrophoresis[11] using 0·05 *M* borate buffer at *p*H 9·2, each nucleoside migrated with the known riboside ; in the presence of borate each showed a greatly reduced mobility in *n*-butanol/water/ammonia. The wave-lengths of the ultra-violet absorption maxima of these ribosides are given in Table 1. The possibility that we were dealing with deoxyribosides rather than ribosides seems unlikely, since the method of preparation of these compounds involved alkaline hydrolysis of the nucleic acid, and since they formed complexes with borate and moved with the same R_F as the synthetic ribosides in the chromatographic systems mentioned. The deoxyribosides of thymine and 6-methylaminopurine were available and showed greater mobility in the butanol solvents. Furthermore, unlike purine deoxyribosides, the purine ribosides were stable in 0·1 *N* hydrochloric acid at 20°, while they were hydrolysed in 1 *N* hydrochloric acid for 1 hr. at 100°[15]. The nucleoside of thymine was unchanged by this treatment but was hydrolysed in 72 per cent (w/w) aqueous perchloric acid in 2 hr. at 100°[16], or, unlike thymidine, by treatment with sodium periodate followed by alkali[17].

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Table 1. WAVE-LENGTHS (mμ) OF ULTRA-VIOLET ABSORPTION MAXIMA OF METHYLATED BASES AND THEIR RIBOSIDES

	Base		Riboside	
	*p*H 1	*p*H 13	*p*H 1	*p*H 13
Thymine	265	291	267	267
2-Methyladenine	266	271	258	262
6-Methylaminopurine	267	273	262	266
6-Dimethylamino-purine	277	281	268	277

The four bases released by hydrolysis of the ribosides had identical ultra-violet absorption spectra (Table 1) and also identical chromatographic behaviour in four solvents to known samples of thymine, 2-methyladenine, 6-methylaminopurine or 6-dimethylaminopurine.

More recently we have isolated what we presume to be the 2′- and 3′-phosphate derivatives of the four ribosides. From the initial *iso*propanol/water/ammonia chromatogram of the soluble nucleotides we eluted the entire area between guanylic acid and the small amount of nucleosides present, and re-chromatographed this material for 48 hr. with the same solvent. By this time, two or three faint bands had separated ahead of uridylic acid ; these were eluted together and run on paper electrophoresis in 0·05 *M* ammonium formate buffer at *p*H 3·5. In this system the mobilities of the ribonucleotides of thymine, 6-methylaminopurine, 6-dimethylaminopurine and 2-methyladenine were 0·90, 0·46, 0·42 and 0·19 of that of a uridine 2′,3′-phosphate marker. Thus, thymine ribonucleotide was separated from the mixture of the nucleotides of 6-methylaminopurine and 6-dimethylaminopurine, which were then distinguished by chromatography in *iso*propanol/water/ammonia. The ribonucleotide of 2-methyladenine was sometimes present on this electrophoretic separation, but was usually found by similar electrophoresis of the uridylic acid band. In the latter instance, it could be separated from any cytidylic acid present by chromatography in *iso*propanol/water/ammonia. These four ribonucleotides were dephosphorylated by prostatic phosphomonoesterase but not by the 5′-nucleotidase present in rattlesnake venom. The ribosides so produced, as well as the bases released by subsequent acid hydrolysis, were identical to those described above.

Table 2. MOLAR PROPORTIONS OF METHYLATED BASES IN SEVERAL RIBONUCLEIC ACIDS

Source of ribonucleic acid	Moles per 100 moles of uracil			
	Thymine	2-Methyl-adenine	6-Methyl-amino-purine	6-Dimethyl-amino-purine
B. coli B/r	0·8	0·5	0·4	0·3
B. coli 15T⁻	0·9	0·25	*	*
Aerobacter aerogenes	1·0	0·25	0·25	0·1
Yeast	0·6	0·15	0·25	0·05
Liver microsomes	—	—	0·65	0·15

* Not examined

In addition to alkaline hydrolysis, we have treated the nucleic acid preparation with rattlesnake venom containing diesterase and 5′-nucleotidase, and have isolated from this digest also the ribosides of thymine (Smith, J. D., personal communication), 2-methyladenine and 6-methylaminopurine, and a small amount of material with the chromatographic behaviour of the riboside of 6-dimethylaminopurine. The preparation of the four ribosides by these two methods strongly suggests that they existed in 3′,5′-phosphodiester linkage, most likely in the polynucleotide chain. This evidence and the thorough washing of the nucleic acid preparation before hydrolysis make it improbable that we are dealing with contaminating free nucleotides. Indeed, it would be unusual for free nucleotides to exist in the 2′- or 3′-phosphate form, and we have searched for and failed to find the ribonucleotide of thymine or 2-methyladenine in the acid ethanol-soluble fraction of the bacteria.

The approximate molar proportion of each base in the five ribonucleic acids we have studied is expressed in Table 2 relative to the amount of uracil. Values were actually determined from the isolated ribosides. Whether the widespread occurrence in ribonucleic acid of small amounts of these four bases is a chance phenomenon or of metabolic importance is not yet apparent.

We are grateful to Dr. D. J. Brown, Dr. D. M. Brown and the American Cyanamid Company for gifts of chemicals, and to Dr. J. D. Smith for much helpful advice. One of us (J. W. L.) wishes to thank the Wellcome Trustees for a travel grant.

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LETTERS TO THE EDITORS

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Iodine-131 in Sheep before and after a Nuclear Reactor Accident

It may be useful to compare the amount of iodine-131 in thyroids of unselected sheep slaughtered in London before and after the release of iodine from the reactor at Windscale in Cumberland on October 10, 1957 [1].

Table 1. Iodine-131 in Sheep Thyroid Glands (mμc./gm. Thyroid)

London				Munich				Nashville			
Date slaughtered (day/month)	No. of sheep	Iodine-131 in thyroids		Date slaughtered (day/month)	No. of sheep	Iodine-131 in thyroids		Date slaughtered (day/month)	No. of sheep	Iodine-131 in thyroids	
		Average	Max./min.			Average	Max./min.			Average	Max./min.
14/8	8	0·99	1·9/0·54					12/8	14	28	145/13
6/9	8	1·0	2·3/0·76					6/9	11	12	24/5·3
10/10		Windscale release						9/10	17	55*	84/19
21/10	15	15	59/5·9					21/10	13	14	48/7·5
				7/11	6	0·36	0·70/0·07	4/11	9	7·2	26/1·4
23/11	11	2·3	6·8/0·74	26/11	4	0·24	0·58/0·20	25/11	14	0·83	2·6/0·21
				8/12	6	0·10	0·2/0·05	10/12	11	0·23	0·44/0·10
20/12	26	0·14	0·19/0·12					20/12	14	0·09	0·19/0·07

* Maximum for the period September–December.

For three years our laboratory has frequently measured the iodine-131 in thyroids of sheep and cattle slaughtered in certain cities of the United States, London, Japan and Germany (Munich).

During the summer of 1957, the sheep thyroids received once each month from London contained 1–10 per cent of the amount present in thyroids from Nashville, Tennessee. This radioactivity was considered to originate west of Tennessee. Similar results were published in 1956 [2]. The reduced amount in the English and Munich animals was possibly due to the three to four additional half-lives of time necessary for the isotope to appear in the sheep of the more distant areas.

Table 1 shows that in August and September of 1957 the concentrations of iodine-131 in thyroids of sheep slaughtered in London averaged 1 mμc./gm. This was less than one-tenth of the concentrations found during the same period in specimens from Tennessee. In October the greatest concentrations in thyroids of Tennessee sheep averaged 55 mμc./gm., on October 9, the day before the Windscale incident. Most of this iodine-131 is believed to have originated from nuclear weapons tests, 1,500 miles west of Tennessee. Ten days after the Windscale release, our specimens of British and American sheep thyroids both averaged 14–15 mμc./gm.

Sheep slaughtered in Munich in early November contained 1–10 per cent as much iodine-131 as the average of Tennessee sheep. This suggests that most of the iodine-131 in the German animals could have originated west of Tennessee. The concentrations of iodine-131 in German sheep have decayed more slowly than those in Tennessee sheep. This slow decay is interesting but not unexplained.

In general, these results suggest that sheep slaughtered in London have received less iodine-131 from the Windscale incident than sheep slaughtered in Tennessee have received from distant nuclear weapons tests.

In the United States, animals grazing east of the Nevada proving ground are more sensitive indicators to iodine-131 fall-out than those west of the test site. Therefore, directly east of Windscale, sheep may have contained more iodine-131 than those reported here. It is further suggested that valuable information can be obtained by continuous monitoring of thyroids from slaughtered sheep and cattle. A good index is thus obtained regarding the biological concentration of air-borne radioactive fall-out.

This investigation was supported by grants from the U.S. Atomic Energy Commission and the U.S. Public Health Service.

Thyroid glands were sent to us by Mr. E. F. McCleary, of the Metropolitan Cattle Market, London; Herr Schurry, of Max Muhlpointner and Co., Munich, Germany; and the Neuhoff Packing Company (Division of Swift and Co.), Nashville, Tennessee.

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Symmetry of Snow Crystals

The frequently portrayed beautiful six-ray star-shaped crystals of snow have long been quoted as outstanding examples of well-developed crystal forms. Despite an infinite variety in the patterns which appear, there does often exist a remarkable symmetry in the six rays, the complex tree-like pattern repeating closely in each arm, indeed, surprisingly so. Since each of the six arms of the crystal would appear to be growing independently, this symmetry poses a problem in crystal growth, for it almost seems as if each arm of the six-ray star 'knows' what the other five are doing and follows suit. In fact I believe that each arm does 'know' what the others are doing and I offer the following explanation.

I conjecture that the crystal is vibrating mechanically as a flat plate, in fact as a Chladni plate, with of course a hexagonal symmetry. Such a mechanically vibrating system will have a complex, yet fundamentally hexagonal, distribution of nodes and anti-nodes. A growing crystal is in a dynamic state, being bombarded by water-vapour molecules, some of which can and do adhere locally to promote local growth. When the molecules adhere to achieve growth at any particular region on one arm, this immediately introduces a localized damping action on the vibrations. One can certainly anticipate that in a delicate equilibrium water molecules are less likely to adhere in regions in violent motion, and more likely to adhere in nodal or damped regions. Thus once growth starts it has a tendency to continue.

But this very damping is at once felt simultaneously at the corresponding positions on the other five arms. Thus molecules arrive and adhere easily at the other five arms in precisely the same situations as on the first arm; in other words, what happens on any one arm tends to be repeated on the others; hence the symmetrical growth, despite the apparent independence of each arm. The final symmetry is then explicable purely in terms of localized damping of mechanical vibrations, provided of course that the crystal is growing in conditions of delicate equilibrium, which is doubtless the case with the very perfect examples often found.

Of course, it is possible to produce alternative explanations; but they appear far-fetched. For example, to assume that some identical dislocation factor appears throughout the whole complex pattern and therefore simultaneously influences each arm seems most unreasonable and untenable. To postulate that ambient variations (temperature concentration, etc.) could identically affect each arm at every point simultaneously seems also unrealistic.

If the conjecture as to mechanical vibration, offered here, is correct, there would appear to be several implications. Thus: (1) The freely falling snowflake, being unconstrained to vibrate, might be expected in general to be more symmetrical than one grown on a solid surface. (2) The mechanical vibration of the crystal might conceivably be detectable as an ultra-sonic sound vibration. The dimensions of typical snowflakes indicate that these would be of very high frequency indeed, would have a complex spectrum, and doubtless would have very small amplitude. Indeed the detection of any such radiation would offer a most formidable problem. (3) On the other hand, if growing vibrating snowflakes are subjected to the right kind of ultra-sonic frequency, it might well be expected that the growth symmetry would be markedly affected.

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A Photographic Observation of the Satellite 1957 Beta leaving the Earth's Shadow

On December 15 a photograph of the satellite 1957 Beta was taken at the Warner and Swasey Observatory of the Case Institute of Technology, Cleveland, Ohio, which shows the satellite coming out of the Earth's shadow (Fig. 1). This observation can be used for deriving the distance of the satellite from the Earth's surface. It was concluded from visual observations made the previous morning that the satellite should leave the Earth's shadow in the constellation Ursa Major. An exposure, therefore, was started at 5h. 10m. 00s. E.S.T. with Ursa Major in the centre of the field, although the satellite was not yet visible. The satellite was first observed visually between 5h. 10m. 20s. and 5h. 10m. 30s. It is estimated that it came out of the shadow not earlier than 5h. 10m. 10s. The position where the track is first recorded on the photograph is α = 11h. 53m., δ = + 54·8°. It is possible that the satellite at this position had already left the shadow, but was not recorded earlier because it was at minimum brightness. Nevertheless, since the period of light variation was about 40 sec., the real position should be between the value already given and α = 11h. 37m., δ = + 61°. From these two positions, heights above the surface of 770 and 800 km. respectively were derived, assuming a spherical Earth and a cylindrical shadow with a radius equal to that of the Earth. If refraction is taken into account, smaller values of the height result. Assuming a deflexion of the light rays from the Sun of 1°, the corresponding heights are 713 and 739 km. It would appear then that the derived value of 785 ± 15 km. is a maximum one. From predictions of the Smithsonian Institution a height of about 1,000 km. was expected. According to our observations this is too large by at least 200 km.

Fig. 1. Photograph of the satellite 1957 Beta coming out of the Earth's shadow near γ Ursae Majoris on December 15. Exposure time: 5h. 10m. 00s. to 5h. 10m. 58s. E.S.T. (35-mm. camera, $f/2\cdot8$; Kodak 'Tri-X' film)

From observations on December 14 and 15 a period of 101·7 min. and, therefore, a value of 7,310 km. for the semi-major axis have been derived. Assuming the distance at perigee of 6,543 km. computed from the elements given in Harvard Announcement Card 1384 has not changed, the computed value of the eccentricity is $e = 0\cdot0927$. With these values the true anomaly can be derived for a given height. With the value of the inclination (62·5°) also given in Harvard Announcement Card 1384, the argument of perigee can be derived. While a height of 1,000 km. gives for the true anomaly and argument of perigee 109° and 22·5°, respectively, the corresponding values of 90·5° and 41° follow from these observations. The argument of perigee at November 4·0 was 44° according to Harvard Announcement Card 1384. It follows that the value of regression of the perigee is only −0·07°/day according to our observations, whereas a height of 1,000 km. gives a rate of −0·52°/day, close to the value of −0·6°/day given in Harvard Announcement Card 1384.

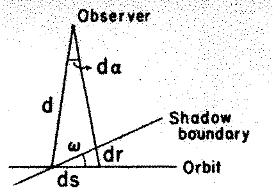

Fig. 2. The error in height as computed from the error in position. $ds \approx (2\pi d/360)\ d\alpha$; $dr \approx \tan\omega\ ds$. With $\omega_{\text{max.}} = 27{\cdot}3°$ and $d = 800$ km., $dr/d\alpha = 7{\cdot}2$ km./deg.

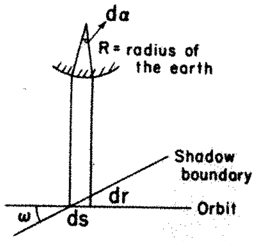

Fig. 3. The error in height as computed from the error in time. In the time dt (in min.) a point on the Earth's surface at latitude φ has moved by the amount $ds = 2\pi/360\ R \cos\varphi\ d\alpha = 2\pi/360\ R \cos\varphi\ dt/4$. $dr = \tan\omega\ ds$. $dr/dt = 10{\cdot}8$ km./min. for the latitude of Cleveland

Observations of a shadow-egress give very accurate values for the height of a satellite above the Earth's surface. At a height of 800 km. the largest angle possible between the orbit and the boundary of the shadow is 27·3°. From Figs. 2 and 3 it follows that an error in the observed position of egress of one degree results in a maximum error of 7·2 km. in the distance. An error of one minute in time results in an error of 10·8 km. in distance. Therefore, even approximate observations give rather accurate values for the height of a satellite, at least within ± 30 km. The height of 1,000 km. which was expected would require that the satellite had already left the shadow at a distance of 30° from our first observed position. There seems to be no reason why the satellite should not have been visible if this were correct.

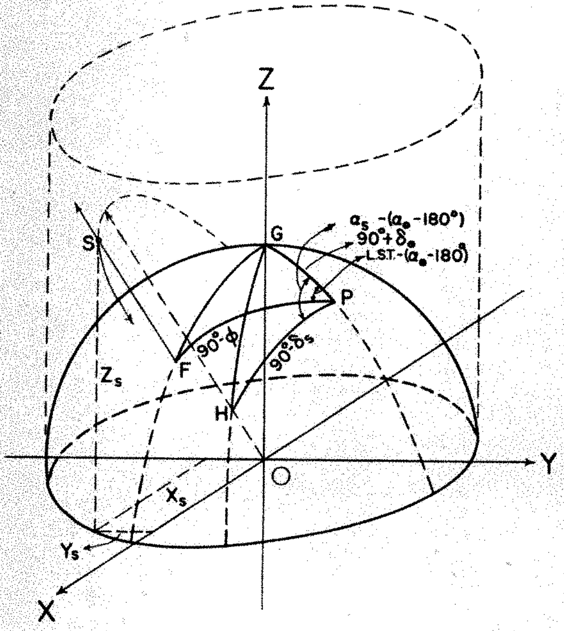

Fig. 4. Derivation of the height of a satellite above the Earth's surface. *F*, observer; *P*, pole of the Earth; *G*, point opposite to the Sun; *H*, point with the observed egress position in the zenith; *S*, satellite leaving the shadow; φ, observer's latitude; α_s, δ_s, right ascension and declination of the observed position of *S*; $\alpha\odot$, $\delta\odot$, right ascension and declination of the Sun; L.S.T., local sidereal time

The method used for the derivation is shown in Fig. 4. From the observed position of egress, the sidereal time, the latitude of the observer, and the spherical co-ordinates of the Sun, rectangular co-ordinates can be derived for the points *F* and *H*. The equations for the line $\overline{OH}$ give the direction toward the observed position of egress. The intersection of a line through *F* parallel to $\overline{OH}$ with the cylindrical or conical shadow gives the rectangular co-ordinates X_s, Y_s, Z_s for the satellite leaving the shadow. The distance from the Earth's centre is then $r = (X_s^2 + Y_s^2 + Z_s^2)^{1/2}$.

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Precision Determination of the Velocity of Electromagnetic Waves

The free-space phase velocity of electromagnetic waves *in vacuo* has been measured by means of a millimetre-wave interferometer operating at a frequency of 72 Gc./s., corresponding to a wave-length of about 4 mm. The result is:

$$c_0 = 299\,792{\cdot}50 \pm 0{\cdot}10 \text{ km./s.}$$

The variation represents the standard deviation of a single observation in statistical combination with estimated systematic uncertainties, the greatest of these being in the measurement of the standards of length used (derived by optical interferometry), and in the measurement of the refractive index of the air surrounding the microwave interferometer (obtained by means of a microwave refractometer).

The 24-Gc./s. prototype instrument has already been described[1], the 72-Gc./s. interferometer being basically identical, but considerably improved in performance. A full report of the present determination will be published in due course, but it should be noted here that the value previously assigned to the one-metre length-standard used with the prototype interferometer was too great, and this has caused the published value of c_0 obtained from that instrument to be high by 0·2 km./s. Thus the corrected value of the earlier determination[1] is: $c_0 = 299\,792{\cdot}7_5 \pm 0{\cdot}3$ km./s.

This work has been carried out as part of the research programme of the National Physical Laboratory and is published by permission of the Director of the Laboratory.

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Nov. 5.

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[1] Froome, K. D., *Proc. Roy. Soc.*, A, **223**, 195 (1954).

Metallographic Studies of Iron Carbide and Tungsten Carbide

In most metallographic investigations of steels or of cemented carbides the fine details of the carbides are not studied. We have just completed an etching study of iron carbides made in three different ways and of some tungsten carbide (1/32-in. equilateral triangles) single crystals. The iron carbide studies, made with Carapella's reagent (5 gm. ferric chloride,

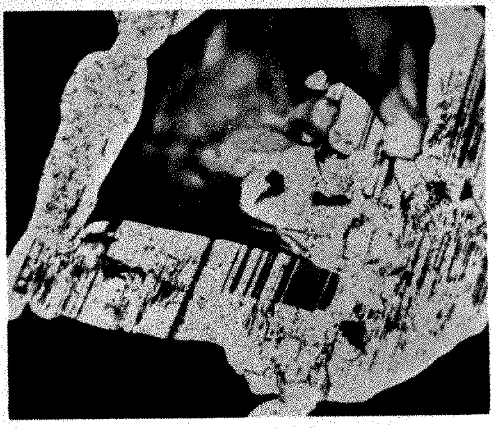

Fig. 1. Striæ in carburized iron ('Puron') carbide. Carapella's reagent. (× 1,000)

2 ml. concentrated hydrochloric acid and 99 ml. methyl alcohol) etching for 20–60 min., revealed cracking as the principal deformation mechanism and twinning as the secondary agency. The cracking behaviour has been described previously, but the twinning appears to be a new observation[1]. In two cases only, out of hundreds of samples studied, the cracks found were aligned along the twinning planes in the carbides. These observations were made upon a carburized plain carbon steel, upon a carburized 'Westinghouse Puron' iron (spectrographically pure) and upon a pure, massive, polycrystalline, iron-manganese carbide kindly supplied by Dr. L. S. Darken of U.S. Steel Research from his recent ternary system studies. In the two carburized samples there was no possibility of mechanical work having caused cracking of the carbide. Fused caustic, 50 per cent nitric acid and 50 per cent hydrochloric acid were also successful etching reagents.

The tungsten carbide crystals etched nicely in fused sodium hydroxide held just above its melting point in a nickel crucible heated electrically by a knife-blade type heater insulated with glass wool and controlled by a 'Variac'. This reagent and technique also etched pure tantalum carbide crystals. Only the fused caustic served as an etching reagent for the tungsten carbide crystals. After this caustic etching, the sample surfaces were cleaned in an acid solution, either 'Nital' or Carapella's reagent being satisfactory. For those who are concerned with hard carbides, cemented carbides, or the production of carbide die patterns, this fused caustic etching technique may prove useful.

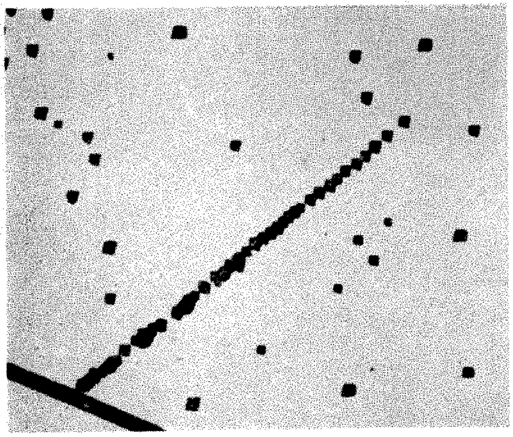

Fig. 2. Etch-pit array (dislocation line?) in iron–manganese carbide. Dark solid line in lower left is a grain boundary. Carapella's reagent. (× 625)

We believe that the twins in the iron carbides are an index of the carbide orientation and morphology. Most of the large iron carbides present in the steels are single crystals of irregular shape. The cracking and the presence of twins indicate high internal stresses.

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Oct. 21.

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[1] Hopkins, B. E., *West of Scotland Iron and Steel Inst. J.*, discussion, **60**, 340 (1953).

Two Borides with the Cementite Structure

An investigation by X-ray powder methods of the nickel–boron and the cobalt–boron systems has revealed the existence of two isomorphous borides, Ni_3B and Co_3B. A nickel boride with a boron content about 25 atom per cent has previously been reported by Andersson and Kiessling[1], but no reports on Co_3B seem to have been published.

Alloys were prepared by heating mixtures of amorphous boron (99·1 per cent) with nickel powder (99·8 per cent) or cobalt powder (99·2 per cent, containing 0·45 per cent nickel) in an argon-arc furnace or in evacuated and sealed silica tubes. X-ray diffraction patterns were recorded in chromium K_a and copper K_a radiation with Guinier-type focusing cameras.

The orthorhombic unit cell of Ni_3B has the dimensions $a = 4 \cdot 389$ A.; $b = 5 \cdot 211$ A.; $c = 6 \cdot 619$ A. The lattice dimensions of this phase showed no significant variations in alloys of different composition. The unit cell of Co_3B was found to vary between $a = 4 \cdot 408$ A.; $b = 5 \cdot 223$ A.; $c = 6 \cdot 629$ A. and $a = 4 \cdot 411$ A.; $b = 5 \cdot 235$ A.; $c = 6 \cdot 634$ A. The lattice parameter values are probably accurate to 0·05 per cent. As seen from Table 1, the visually estimated intensities of the lines are in qualitative agreement with the powder data for cementite (Fe_3C) given by Lipson and Petch[2].

It is interesting to note that up to 80 per cent of the carbon in Fe_3C can be substituted by boron while retaining the cementite structure[3]. No binary boride Fe_3B seems to exist, but it may be mentioned that in the ternary system iron/boron/phosphorus a phase

Table 1. Intensity Observation for Co_3B (Chromium $K\alpha$ Radiation) compared with Data for Fe_3C given by Lipson and Petch (Ref. 2)

hkl	$I_{obs.}$ Co_3B	$I_{obs.}$ Fe_3C	*hkl*	$I_{obs.}$ Co_3B	$I_{obs.}$ Fe_3C
101	*v.w.*	—	103	*st.*+	23·2
002	*w.*	—	211	*st.*	12·6
111	*w.*	—	122	*st.*	9·2
020	*w.*	1·0	113	*st.*	7·2
021	*m.*	14·4	202	*w.*	—
112	*st.*		212	*st.*	8·8
120	*m.*	5·8	023	*m.*	3·8
200	*w.*	6·3	004	*m.*	
121	*st.*	14·2	221	*v.w.*	1·6
022	*st.*	14·2	130	*m.*	4·5
210	*st.*	15·6			

v.w., very weak; *w.*, weak; *m.*, moderate; *st.*, strong.

$Fe_3B_xP_{1-x}$ with variable composition ($0{\cdot}5 < x < 1$) has been found which exists with phosphorus content less than 1 atom per cent (unpublished work). The structure of this phase, based on a primitive tetragonal lattice, shows no obvious resemblance to the cementite structure, however.

A detailed report of this work, together with a structure determination of Ni_3B from single-crystal data, will soon be published in *Acta Chemica Scandinavica*.

This work has been supported by a scholarship from Statens Tekniska Forskningsråd, which is gratefully acknowledged.

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Oct. 8.

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Amplitude of a Quartz Plate vibrating in Liquids

Some attempts have been made to measure the amplitude of a vibrating quartz crystal, but no method at present exists by which its absolute value in a liquid can be determined experimentally, although the amplitude can be calculated theoretically from the relation given by Vigoureux[1]:

$$a = \frac{2c_{11}Vd}{\pi c_1 \rho_c}$$

where c_{11} is the elastic modulus governing the thickness vibration of X-cut plate; d the change in thickness of the plate per volt (2μμm.); V the voltage applied; c_1 the velocity of sound in quartz and ρ_c the radiation resistance of the transmission medium.

The development of a thermosonic method in this laboratory has now enabled us to determine the amplitude of vibration. The principle of the method lies in evaluating the amplitude of the plane sound-wave at the source of the ultrasonic beam from the mean power of the sound from the formula[2]

$$P = 2\pi^2 \rho_c \xi^2 N^2 S$$

where N is the frequency; ξ the amplitude and S the area of source of sound. The mean power of the sound, P, is obtained from the relation[3]: $I = JH$, which involves the measurement of heat produced by a calorimetric method.

The amplitude of a quartz plate as determined from Vigoureux's formula and the amplitude of sound calculated from power measurements of the output of sound, carried out in this laboratory[4] for 1 V. input at about 5 Mc. are given in Table 1.

Table 1

Liquid	c (m./sec.)	ρ (gm./sec.^{3})	$\rho_c \times 10^{-3}$	Voltage	Ultrasonic output (watts)	$\xi \times 10^9$ (cm.)	$a \times 10^9$ (cm.)
Methyl alcohol	1,123	0·792	88·9	160	2·393	1·96	2·18
Acetone	1,192	0·792	94	158	1·626	1·59	2·06
Methyl ethyl ketone	1,207	0·805	97·2	94·5	0·579	1·56	1·99
Butyl alcohol (*n*)	1,268	0·810	103	165	1·514	1·40	1·88
Xylene (*m*)	1,340	0·863	116	158	1·364	1·31	1·67
Benzene	1,326	0·878	116	155	1·199	1·25	1·67
Chlorobenzene	1,291	1·107	143	162	1·308	1·13	1·36
Carbon tetrachloride	938	1·595	150	173	1·361	1·05	1·29
Glycerine	1,923	1·261	242	173	1·026	0·72	0·80

These results show that the agreement between the amplitudes of oscillation of the quartz and of sound is good. It is observed that the amplitude of the sound wave is always less than that of the quartz, the variation lying between 10 and 25 per cent. It is also noticed that the difference between the two amplitudes, albeit small, varies with the nature of the liquid used. It is likely that this variation is related to some property of the liquid or of the quartz crystal, although it may be due to experimental limitations.

Further investigations are in progress, and full details will be published elsewhere.

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of India,
New Delhi.
Sept. 30.

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Surface Hardness of Explosive Materials by Micro-indentation

The influence of adulterating grit on the impact and friction sensitivity of a number of explosives has been shown to be considerable[1]. It is generally agreed that grit sensitizers act through modification of conditions necessary to produce frictional hot-spots, and that this process is influenced to a large extent by the hardness of the grits. Although detailed hardness data are now available for many of the common grits[2], little or none exists for the explosives themselves.

The following technique, designed to follow the modifying effect of X-rays and light on the hardness of α-lead azide, makes such detailed information readily available in many instances. The apparatus used is the Cooke, Troughton and Simms micro-indentation hardness tester fitted to a Vickers projection microscope[3]. With this instrument, materials may be indented at known load with a diamond pyramidal indenter and the indentation measured. The Vickers hardness number is obtained from the ratio of load to indentation surface.

The crystals to be tested are readily mounted in suitable presentation by the following technique. A 'Perspex' plug, ½ in. deep and machined from a rod 1 in. in diameter, is softened on one face by a few minutes immersion in chloroform. This face is allowed to become tacky in a current of warm air and is then pressed squarely down on to the crystal sample carried on a glass plate. The plug is withdrawn

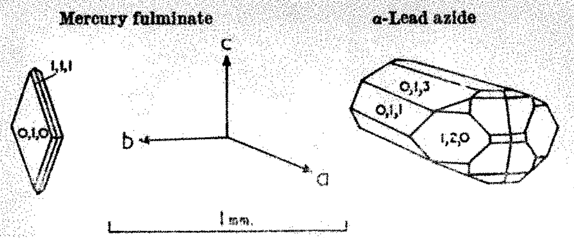

Fig. 1

and the crystals allowed to set hard. In this way, principal faces are oriented away from the plug and suitable for indentation. Lesser faces may be brought into orientation while the 'Perspex' is still plastic by careful probing under a microscope.

The plug is now inserted in the chuck of the micro-indenter and indented in standard fashion.

Small fragments of annealed 'from the melt' crystals of sodium chloride and lithium fluoride were selected as controls and mounted and indented by the above method. These two salts have hardness values of an order similar to those of the initiators mercury fulminate and α-lead azide. Vickers hardness numbers of the 1,0,0 forms of sodium chloride and lithium fluoride for an indentation diagonal of 30μ were found to be 19·5 and 103 respectively in good agreement with published values[4]. No surface hardening was observed, the apparent Meyer coefficients being widely constant over the loading range at 2·04 and 2·13 respectively.

Crystals of the two important initiators, mercury fulminate and α-lead azide, were selected for examination. Crystals of the pure material, larger than normal, were grown by crystallization from solution in aqueous ammonium chloride and ammonium acetate respectively. The faces examined were those principally defined in material used for Service purposes, and were distributed as shown in Fig. 1.

A number of crystals of each initiator were mounted and indented at various loads, results from several crystals and by two operators being incorporated in the results. The result for a 10-gm. load on the 0,1,3 form of α-lead azide is a particularly well-established value, being the result of seventy-five determinations. Figs. 2 and 3 show the plot of the logarithms of load against indentation diameter for the appropriate crystal forms.

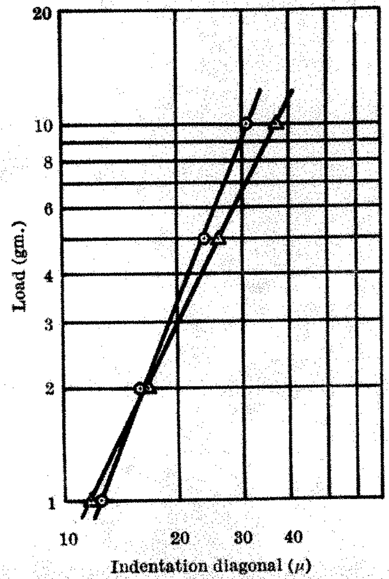

Fig. 2. A log/log plot of indentation diagonal against appropriate load for mercury fulminate: ⊙, for 1,1,1 form; △, for 0,1,0 form

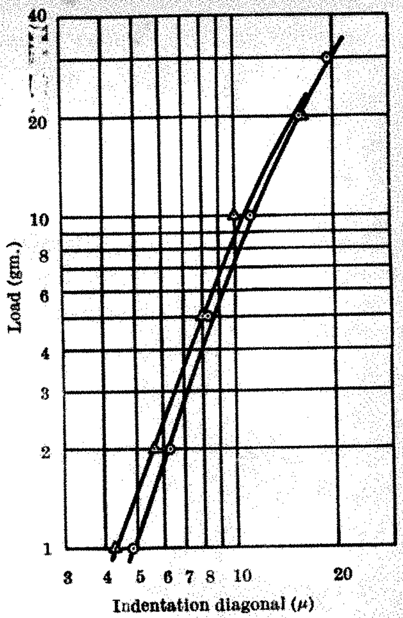

Fig. 3. A log/log plot of indentation diagonal against appropriate load for α-lead azide. ⊙, for 0,1,1/0,1,3 forms (individual curves irresolvable); △, for 1,2,0 form

Where the gradient of this line is uniform and equal to 2, the Vickers hardness number is constant for all loads: otherwise, it is variable and must be quoted against experimental conditions. In the present context, it is convenient to present the hardness figures against standard load and this has been done in Table 1.

Table 1

Initiator	Miller indices of crystal form	Vickers hardness number			
		At 1-gm. load	At 5-gm. load	At 10-gm. load	At 20-gm. load
Mercury fulminate	0,1,0 1,1,1	13·5 12·3	14·1 17·4	14·4 19·9	— —
α-Lead azide	0,1,1 } 0,1,3 }	80	131	144	145
	1,20,	99	151	165	161

These hardness values relate to material substantially unexposed to light. We have shown (unpublished work) that the hardness of α-lead azide is severely modified by exposure to soft X-rays, and related questions such as the effect of exposure to ultra-violet light are being investigated.

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E. Parry

Ministry of Supply,
Armament Research and Development
Establishment,
Fort Halstead. Nov. 4.

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Vapour Pressure of Tritiated Water

A SURVEY of the literature for the vapour pressure of hydrogen tritium oxide (HTO) revealed one reference only[1]. No values were quoted for the vapour pressure at any temperature, but the authors stated the boiling point of tritiated water was less than that of ordinary water. The work reported here is the determination of the vapour pressure of hydrogen tritium oxide in the range 25–80° C.

Table 1. VAPOUR PRESSURE OF ORDINARY AND TRITIATED WATER IN MM. OF MERCURY

Temperature (° C.)	$\frac{\text{V.p. HTO}}{\text{V.p. } H_2O}$	V.p. H_2O (ref. 3)	V.p. HTO
25·70	0·77	24·76	19·07
27·84	0·81	28·05	22·72
39·98	0·84	55·27	46·43
55·02	0·88 (5)	118·04	104·47
75·60	0·89 (5)	296·3	265·2

A standard sample of tritiated water was obtained from the Atomic Energy Research Establishment, Harwell. Stock solutions of activity 4·84, 9·61, 16·75 and 24·9 μc./ml. were prepared from this standard using 'Analar'-grade distilled water. These samples were allowed to equilibriate with their vapours in a glass apparatus totally enclosed in a thermostated bath. Using this apparatus, it was not found possible to make measurements above 80° C. due to 'streaking' occurring in the high-vacuum grease used to lubricate the glass stopcocks and joints. The water vapour was isolated from the liquid phase and analysed by the butane method of Glascock[2]. At any one temperature the ratio of the activity in the vapour to that in the liquid was constant, showing that the system obeyed Henry's law. It may be shown that this ratio equals the ratio of the saturation vapour pressure of tritiated to that of ordinary water. The results are given in Table 1.

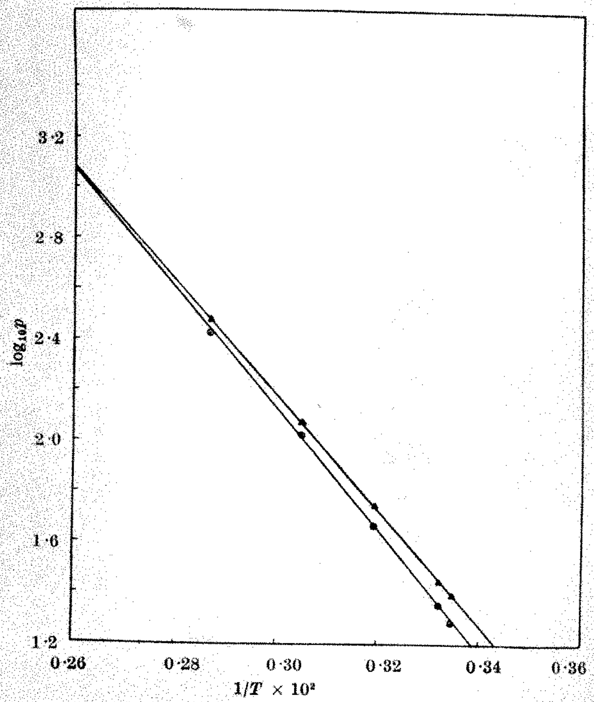

Fig. 1. Variation of $\log_{10}p$ with $1/T$ for tritiated water, ⊙ ; and for ordinary water, △

It is seen that the vapour pressure of tritiated water is less than that of ordinary water up to 80° C., and extrapolation using a $\log_{10}p$ versus $1/T$ plot (Fig. 1) shows the boiling point of the former to be greater than that of the latter. The molar heat of vaporization of tritiated water is found to be 10·9 kcal., compared to a mean value of 10·3 kcal. for ordinary water.

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Nov. 8.

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Use of Gaussian Functions for Intermolecular Potentials

THE purpose of this communication is to point out that the superposition of two Gaussian functions,

$$\varphi(r)^G = -C_1 \exp(-c_1 r^2) + C_2 \exp(-c_2 r^2) \quad (1)$$

with suitably chosen constants (C_1, c_1, C_2, $c_2 > 0$) provides a good approximation to the Lennard-Jones potential,

$$\varphi(r)^{L\text{-}J} = -a\,r^{-6} + b\,r^{-12} \quad (2)$$

which is approximately valid for the interaction between spherically symmetrical molecules ; and that the use of (1) leads to comparatively simple expressions in certain types of theoretical work.

Fig. 1 shows that the agreement between (1) and (2) is close except at large values of r where $|\varphi(r)|$ has become small ; the fact that (1) remains finite as $r \rightarrow 0$ does not prevent a sufficiently rapid increase with decreasing r in the practically important range. The question whether the larger number of adjustable constants in (1) offers any advantage in the direct correlation of experimental data has not been investigated.

A mathematical advantage of (1) arises from the fact that the average potential energy, $\overline{\Phi}$, of an assembly of particles interacting according to (1), and for which the probability density in configuration space is expressible in terms of Gaussian functions and their derivatives, can be evaluated in closed form. Probability densities of this type may be reasonably realistic models for the liquid (and solid) state.

In particular, (1) has been used to calculate the average potential energy for the following statistical models :

(*a*) A lattice distorted by plane displacement waves with normally distributed amplitudes :

$$\rho(\,.\,.\,\mathbf{x}_j,\,.\,.\,) = \prod_{j=1}^{j=n} \delta[\mathbf{x}_j - \mathbf{s}_j - \sum_{\mathbf{k},\alpha} \mathbf{a}(\mathbf{k},\alpha)\exp(2\pi i\mathbf{k}.\mathbf{s}_j)]$$
$$\prod_{\mathbf{k},\alpha}[2\pi\sigma^2(\mathbf{k},\alpha)]^{-1/2}\exp\{-|\mathbf{a}(\mathbf{k},\alpha)|^2/2\sigma^2(\mathbf{k},\alpha)\} \quad (3)$$

($\mathbf{x}_j$ denotes the position vector of the particle displaced from the lattice site $\mathbf{s}_j$; δ the Kronecker symbol ; $\mathbf{a}(\mathbf{k},\alpha)$ the amplitude and direction of displacement caused by the wave with the wave vector $\mathbf{k}$ and polarization α ; $\sigma(\mathbf{k},\alpha)$ are constants). One obtains for the mean potential energy between two particles attached to the lattice sites $\mathbf{s}_j$ and $\mathbf{s}_{j'}$ an expression of the form :

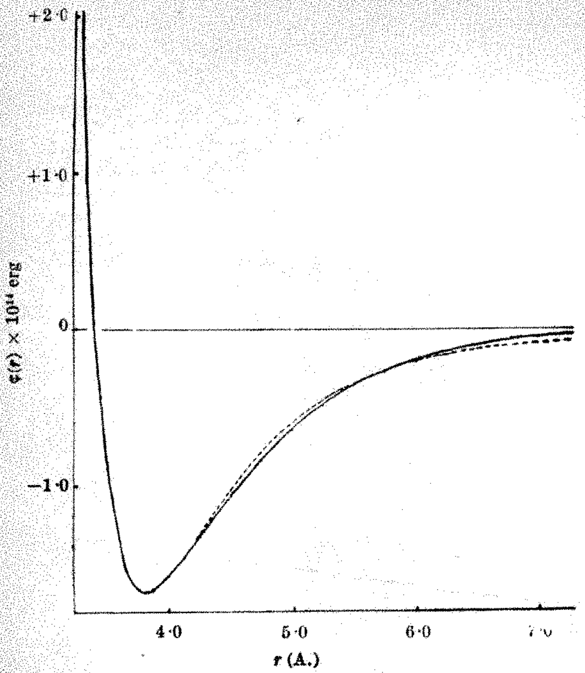

Fig. 1. Comparison of $\varphi(r)^{G}$ and $\varphi(r)^{L-J}$ for argon: – – –, $\varphi^{L-J} = -1{\cdot}05 \times 10^{-10}\ r^{-6} + 1{\cdot}63 \times 10^{-7}\ r^{-12}$ (see ref. 1); ———, $\varphi^{G} = -9{\cdot}12 \times 10^{-14} \times \exp(-0{\cdot}106\ r^{2}) + 2{\cdot}40 \times 10^{-10} \times \exp(-0{\cdot}783\ r^{2})$. φ in ergs in each case, r in Ångström units

$$\overline{\Phi}_{jj'} = -C_1\, g(c_1)^{-3/2} \times \exp\{-|\mathbf{s}_j - \mathbf{s}_{j'}|^2 f(c_1)/g(c_1)\} + C_2\, g(c_2)^{-3/2} \times \exp\{-|\mathbf{s}_j - \mathbf{s}_{j'}|^2 f(c_2)/g(c_2)\} \quad (4)$$

where f and g are polynomials of second and third degree respectively in the $\sigma^2(\mathbf{k},\alpha)$'s and in c_1 or c_2. The coefficients in these polynomials are determined by the lattice-type and by the lattice vector $(\mathbf{s}_j - \mathbf{s}_{j'})$.

(*b*) A lattice in which the displacements of particles are mutually correlated and normally distributed:

$$\rho(\,.\,,\mathbf{x}_j,\,.\,) = (2\pi)^{-3n/2}\|Q\|^{-1/2} \exp\{-1/2\sum_{j}\sum_{j'}\sum_{\alpha}\sum_{\alpha'}(x_j^{\alpha} - s_j^{\alpha})Q_{jj'}^{\alpha\alpha'}(x_{j'}^{\alpha'} - s_{j'}^{\alpha'})\} \quad (5)$$

where x_j^{α}, s_j^{α} are the α-components of the vectors $\mathbf{x}_j, \mathbf{s}_j$; $Q_{jj'}^{\alpha\alpha'}$ are (constant) elements of a symmetrical matrix which depends on the symmetry of the lattice; $\|Q\|$ is the corresponding determinant. This leads to

$$\overline{\Phi}_{jj'} = -C_1\{h_1(c_1).h_2(c_1).h_3(c_1)\}^{-1/2} \exp\{-|\mathbf{s}_j - \mathbf{s}_{j'}|^2.c_1/h_1(c_1)\} + C_2\{h_1(c_2).h_2(c_2).h_3(c_2)\}^{-1/2} \exp\{-|\mathbf{s}_j - \mathbf{s}_{j'}|^2 c_2/h_1(c_2)\} \quad (6)$$

where h_1, h_2, h_3 are linearly related to c_1 or c_2 and to the reciprocals of linear combinations of the $Q_{jj'}^{\alpha\alpha'}$.

(*c*) A probability density in which the particles are not attached to lattice sites, and which tends to zero when any two particles are too close to each other or too far apart:

$$\rho(\,.\,,\mathbf{x}_j,\,.\,) = \text{const.} \prod_{j=1,\, j'>j}^{j=n,\, j'=n} |\mathbf{x}_j - \mathbf{x}_{j'}|^{2m} \exp\{-\beta|\mathbf{x}_j - \mathbf{x}_{j'}|^2\} \quad (7)$$

where m is an integer >0, and β a constant > 0. This leads to:

$$\overline{\Phi} = \frac{n(n-1)}{2} \left| \left[\prod_{j'>j}^{n,n} \frac{\partial^m}{\partial\beta_{jj'}{}^m}\left(-H_1 + H_2\right)\right] \cdot \left[\prod_{j'>j}^{n,n} \frac{\partial^m}{\partial\beta_{jj'}{}^m}\, D^{-3/2)}\right]^{-1} \right|_{\beta_{jj'} = \ldots = \beta} \quad (8)$$

where $H_1 = C_1(D + 2c_1\partial D/\partial\beta_{12})^{-3/2}$

$H_2 = C_2(D + 2c_2\partial D/\partial\beta_{12})^{-3/2}$ and

D is the discriminant of $\sum\sum_{j'>j}^{n,n} \beta_{jj'}(u_j - u_{j'})^2$

The distributions (3), (5) and (7) are of interest as models for the liquid or solid state because they also lead to simple or manageable expressions for the configurational entropy, $S_c = -k\int..\int\rho \ln \rho.d\mathbf{x}_1..d\mathbf{x}_n$ and hence to expressions for the free energy which can be minimized (numerically) with respect to the parameters which determine the probability density (that is to say, the $\sigma(\mathbf{k},\alpha)$'s, the $Q_{jj'}^{\alpha\alpha'}$'s and β). Preliminary computations for argon on the basis of (3) have yielded fairly encouraging results; details of the method and results of numerical work based on (3), (5) and (7) will be reported elsewhere.

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Improved Resolution of X-Ray Diffraction Patterns of Protein Crystals at Low Temperature

POSSIBILITIES for X-ray crystal structure analysis of proteins are limited by the minimum spacings observed in diffraction. For many proteins, the minimum spacing is about 2·5 A.—a limit which does not permit the resolution of individual atoms in Fourier maps prepared from the data, even if these are accurately measured, and the problem of the determination of the phases of the X-ray diffraction spectra can be solved successfully. This lack of resolution puts a severe restriction on the use of Fourier methods for structure determination of proteins. For a few proteins, such as bovine pancreatic ribonuclease, data with a minimum spacing of 1·5 A. are available, so that resolution of atoms is possible in principle. Thus the study of protein structure is highly dependent on fortune in obtaining crystals permitting atomic resolution in their diffraction effects.

An investigation of the causes of the limit on the minimum spacing should be of value in indicating possible ways of improving the situation, as well as in providing information about the nature of protein crystals. In general, the value of the minimum spacing is a measure of the average of the deviations of atoms from their mean positions in the structure; these deviations are due to types of disorder which might be either static or dynamic. Static disorder may appear as a result of heterogeneity (configurational or chemical) of the protein, or as a result of packing faults. Dynamic disorder is likely to be a complex phenomenon in protein crystals, involving restricted Brownian movement of the protein molecules about their mean positions, coupled with the surge of molecules of the solvent from one interstice to the next, in addition to the normal thermal vibration existing within each protein molecule. Brownian movement is likely to be greatest for mechanically weak protein crystals, in accord with experience at the Protein Structure Project with the minimum spacings observed for the various modifications of ribonuclease.

If the dynamic disorder is a large component of the total disorder within a protein crystal, the resolution of the diffraction should improve with decrease of temperature, with a limit on improvement, however, imposed by the tendency for 'freezing-in' of disorder at low temperatures, and the fact that the interstices will not, in general, hold an integral number of solvent molecules.

Low-temperature diffraction studies of crystals of ribonuclease II were made by Dr. Vittorio Luzzati (now at Centre de Recherches sur les Macromolecules, 6 rue Boussingault, Strasbourg, France) at the Protein Structure Project; these crystals had been grown from various aqueous alcohols[1]. He found that each crystal showed an abrupt increase in mosaic character at a temperature approximately equal to the freezing point of the pure solvent. This phenomenon is probably caused by disruption of the protein crystal as crystallites of the solvent are produced within the interstices, and precludes, of course, any improvement of resolution on further decrease of temperature.

The range from room temperature to the freezing point of the solvent is usually quite limited. The only recourse appeared then to be to replace the solvent within the interstices with another solution which does not freeze at the desired temperature of study. The investigation of low-temperature diffraction effects of protein crystals was resumed with the study of crystals of ribonuclease II which had been crystallized from 55 vol. per cent 2-methyl-2,4-pentanediol, and had then been soaked for one week in 90 vol. per cent 2-methyl-2,4-pentanediol. The latter composition was chosen as containing the minimum amount of water necessary for maintaining the ribonuclease crystals without visual or X-ray indications of damage. This solvent does not freeze, but becomes highly viscous at dry-ice temperature, and glassy at lower temperatures.

Two crystals were soaked as indicated, mounted in random orientations, and 5° oscillation photographs were taken at room temperature and at −27° C. Of these, the larger crystal showed an improvement at the lower temperature of the minimum observed spacing from 1·69 to 1·41 A., while the smaller showed a change from 1·81 to 1·66 A. On the average, then, the minimum spacing decreased by about 15 per cent. This corresponds to an increase in maximum observed length of reciprocal lattice vector of 15 per cent, or to 50 per cent greater volume covered in reciprocal space.

This degree of improvement of resolution, while not great enough to give a crucial advantage in crystal-structure determination, nevertheless indicates that the limitation on resolution is due at least in part to thermal disorder. It should be noted that ribonuclease crystals give much better resolution than do most protein crystals, and compare well even with simple organic structures, for which the minimum spacing observed is often 0·6–0·7 A. Hence, the room for improvement in resolution in diffraction results from ribonuclease is small. The technique of low-temperature diffraction studies will probably be of more practical benefit in the study of other protein crystals which do not give such good results at room temperature, and may in some cases make possible resolution of atoms in structures for which the room-temperature results do not permit this. In each case, however, it will be necessary to have within the interstices of the crystal a solvent which remains liquid at sufficiently low temperatures. For proteins which would be denatured by organic solvents, solutions of salts or salt mixtures having very low eutectic temperatures might be applicable.

I wish to thank Prof. I. Fankuchen and Dr. Judith Bregman and their co-workers for the use of low-temperature equipment and for invaluable aid and suggestions. Appreciation is expressed to the various institutions (the Dean Langmuir Foundation, the Rockefeller Foundation, the Damon Runyon Fund, New York Foundation, Inc., the Polytechnic Institute of Brooklyn, the International Business Machines Corporation) the continued support of which makes the work of the Protein Structure Project possible.

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Separation of the Lower Fatty Acids (C_1 to C_{10}) by High-Voltage Paper Electrophoresis

Several paper-chromatographic procedures for the separation of the lower fatty acids as their ammonium or ethylamine salts have been described[1]. They suffer, however, from two disadvantages: formic acid cannot be separated from acetic acid and the time required is about 20 hr. By running the chromatograms at 50–60° C. the time required for the separation of the acids C_2 to C_6 could be reduced to 1–2 hr., according to a recent report[2].

During a study of the migration-rates of inorganic cations under high-voltage conditions[3], it was found that under identical conditions many inorganic anions[4] and the lower fatty acids were separable within 10–45 min. The separation of the isomers of C_4 and C_5, however, was not feasible, owing to the very small differences in mobilities. Fig. 1 shows the positions of the acids C_1 to C_{10} under the chosen conditions.

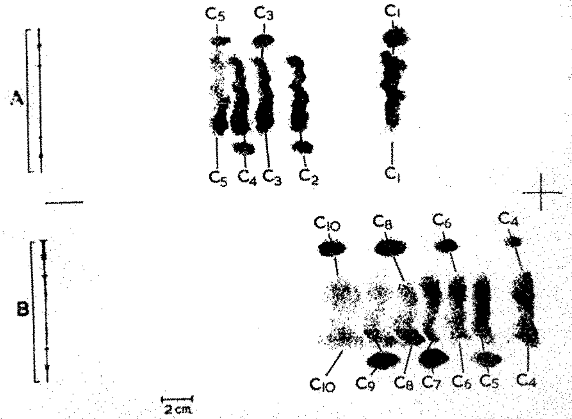

Fig. 1. Electrophoretic separation of the lower fatty acids (C_1 to C_{10}). Conditions: (*A*) 100 V./cm., 13 m.amp./cm., 1·5 lb./in.², Whatman No. 3 *MM*, 4 in. × 22½ in. strip, approx. 0·1 *M* ammonium carbonate solution (7·9 gm./l.), *p*H 8·9, mean temperature of cooling water 12° C., 20 min., applied 2 in. from cathode end 10–20 μgm. of each acid per spot and 50–100 μgm. per band; spraying reagent: 0·025 per cent bromophenol blue in acetone–water (9 : 1) mixture, acidified with 100 mgm. of citric acid per 100 ml. (*B*) as above, 45 min.

The sparingly water-soluble acids C_6 to C_{10} were converted into their sodium salts by dissolution in dilute sodium hydroxide, which did not affect their migration-rates. The acid radical migrates apparently as the free acid, finally forms the ammonium salt and is detected as such.

The first five or six members of the series can be separated within 20 min. at 100 V./cm. (*A*), the rest require 45 min. for complete separation (*B*). The electrograms were dried at 80° C. for about 10 min. and then sprayed with the bromophenol blue reagent, producing blue spots on yellow background stable under ordinary laboratory conditions for at least several hours and of a sensitivity of 2–5 μgm. according to the acid. A more sensitive reagent was found in a solution of 0·05 per cent bromocresol purple in 90 per cent ethanol, with a sensitivity of 0·5–1·0 μgm. for most of the acids but producing rapidly fading colours. The reagent, however, proved useful in the detection of the presence of the faster migrating inorganic anions, for example, chloride and sulphate, in mixtures of fatty acids.

The complete separation of the mixture allowed a convenient quantitative determination of the individual components based on the roughly linear relationship between spot area and concentration over a range of 5–25 μgm. An interesting feature of the paper electrophoretic behaviour of the lower fatty acids is that the mobilities are inversely proportional to the molecular weights, causing a sequence of migration similar to that in vapour-phase chromatography[5] but the reverse of that in paper chromatography. This effect can be utilized for checking doubtful separations by a two-dimensional combination of paper electrophoresis and paper chromatography. There is apparently little correlation between the dissociation constants of the acids and their mobilities, except for the pair formic and acetic acids.

Thanks are due to Mr. H. C. S. de Whalley, director of research, for his interest, Mr. R. W. Butters for technical assistance, and the directors of Tate and Lyle, Ltd., for permission to publish this communication.

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The Basicities of N-Alkyl Anilines

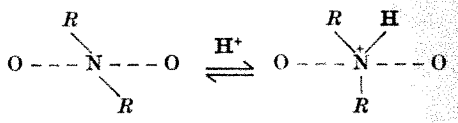
THE order of the basicities of the N-alkyl anilines, for which no satisfactory explanation has hitherto been proposed, can be accounted for by a consideration of the intramolecular overcrowding that occurs in the corresponding anilinium ions.

The observed order of basicities[1], measured in water at 25° C. is :

	pKa		*pKa*
Aniline	4·62	Dimethylaniline	5·98
Methylaniline	4·85	Diethylaniline	6·56
Ethylaniline	5·06	Di-*n*-propylaniline	5·59
n-Propylaniline	5·02	Di-*n*-butylaniline	5·7

The order of basicities is usually explained on the grounds of steric inhibition of resonance[2,3], but this fails to account for the large steric requirements of ethyl groups, and indeed has been criticized by Thomson[3].

The results can, however, be explained as follows :



(I) (II)

In the free base (I), the configuration of the molecule is a compromise between the steric requirements of the alkyl groups (*R*) and the coplanarity demanded by conjugation between the amino group and the benzene ring. The bulkier the alkyl groups, the greater the steric inhibition of resonance, and therefore the greater the basicity. On this consideration, pK_a should increase with increase in size of *R*. In the anilinium ion (II), however, conjugation is eliminated, and the configurational requirements of the ion forces one of the alkyl groups towards an *ortho* position. The larger the alkyl group, the greater the resulting instability of the anilinium ion ; thus the basicity will be reduced.

When *R* is a methyl or ethyl group, intramolecular overcrowding in the anilinium ion is small, and the increasing effect of steric inhibition of resonance in the free base gives an increased basicity on passing from *R* = methyl to *R* = ethyl. For the larger *n*-propyl and *n*-butyl groups, however, instability of the anilinium ion causes a fall in basicity, since no further increase in steric inhibition of resonance can occur.

A similar explanation has been given by Brown[4], using the terms '*B*-strain' and '*F*-strain', to account for the reduced basicity of dimethyl-*m*-2-xylidine over dimethyl-*o*-toluidine. In using these concepts to account for the reduced basicity of trimethylamine over dimethylamine, however, Brown[5] is on more difficult ground, since it is not valid[6] to make a direct comparison of the dissociation constants of primary, secondary and tertiary amines.

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Infra-red Absorption Spectra of Casein and Lactose

A COMMUNICATION by Goulden[1], stating that an interaction between protein and sugar is demonstrated by the infra-red absorption spectra of mixtures of the two, prompted us to study this system in the hope that a similar approach might yield information about antibody–antigen reactions.

The spectrum of a dry intimate mixture of casein and lactose shows sharp bands between 7·0 and 11·0μ, whereas the spectrum of a freeze-dried solution of the same mixture shows broad diffuse absorption bands between these wave-lengths. As these differ-

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ences occur in a region of the spectrum associated with C—O stretching and O—H bending vibrations, Goulden suggested that the casein and lactose are held together either by some form of hydrogen bonding or by residual water molecules which are firmly bound between the protein and the carbohydrate molecules[2].

In the course of our work on the infra-red absorption spectra of mixtures of casein and lactose, it soon became obvious that there was little evidence for an interaction. An examination of the spectra of α-lactose monohydrate, anhydrous α-lactose, β-lactose and the glasses formed by evaporating aqueous solutions of these sugars showed that the glasses gave spectra with broad, poorly resolved bands, whereas samples of the same sugars examined as finely ground powders in mineral oil or in potassium bromide or chloride disks gave sharper and better resolved absorption bands (Fig. 1). This dependence of the spectrum of a sugar upon the physical state of the specimen has been reported by several workers[3-5]. It seems likely, therefore, that a large part of the difference in spectrum attributed to an interaction between casein and lactose is due to the lactose changing from the crystalline to the glassy (amorphous) state. This possibility is confirmed by two simple experiments. (1) The spectrum of a freeze-dried solution containing both casein and lactose can be reproduced by casting a film of lactose in the glassy state on one side of a silver chloride support and a film of casein on the other. (2) The change observed by Goulden can be reversed by exposing a film of casein and amorphous lactose to a humid atmosphere (relative humidity 75 per cent); under these conditions the amorphous lactose recrystallizes to the α-monohydrate. It may still be that there is some residual change in spectrum due to an interaction, but its magnitude is much less than that due to the change in the lactose.

The infra-red absorption spectra of pressed alkali halide disks containing sugar are liable to change during storage[4], and to minimize such changes we have followed the procedure recommended by Barker *et al.*[5]. Despite these precautions changes have been observed in the spectra of disks stored for several months. In particular, the conversion of anhydrous α-lactose to α-lactose monohydrate and β-lactose to α-lactose monohydrate can be followed by changes in the spectrum of the disk. Specimens of anhydrous α-lactose have to be handled with care because, when they are exposed to the laboratory atmosphere (relative humidity 60 per cent), the change to α-lactose monohydrate takes place in less than three hours.

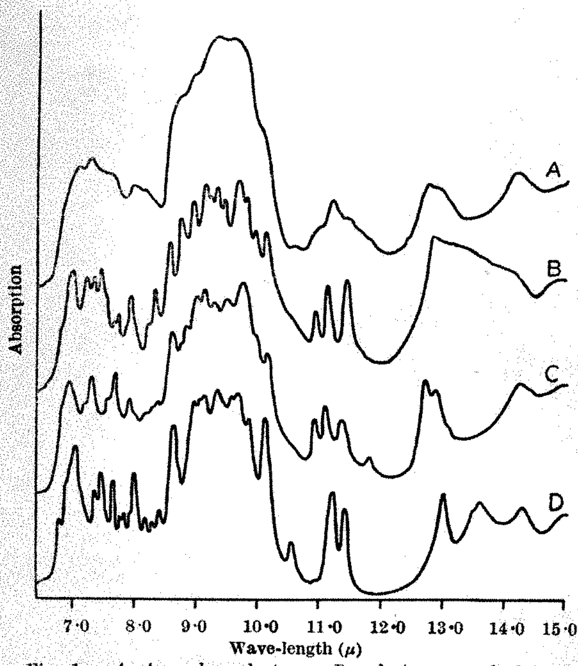

Fig. 1. *A*, Amorphous lactose; *B*, α-lactose monohydrate; *C*, anhydrous α-lactose; *D*, β-lactose. *A* is a glass-like film on silver chloride; *B*, *C* and *D* are potassium chloride disks

The physical state of lactose obtained by drying a solution of lactose depends upon the conditions of drying, the presence of materials other than lactose in the solution and their concentrations. The monohydrate of α-lactose crystallizes easily from solution at temperatures below 95° C., and the anhydrous sugar can be prepared by heating the monohydrate at 120–130° C.

The importance of the conditions of drying is indicated by the published spectra[2] of heat-dried full-cream milk and freeze-dried separated milk, which show bands typical of α-lactose monohydrate and the glass form respectively.

We wish to thank Mr. S. J. Lovett for making the sample of β-lactose; this had $[\alpha]_D^{19°} = 34°$.

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Effects of Crystallinity on the Infra-red Absorption Spectra of Lactose and Dried Milk

In an earlier communication[1], it was shown that the infra-red absorption spectra of lactose–casein mixtures showed very marked changes after freeze-drying from aqueous solution. This was interpreted as indicating the presence of an interaction between the lactose and the casein. During the course of attempts to elucidate further the nature of this interaction, it has now been shown that these changes are due largely to the state of crystallinity of the lactose.

Fig. 1*a* shows the spectrum of crystalline lactose, obtained from a sample of the crystalline α-monohydrate. Fig. 1*b* shows the spectrum of amorphous lactose, obtained by freeze-drying a dilute aqueous solution, or by heat-drying a thin film of lactose solution on the surface of a barium fluoride plate. Examination with a polarizing microscope of the samples used for these spectra confirmed the presence of crystalline and amorphous material in the respective samples.

When saturated lactose solutions were used for freeze-drying, the lactose appeared in the crystalline

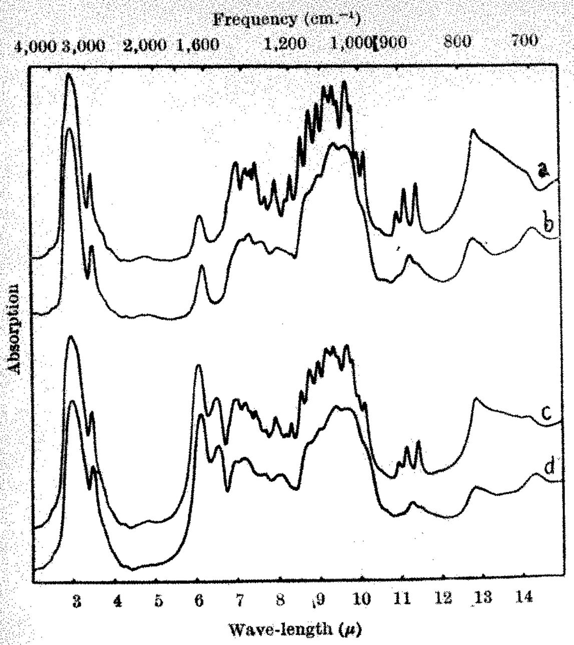

Fig. 1. Infra-red spectra of (*a*) crystalline lactose, (*b*) amorphous lactose, (*c*) 'soluble' dried separated milk, (*d*) dried separated milk

form, if the initial freezing stage was carried out too slowly. The effects of this can be seen in the spectrum 1*A* of ref. 1.

These results are of particular interest in the interpretation of the infra-red spectra of dried-milk samples, since the spectra of samples of dried separated milk made 'soluble' by the 'Instant' process[2] show that the lactose has been converted into the crystalline form (Fig. 1*c*). The spectra of samples which have been dried in the normal way show that the lactose exists in the amorphous form (Fig. 1*d*). Further confirmation of this change in the state of the lactose is afforded by freeze-drying solutions of 'soluble' milk powder, when the spectra are similar to Fig. 1*d*, showing that the lactose has reverted to the amorphous form.

The conversion of dry amorphous lactose to the crystalline α-monohydrate on exposure to atmospheric water vapour can be shown by the infra-red spectra, and similar changes can also be seen in the spectra of dried-milk samples under similar conditions.

The spectra were obtained with a double-beam Grubb Parsons *S3A* spectrometer fitted with a rock-salt prism, and the samples were examined using the potassium bromide pressed-disk technique. Similar results were obtained when the samples were examined by the 'Nujol' mull technique.

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'Multiple' Hæmoglobins in the Horse

THE finding of electrophoretically distinct hæmoglobins in man has, in recent years, been followed by similar reports in animals. In cattle[1,2], for example, and in sheep[3], hæmoglobins have been discovered which seem to be inherited as simple allelomorphs.

Cabannes and Serain[1] examined the hæmoglobin of forty-eight horses by paper electrophoresis at alkaline *p*H. In forty-five samples the hæmoglobin resolved into two fractions moving at different speeds; in the remaining three only the faster-moving component was seen. We have examined hæmoglobin from sixty-five horses and found two fractions in sixty-four and only one, the fast-moving component, in one. Thus of 113 samples, 109 (96·5 per cent) were composed of two components, and four (3·5 per cent) showed only one, which was the fast-moving component in each.

If, as in cattle and sheep, the two hæmoglobins were allelomorphs, this result would represent a remarkable example of hybrid vigour. We decided, therefore, to re-investigate the one horse in which we had found only one hæmoglobin. By the use of starch or agar zone electrophoresis, in which larger quantities of protein can be used, it was found that this specimen also consisted of two hæmoglobin fractions. But, whereas usually the quantity of slow to fast is 0·67 : 1, in this particular horse it was 0·25 : 1. By using thicker paper and more hæmoglobin, the slow fraction could be demonstrated also by paper electrophoresis.

We were thus satisfied that in our series of sixty-five specimens two fractions were present in all, and that this distribution strongly indicated the presence of 'multiple' hæmoglobins in the horse rather than that of two allelomorphs.

We have another indication that the two horse hæmoglobins are not allelomorphs, as it seems that mules and jennets do not inherit one but both these hæmoglobins. Cabannes and Serain[1] had shown that donkeys possess one hæmoglobin and that mules may possess two. Of four mules, two showed a hæmoglobin pattern not unlike that of the horse, and in two, paper electrophoresis demonstrated only one, the slow-moving fraction. In fourteen specimens from donkeys, we have found only one fraction which moved slightly faster than the 'slow' horse fraction. On examining blood from nineteen mules and three jennets, each one was found by us to be resolved into two fractions, of which the faster amounted to about 38 per cent; neither fraction moved exactly in coincidence with those of the horse hæmoglobin (Fig. 1). When donkey hæmoglobin

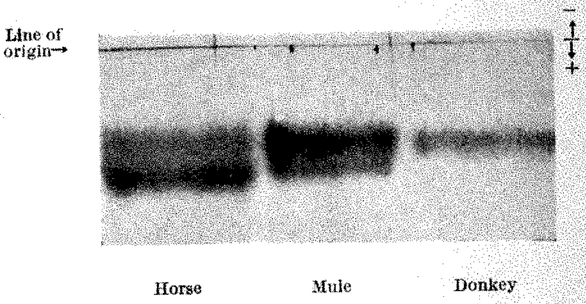

Fig. 1. Paper electrophoresis at *p*H 8·6 of horse, mule and donkey hæmoglobin ('hanging strip' technique, ref. 4). Compared with the two fractions of the horse, the 'slow' component of the mule hæmoglobin moves a little faster, and the 'fast' component more slowly. The single band seen in the donkey hæmoglobin does not coincide with any of the other four

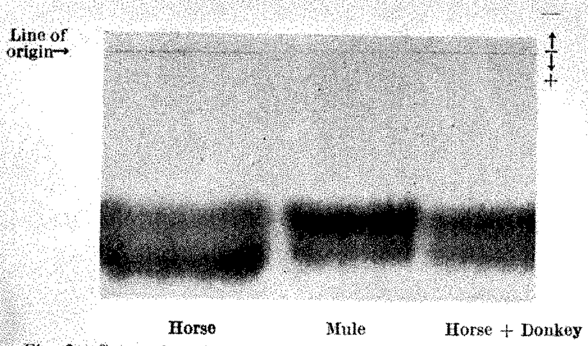

Fig. 2. Comparison by paper electrophoresis at pH 8·6 of the hæmoglobin of horse and mule, and of a mixture from horse and donkey ('hanging strip' technique, ref. 4). The mixture of horse and donkey hæmoglobins resemble mule hæmoglobin in its electrophoretic behaviour. The 'fast' component of the horse pigment moves in this mixture like the 'fast' component in the mule

was added to horse hæmoglobin so that the proportion of the 'fast' horse component was 38 per cent of the total, then the mixture showed an electrophoretic pattern identical with that of mule or jennet hæmoglobin (Fig. 2). When the fast-moving fraction of mule hæmoglobin or of the donkey/horse mixture was eluted and added to an eluted solution of 'slow' horse hæmoglobin, this mixture produced a pattern identical with that found in horse. Although we have not achieved a resolution of mule and jennet hæmoglobin into three fractions (one donkey and two horse hæmoglobins), it seems to us that there is circumstantial evidence that three hæmoglobins are in fact present.

We wish to acknowledge the help of the following in obtaining samples of blood: Dr. R. K. Archer, Equine Research Station, Newmarket; Capt. H. W. Bishop, R.A.V.C., Hong Kong; Dr. S. L. Hignett and Mr. J. Scarnell, Wellcome Veterinary Research Station, Frant; Prof. J. A. Nicholsen, Veterinary College of Ireland, Dublin; and Mr. D. Russel, Tipperary.

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The Diego Blood Group System

In previous communications we reported the presence of the blood group antigen Di^a in Chippewa Indians in North America and in Japanese[1], and its absence in 156 Eskimos of the eastern Canadian Arctic[2]. Since then Layrisse and Arends[3] and Junqueira and Wishart[4] have reported the absence of Di^a in 107 and in 150 pure blood Negroes, while Simmons[5] has reported its absence in 80 eastern Polynesians, 162 Australian aborigines, 23 Papuans and 74 natives of New Britain.

We have now had an opportunity of studying, through the kindness of Dr. Eric Nation of the Canadian Red Cross Blood Transfusion Service, 50 specimens from Blood Indians living in southern Alberta, finding 3 to be $Di(a+)$, while Dr. J. Hildes, of the Department of Physiology and Medical Research of the University of Manitoba, recently collected for us another 68 specimens from Eskimos of the eastern Canadian Arctic; like the first 156, these were all $Di(a-)$. Dr. Hildes's specimens were distributed as follows: east central Baffinland 49, south Baffinland 11, south shore of Davis Strait 8. The Blood Indians were not selected to rule out close relatives whereas the Eskimos were.

Layrisse and Arends[6] found 5 of 100 Chinese (5 per cent) and 8 of 65 Japanese (12·3 per cent) to be $Di(a+)$; we[7] found 10 out of 145 Japanese (6·9 per cent) to be $Di(a+)$, while Dr. Mitsuo Yokayama of the Blood Typing Laboratory, University of Tokyo, informs us that he has found the percentage in Japanese to be 5–7. It seems probable that Di^a is about as common both in large Asiatic and large American Indian populations as *Kell* is in Whites; no high-frequency area for *Kell* has been reported which compares with the high frequencies found in certain South America Indian tribes by Layrisse and Arends[8] and by Junqueira *et al.*[9]. The apparent absence of Di^a in Eskimos of the eastern Canadian Arctic continues to intrigue us.

Our studies have been supported by the National Museum of Canada.

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Separation of Carotenoid Synthesis from Fat Synthesis in *Rhodotorula gracilis* by Diphenylamine

In the fat-synthesizing red yeast *Rhodotorula gracilis* Rennerfelt fat synthesis occurs simultaneously with carotenoid synthesis. Since Turian[1] and Goodwin[2] found that carotenogenesis in *Mycobacterium phlei* and in *Phycomyces blakesleeanus* can be inhibited by diphenylamine, we thought it of interest to see whether carotenoid and fat synthesis in *R. gracilis* might be separated by the action of diphenylamine.

The cells of *R. gracilis* were grown aerobically at 25° C. for three days in a synthetic medium[3] containing various amounts of diphenylamine. The concentrations of diphenylamine tested and the final dry-weight determinations of the cells are given in Table 1. The results show that with up to 45 mgm. of diphenylamine in 1,000 ml. of the cultivation medium there is no inhibition of growth of *R. gracilis* to be noted, although it could be observed that the colour of the cells diminished gradually with increasing concentrations of diphenylamine. With 40 and 45 mgm. diphenylamine in 1,000 ml. medium, the cells are colourless and do not contain any

Table 1. EFFECTS OF DIPHENYLAMINE ON THE GROWTH OF *Rhodotorula gracilis*

Mgm. diphenylamine in 1,000 ml. medium	Dry weight of cells in 10 ml. medium
0	71·2
5	70·5
10	70·8
20	71·0
30	70·2
40	69·8
45	69·5
50	1·2

Table 2. FAT CONTENT OF CELLS OF *Rhodotorula gracilis*, GROWN IN THE PRESENCE OF DIPHENYLAMINE

Mgm. diphenylamine in 1,000 ml. medium	Per cent fat in the dry weight of the cells
0	60·5
5	61·0
30	59·8
45	57·0

carotenoids. In these conditions, however, the fat synthesis is not impaired, as shown by fat content determinations (cf. Table 2). Even with the highest concentration of diphenylamine, namely, 45 mgm. in 1,000 ml., the fat content of the cells is only insignificantly decreased.

In agreement with Goodwin[2], we found the inhibitory action of diphenylamine towards carotenogenesis to be irreversible in a certain sense. When the cells of *R. gracilis* are grown in a medium containing diphenylamine and then, after centrifugation and washing, are transferred into a medium which contains neither diphenylamine nor a nitrogen source, where under normal conditions carotenoid synthesis can take place, the cells remain colourless. If, however, the cells treated with diphenylamine are transferred into a medium containing a nitrogen source and thus are allowed to proliferate, they gradually recover their capacity of carotenoid synthesis.

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Preparation of Transparent Starch Gels after Electrophoresis

IN the method of electrophoresis on starch gel recommended by Smithies[1], the gels obtained after the electrophoresis and staining of proteins are opaque, difficult to preserve and not suitable for photometric evaluation. For this reason we have devised a technique for preparing starch gels which remain transparent after staining.

Since a protein dye in alcoholic solution, for example, a saturated solution of amidoschwarz in 10 per cent acetic acid in methanol, results in a permanently opaque gel, we prefer to use the dye in aqueous solution; 1 per cent amidoschwarz in a sodium acetate/acetic acid buffer (sodium acetate 0·1 *M*, 450 ml., acetic acid *M*, 450 ml., amidoschwarz, 1 gm.), being used for staining in agar electrophoresis[2].

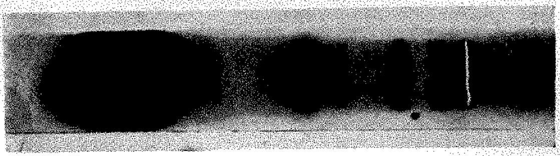

Fig. 1. Transparent starch gel after electrophoresis (human serum)

After fixing for one night in 5 per cent aqueous acetic acid the bands are stained for 10 min. and decolorized by successive washings in 5 per cent aqueous acetic acid. This washing should be prolonged (nearly 48 hr.).

A completely transparent starch gel can be obtained in the following way. A 1-mm. transverse section of stained starch gel is placed on a plate of photographic glass which has been covered with a film of melted agar and then dried in an oven. The glass plate is placed in a rectangular basin and a 1·50 per cent solution of melted agar is poured over it. After the agar has solidified the glass plate carrying the starch electrophoresis included in agar is withdrawn and a sheet of paper (Arches 302 or Whatman No. 1), is applied to the surface so as to regularize the evaporation and to absorb the non-volatile mineral salts. It is left to evaporate in an oven at 37° C. After 48 hr. a transparent film is obtained permitting the photometric evaluation of the different protein fractions of the serum (Fig. 1).

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Reversal of Thymine Xyloside Inhibition in *Escherichia coli* by Glutathione

AN unexpected competitive relationship between thymine xyloside and glutathione has been found. Thymine xyloside inhibits the growth of *Escherichia coli* in a synthetic medium. This inhibition is competitively reversed by glutathione.

A wild-type *E. coli* (ATCC 26) was grown in brain-heart infusion broth for 6 hr. at 37° C., then diluted to 1/50,000 in a synthetic medium of the following composition: sodium phosphate 0·6 per cent, acid sodium phosphate 0·3 per cent, ammonium chloride 0·1 per cent, sodium chloride 0·1 per cent, magnesium sulphate 0·01 per cent, potassium chloride 0·3 per cent, glucose (autoclaved separately) 0·4 per cent. The size of the inoculum in these conditions was about 5×10^4 cells per ml. The inoculated medium was pipetted into sterile 13 mm. × 100 mm. test tubes and the thymine xyloside or reversing agents added in seeded synthetic medium. The tubes were incubated overnight at 37° C., and the presence or absence of growth was determined by visual inspection. The minimum concentration of inhibitor to prevent growth completely was recorded.

The minimum inhibitory concentration of thymine xyloside varied with the preparation used. The best preparation gave an end-point of 1 μgm./ml. in these conditions. However, the reversal experiments were carried out with a preparation of inhibitor which gave an end-point of 6·4 μgm./ml. and were confirmed with the more active material.

Table 1. GROWTH INHIBITION OF *E. coli* BY THYMINE XYLOSIDE AND ITS REVERSAL BY GLUTATHIONE

Thymine xyloside concentration (μgm./ml.)	Glutathione concentration necessary to reverse inhibition (μgm./ml.)	Ratio
100	12·3	8/1
33	3·2	10/1
10	0·8	12/1

In a search for a possible reversing agent, glutathione was tried. This proved extremely effective in reversing the inhibition. About 0·1 mole of glutathione reversed 1 mole of thymine xyloside and this reversal was competitive (Table 1).

Reversal studies with purine and pyrimidine bases and nucleosides revealed no significant effects of these compounds. Fair reversal was obtained with technical casamino-acids ('Difco'). A survey of amino-acids revealed no single one which was as active as the casamino-acids. No agent was found which was as effective as glutathione in reversing the inhibition.

This competitive relationship between thymine xyloside and glutathione is quite interesting, and there is no apparent simple biochemical explanation for it. Beltz and Visser[1] have commented that 5-substituted deoxyribosyl-pyrimidines are the only substituted nucleosides which inhibit the growth of micro-organisms not requiring purines and pyrimidines for growth. Since thymine xyloside is a 5-substituted nucleoside with an unnatural sugar, it may be inhibiting in an analogous manner. It might be possible to use thymine xyloside to induce glutathione deficiencies so that glutathione metabolism and function can be more readily studied.

The thymine xyloside used in these studies was prepared by the method of Fox *et al.*[2] and was kindly supplied by Dr. J. H. Hunter of these Laboratories. Dr. Seymour Cohen has given helpful advice and encouragement.

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Aerobic Inhibition of Glycolysis

DURING investigations on the synthesis of sucrose from glucose-1-phosphate and fructose by pea seed extracts it was observed that a glycolytic system was operating in the enzymic digests[1,2]. The pea extract had been partially purified by precipitation with ammonium sulphate (80 per cent saturation) and dialysis against phosphate buffer at *p*H 7·0. It was found that there were differences in glycolytic activity when the enzymic digests were incubated under aerobic and anaerobic conditions.

When digests containing glucose-1-phosphate and fructose were incubated in air there was a small increase in inorganic phosphate after 40 hr. (Table 1). In nitrogen the inorganic phosphate decreased. Visual examination of the phosphoric compounds of the digest samples on paper chromatograms developed in *n*-propyl alcohol/ammonia/water (60 : 30 : 10, v/v) and *tert*-amyl alcohol/water/formic acid (90 : 90 : 30, v/v)[3] confirmed this decrease in inorganic phosphate and showed that extra phosphoric esters accumulated in nitrogen. This accumulation appeared to be largely due to increases in fructose-1,6-diphosphate, hexose monophosphates and a substance running in a position similar to adenosine triphosphate. Incubation of the enzymic digests *in vacuo* gave similar results to those obtained in nitrogen.

Table 1. EFFECT OF ANAEROBIC CONDITIONS ON INORGANIC PHOSPHATE CONTENT

Gas phase	Inorganic phosphate (μmoles/ml. digest)	
	0 hr.	40 hr.
Air	9·5	11·5
Nitrogen	9·5	2·2

Digest: glucose-1-phosphate, 0·0144 *M*; fructose, 0·0244 *M*; $MgCl_2$, 0·01 *M*; yeast nucleotide fraction, 0·5 ml.; partially purified pea extract, 1 ml.; total volume, 1·8 ml. *p*H 7·0, 25° C.

Table 2. EFFECT OF ANAEROBIC CONDITIONS ON FRUCTOSE LOSS

Gas phase	Fructose (μmoles/ml. digest)	
	0 hr.	20 hr.
Air	24·4	10·1
Evacuated	24·4	0

Digest: as in Table 1.

Anaerobic conditions also accelerated the decrease in fructose in the enzymic digests (Table 2). Fructose had disappeared after 20 hr. under anaerobic conditions, whereas in air a considerable quantity of this sugar remained.

When the gas exchange of the enzymic digests was examined, it was found that in air there was a barely significant oxygen uptake suggesting that oxidative processes were not proceeding to an appreciable extent. There was a considerable carbon dioxide output in air, and this was increased markedly in an atmosphere of nitrogen.

The effect of oxygen on the enzymic digests may be analogous to the Pasteur effect, for which a number of explanations have been proposed[4-6]. If so, the results obtained in the present investigation may support the hypothesis of Lipmann[7] that oxygen inhibits glycolysis by inactivating one or more of the glycolytic enzymes. In the simple system investigated here (which is not complicated by the existence of respiratory processes) glycolysis is the only source of adenosine triphosphate or energy-rich phosphate bond. It seems probable that the rate of hexose utilization is decreased under aerobic conditions because of a decreased production of adenosine triphosphate and this may in part be due to a partial inactivation of one of the glycolytic enzymes.

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Formation of Histamine-containing Dinucleotides by Enzymatic Interaction of Histamine and Coenzyme I

DIPHOSPHOPYRIDINE nucleotide (coenzyme I) reacts, in the presence of a soluble purified preparation of diphosphopyridine nucleotidase[1], with 4-amino-5-carboxamido-imidazole yielding the pyrophosphate of adenosine-5′-phosphate and of the 4-amino-5-carboxamido-imidazole ribotide[2,3]. The latter may serve as a precursor in the biosynthesis of inosinic acid[4].

It was of interest to study the influence of various side-chains attached to carbons number 4 and/or 5 upon the ability of the imidazole to participate in such diphosphopyridine nucleotidase catalysed reactions. Histamine was selected as a first example.

In a typical experiment (Table 1) histamine (252 µmol.), diphosphopyridine nucleotide and diphosphopyridine nucleotidase (21 units[1]) were incubated in a volume of 0·25 ml. at 38° C. at an initial *p*H about 8·0 for 4 hr. The *p*H was maintained relatively constant by means of the proper ratio of histamine (free base, 157 µmol.) to histamine dihydrochloride (95 µmol.). This ratio was calculated from the *pK* values of the histamine mono- and di-hydrochlorides (9·7 and 6·0 respectively). Sample number 3 (Table 1) was buffered with *tris*-hydroxy-methyl-amino-methane to *p*H 8·0.

Normally, two molecules of *d*-ribose and two molecules of organically bound phosphate[5] correspond to every coenzyme I molecule, measured by means of the alcohol dehydrogenase[6] and the cyanide[7] techniques. It was found that the amount of *d*-ribose, as measured by conversion to furfural in the presence of orcinol[8], diminished as the incubation proceeded, and tended to reach one-half of its original value (Table 1). However, periodate oxidation used for quantitative determination of vicinal *cis*-hydroxyls (*cis*-glycols)[9], represented by the 2,3-alcoholic hydroxyls of the *d*-ribose, indicated that their number per mol. of coenzyme I remained constant during incubation and was the same as the number of organically bound phosphate groups (Table 1).

In order to separate the products of this reaction, coenzyme I (340 µmol.) and diphosphopyridine nucleotidase (280 units) were incubated with carbon-14 2-(ring)-labelled histamine (500 µc., 2,000 µmol. of the described mixture of the free base and its dihydrochloride). The initial *p*H was approximately 8·0 and the total volume was 4 ml. Upon consumption of all the coenzyme I present (16 hr., 38° C.), the mixture was passed through a 'Dowex' 1 × 10, chloride form, column.

The main product of the reaction, a dinucleotide (dinucleotide I), was eluted with 0·00025 *N* hydrochloric acid, *p*H 3·6. A second dinucleotide (dinucleotide II) was eluted from the column with 0·004 *N* hydrochloric acid, *p*H 2·4, in much smaller quantities (approximately a quarter of dinucleotide I).

Both dinucleotides I and II corresponded to the formula: Histamine–(ribose)–phosphate–phosphate–ribose–adenine. For as yet unknown reasons, the ribose moiety placed in the formula in parenthesis was not reactive in the orcinol test[8]. Both dinucleotides I and II were radioactive (about 0·24 µc. per µmol.), gave positive ninhydrin tests (primary amines), and crystallized as picrates. They coupled with diazotized sulphanilic acid (yellow at *p*H 10, maxima at 402 mµ and 438 mµ respectively), and had characteristic absorption spectra in the ultraviolet. For example, at *p*H 2·0, dinucleotide I showed two maxima, at 257 mµ and 208 mµ, and a minimum at 234 mµ. Dinucleotide II at the same *p*H, besides the maximum at 257 mµ, had a shoulder at about 208 mµ. Organic pyrophosphatase[10] split both dinucleotides I and II into adenosine-5′-phosphate[3] and a histamine–(ribose)–phosphate moiety (mononucleotides I and II). Ascending R_F values in the system alcohol/0·1 *M* acetic acid (1 : 1)[6] were 0·53 and 0·68 for dinucleotides I and II respectively; 0·69 and 0·76 for mononucleotides I and II respectively.

Electrophoretic studies[3] were conducted in ammonium formate, *p*H 3·6 and *tris*-hydroxy-methyl-amino-methane, *p*H 7·6, at concentrations that showed specific resistance of 210 ohms at 4° C. and potential differences of 10 volts per cm. At *p*H 7·6 dinucleotide I and mononucleotide I moved towards the positive electrode and covered the same distance as coenzyme I, while dinucleotide II and mononucleotide II covered about twice the distance in the same direction. The mobility of the latter compounds was similar to that of adenosine-5′-phosphate at the same *p*H. At *p*H 3·6, dinucleotide I had zero mobility, while mononucleotide I moved towards the negative electrode. Dinucleotide II moved towards the positive electrode and mononucleotide II had zero mobility.

From the analytical results and the action of organic pyrophosphatase, it was concluded that dinucleotides I and II, like coenzyme I, possessed two negative charges at both *p*H 3·6 and 7·6, and mononucleotides I and II, like adenosine-5′-phosphate, possessed two negative groups at *p*H 7·6, and one at *p*H 3·6. Therefore, the above-mentioned mobilities might indicate that dinucleotide I had a pentavalent nitrogen structure which retained its positive charge at both *p*H 3·6 and 7·6 while dinucleotide II lacked such a structure. Both dinucleotides I and II had an additional positive group fully ionized at *p*H 3·6 (probably the aliphatic amine). The presence of a pentavalent nitrogen structure in dinucleotide I and of a trivalent nitrogen structure in dinucleotide II indicated a combination of either the basic or the pseudo-acidic forms of the imidazole[11] with (ribose). This may have resulted from changes in the *p*H

Table 1

Sample	Coenzyme I				Organic phosphate		Periodate consumed		*d*-Ribose	
	Alcohol dehydrogenase		Cyanide							
	Zero time	4 hr.	Zero time	4 hr.	Zero time	4 hr.	Zero time	4 hr.	Zero time	4 hr.
1 Complete system	4·90	0·00	5·20	0·42	11·30	11·40	12·60	12·80	10·70	6·60
2 Coenzyme I omitted	0·02	0·00	0·08	0·04	0·84	0·90	2·60	2·80	0·25	0·47
3 Histamine omitted	4·30	0·00	4·50	0·38	9·50	10·00	11·70	12·90	9·26	10·10
4 Enzyme omitted	4·60	4·22	5·00	4·44	10·30	10·60	10·10	10·20	9·70	9·90

All figures in µmoles.

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(from pH 8·0 to about 6·0) during the enzymatic reaction. Such pH changes can be tolerated by the enzyme[1,12].

Under our conditions the enzymatic reaction appeared to proceed completely towards the formation of the new dinucleotides. Nicotinamide inhibited this reaction.

Since histamine may be released in tissues[13] and in view of the wide distribution of diphosphopyridine nucleotidases of the glycosidase type similar to the one used in these experiments, it is possible that the reaction described may be involved in the mechanism of anaphylactic shock. Experiments are under way to test this possibility.

I am indebted to Dr. Israel Davidsohn, director of research, and Dr. Kurt Stern, associate director of Mount Sinai Medical Research Foundation, Chicago, for their interest in this work.

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Accumulation of α-Alanine and of Pyruvate in Diphtherial Culture Filtrate and its Relation to Iron Deficiency of Medium

It was shown by Linggood and Woiwod[1] that marked changes, particularly an increase in the quantity of α-alanine, occurred in the chromatograms of a casein hydrolysate medium before and after the growth of a strain of *C. diphtheriae* under conditions favourable for toxin production. While studying the effect of iron on the amino-acid metabolism of a strain of *C. diphtheriae* in a simplified, chemically defined medium developed in our laboratory[2,3], we have also found that several amino-acids, especially α-alanine, appear and accumulate in the culture filtrate when the medium is deficient in iron. In further experiments, it has also been demonstrated that an accumulation of pyruvate takes place under the same conditions, and that the amounts of α-alanine and pyruvate appearing in the filtrates, decrease with the increasing iron content of the medium.

Small inocula of the four-day-old pericle of a variant (*SM*-1) of Park Williams No. 8 strain were grown on AMC media[2] containing varying amounts of iron. After four days of still incubation, the whole cultures were harvested and centrifuged at 4,000 r.p.m. for 30 min. The precipitated cells were washed three times with saline before measuring the bacterial nitrogen by a modified micro-Kjeldahl method, while the clear supernatants were used as materials for paper chromatography and also for the estimation of toxin by flocculation reactions, and of the pyruvate by the method of Friedmann and Haugen[4]. For the quantitative determination of α-alanine, the following method was used: Tōyō filter paper No. 50 was spotted with an aliquot of the supernatant, which had been boiled at pH 4·6, and then developed with phenol/water (4 : 1 v/v) and butanol/acetic acid/water (4 : 1 : 1 v/v/v) by the ascending technique. The part of the paper corresponding to the location of α-alanine on the two-dimensional chromatogram was cut to pieces and placed in a test tube. After complete colour development according to Fowden[5], the disrupted papers were removed by centrifugation at 3,000 r.p.m. for 2 min. and the colour intensity of the clear supernatant was then measured at 570 mμ with a Coleman-type spectrophotometer.

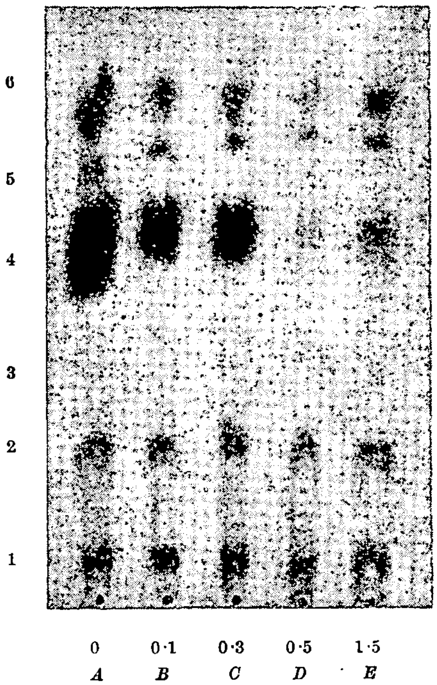

Fig. 1. One-dimensional paper chromatogram of supernatants harvested from diphtherial cultures grown with varying amounts or iron. 1, Aspartic acid and lysine group; 2, glutamic acid and cystine group; 3, asparagine, glycine and serine group; 4, α-alanine; 5, valine; 6, methionine, leucine and *iso*leucine group. μgm. of iron added per litre of medium: *A*, none; *B*, 66; *C*, 200; *D*, 330; *E*, 1,000. Solvent used: phenol/water (4 : 1 v/v)

From the accompanying photograph, showing a typical one-dimensional paper chromatogram of the culture filtrates, no major differences can be seen in the amino-acids present in each filtrate; however, the quantity of each amino-acid, particularly of α-alanine, varies with the amount of iron added to the medium. Quantitative results, showing the effect of iron on both α-alanine and pyruvate accumulations, are given in Table 1. Although the medium used in this experiment was not completely free of iron, added iron had a remarkable effect on the formation of α-alanine and of pyruvate by the diphtheria bacillus. It can be seen in Table 1 that the amounts of both α-alanine and pyruvate detected in culture filtrates at the end of incubation markedly decrease with the increase of iron added. Thus, for example, the quantity of pyruvate produced by the organism in the presence of 330–660 μgm./l. of added iron is

Table 1. EFFECT OF IRON ON THE FORMATION OF α-ALANINE AND PYRUVATE BY A STRAIN OF *Corynebacterium diphtheriae*. FOUR-DAY STILL-INCUBATION AT 32–33° C.

Iron added (μgm./l.)	Bacterial growth (μgm. N/ml.)	Toxin (Lf./ml.)	Pyruvate formed (μgm./ml.)	Alanine formed (μgm./ml.)
0	543	60	220	617
16·5	592	55	196	547
33	561	52	172	553
66	634	44	95	373
100	627	47	120	313
133	561	23	57	307
330	546	3	11	127
660	563	0	11	97

almost one-twentieth of the quantity formed in the absence of iron. A similar variation will be seen in the amounts of toxin and α-alanine formed.

Although the primary metabolic sequence affected by iron deficiency still remains uncertain, these results clearly indicate that traces of iron exert a distinct influence not only on the liberation of toxin but also on the pyruvate metabolism of the organism. Our previous work[6] has shown that significant quantities of glutamate–pyruvate transaminase were present in the cell-free extracts of *SM*–1 culture. Consequently, the accumulation of pyruvate due to iron deficiency may result in the appearance of large amounts of α-alanine in the filtrates. Further work is now in progress, and the details will be published elsewhere.

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Thyroxine Metabolism by Extracts of Rat Liver

THE *in vitro* de-iodination of thyroxine has been reported in a variety of biological systems, including slices, homogenates, and extracts of mammalian organs[1–3]. In particular, a system present in rat liver has been fairly extensively investigated and a technique evolved whereby quantitative measurements of de-iodination can be readily obtained[4]. At the outset of the present work, this technique was employed to re-investigate the properties of the de-iodinating system of rat liver. The heat stability of the homogenate[3] and the heat lability of the extract were confirmed, and the system shown to be inhibited by potassium cyanide. The rate of de-iodination was fastest at the beginning of the incubation period and fell off with time, levelling off after 1–2 hr. when 50–70 per cent de-iodination had occurred. Substrate specificity was not absolute, tri-iodothyronine being metabolized to a lesser extent. In all these respects the system used resembles that previously described by other workers[4].

All these preliminary experiments employed thyroxine labelled with iodine-131 in the 3′ : 5′ positions and chromatography of the incubation mixture failed to reveal any radioactive metabolites apart from iodide and a varying amount of excess thyroxine. Such chromatograms were frequently run together with a marker of stable tri-iodothyronine, but no trace of this compound could be identified among the labelled reaction products. It seems likely, therefore, that the two iodine atoms in the 3′ : 5′ positions are removed simultaneously, or very nearly so. It was thereupon decided to synthesize radioactive thyroxine labelled with iodine-131 in the 3 : 5 positions, and to trace the metabolic fate of these atoms in the same system. It was immediately apparent from the first trials that de-iodination from these positions was slight; 80–95 per cent of the radioactive label remained adhering to the protein of the extract, and was thus presumably still in organic combination, iodide passing through the filter. An experiment was also carried out in which the samples of thyroxine contained the label in varying proportions on the two rings. The results show a proportionality between the extent of de-iodination and the percentage of the label present in the 3′ : 5′ positions.

Percentage of label in 3′ : 5′ positions	De-iodination (per cent)
0	8·0
20	19·5
40	29·9
60	35·0
80	43·6
100	53·9

Thyroxine is thus apparently metabolized to a compound (or compounds) which contains the 3 : 5 iodine atoms but from which the 3′ : 5′ iodine atoms are absent. Work which is still in progress indicates that this unknown compound can be separated from excess thyroxine by butanol extraction. Its chemical structure is apparently such that the alanine side-chain and proximal ring are preserved intact, because, on treatment by hydrolytic procedures, a labelled degradation product is obtained having the chromatographic properties of 3 : 5 di-iodotyrosine.

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The Biuret Complex of Gelatin and the Mechanism of Gelation

THE gelation of gelatin results from a thermally reversible cross-linking process involving hitherto unknown functional groups. In studies of gelation–molecular weight correlations of chemically modified gelatins (amino-acetylated, carboxyl-esterified, hydroxyl-acetylated, guanidino-nitrated) and of hypobromite-treated gelatin we have found that the polar and charged side-chain groups are of little importance in gelation[1]. Further, by study of the effects of various electrolytes on the melting points of gels of gelatin and of chemically modified gelatins, we have found that binding of ions at the polar and charged side-chain groups is not the mechanism by which electrolytes affect gelation[2]. These results have directed our attention to the role of the peptide group.

By the use of the well-known biuret reaction, we now show that the peptide group plays an important part in gelation. Formation of the biuret complex of gelatin with as little as 0·03 *M* copper (II) or cobalt (II) chloride in 5 per cent gelatin (peptide group to metal ratio 17) at *p*H 10–12 caused reversible suppression of gelation. Such solutions did not gel at 0°. However, they did gel, almost instantaneously, at 0° on destruction of the complex and the characteristic violet-red colour ($\lambda_{\text{max.}}$ 550) by acetic acid, sodium cyanide or ion-exchange resin. The melting point of the decomplexed gel was 27°, while those of ordinary gels of the same concentration at *p*H 3–12 are 28–30°. Inhibition of gelation by alkaline copper is, therefore, caused by complex formation and not by the high *p*H or by hydrolysis. The gelation on destruction of the complex is a property of the gelatin, and is not caused by copper or cobalt ions, as was shown by independent experiments in which the metals were removed by ion-exchange or dialysis. Copper and cobalt in alkaline solution are the most effective melting-point reducers found so far. By comparison, sodium thiocyanate and lithium diiodosalicylate[2] in 0·03 *M* solution lower the melting point of the gel by 0·5° and 4°, respectively.

Copper complexes of gelatins having amino- or hydroxyl-groups quantitatively acetylated[3], carboxyl groups 85 per cent methylated[4] or guanidino-groups 70 per cent nitrated[1] also did not gel at 0°, but did gel after destruction of the complex by acidification. These results show that the inhibition of gelation is due to the copper–peptide complex and not to side-chain complexes.

There are several ways in which formation of the copper–peptide complex may prevent gelation. One is by blocking peptide groups that normally engage in cross-linking through hydrogen bonds. A second is by inhibiting a required configuration either by blocking the peptide groups which maintain the configuration through hydrogen bonding or by forming 'knots' that disrupt the configuration. The 'knots' may also prevent gelation by steric interference with intermolecular association. A combination of these causes may be operative.

Although inhibition of gelation of gelatin requires only one copper or cobalt ion per seventeen peptide groups, actually a larger portion of the peptide groups is complexed, since in biuret type complexes of $\lambda_{\text{max.}}$ 550 three or four peptide groups are linked to one metal atom. For example, the lowest polyglycine to give the complex is triglycylglycine, while dialanylalanine gives only a weak reaction[5]. Also, two copper atoms combine with the octapeptide leucylhexaglycylglycine[6], and one copper atom combines with two molecules of biuret[7]. Thus, the complexation of $\frac{1}{6}$–$\frac{1}{8}$ of the peptide groups appears adequate to prevent gelation, particularly as gelation of gelatin appears to involve not the random association of pairs of functional groups but of a number of groups in ordered segments or crystallites[8,9]. The maximum copper binding by gelatin has been reported as one to about six peptide groups[10], which we have confirmed. The ratio of four cannot be realized because of the proline and hydroxyproline residues which contain no replaceable peptide hydrogen. The fluid, rather than cross-linked, nature of the complex shows that the binding is intramolecular.

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Autoradiographic Visualization of Synthesis of Deoxyribonucleic Acid in Tissue Culture with Tritium-labelled Thymidine

THYMIDINE is a specific precursor of deoxyribonucleic acid[1]. The very low energy of tritium electrons permits precise localization on autoradiographs (within less than one micron on average) of the atom that disintegrates. This is not possible with other radioisotopes[2] such as phosphorus-32 or even carbon-14 or sulphur-35.

Tritium-labelled thymidine was prepared by hydrogen exchange between ordinary thymidine (California Foundation for Biochemical Research) and tritiated water in the presence of freshly reduced Adams's catalyst at 100° C. for 24 hr. After the catalyst had been filtered off and the tritium water removed by distillation, the residue was heated in 0·2 *N* sodium hydroxide so that only firmly bound tritium was retained; the solution was then neutralized with sulphuric acid and evaporated to dryness. The labelled thymidine was extracted with hot butanol, and, after treatment with charcoal, crystallized twice from butanol. White needles melting at 185°–186° C. (corr.) were obtained which gave the ultra-violet spectrum of pure thymidine. The radioactivity determined in an ionization chamber after combustion of the compound and reduction of the water to hydrogen was 14·9 mc. per millimole; it was exclusively localized in the pyrimidine moiety, as it was found entirely in the thymine isolated after hydrolysis of the labelled thymidine. A complete description of this preparation has been published elsewhere[3].

To hanging-drop cultures of chick fibroblasts prepared on a specially thinned medium, tritium-labelled thymidine (2×10^{-3} *M*) in tyrode solution was added, either from the time of explantation or later, for various periods. After excision of the original explants (leaving only the growth zone on the coverslip) and careful washings in Tyrode solution to remove the tritium-labelled thymidine present outside the cells, the cultures were fixed in 80 per cent ethanol. The coverslips were then mounted upside down on slides and stripping-film autoradiographs were made.

Development of these autoradiographs showed very low background and the cytoplasms were never

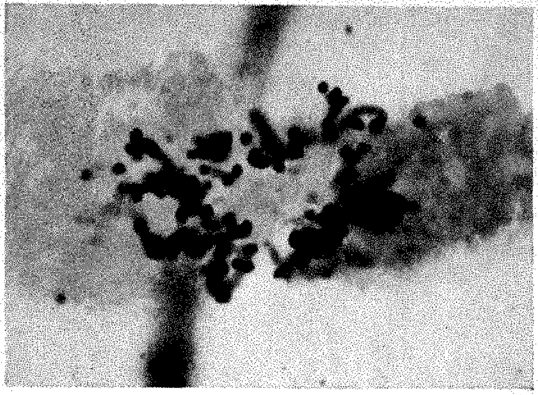

Fig. 1. Equatorial plate in a fibroblast. The chromosomes are grey. The sharp black dots are silver grains developed in the overlying autoradiographic film. × 2,100

labelled. Silver granules denoting the presence of tritium appear only over resting cell nuclei and on chromosomes in dividing cells (Fig. 1). The periphery of nucleoli often contains more grains than other areas of similar size in the nuclei. All labelled structures can be identified within less than 1μ, as already shown by Taylor, Woods and Hughes on another material[4]. The grains can be considered as indicative of the presence of tritium-labelled thymidine in an insoluble form, mainly incorporated into deoxyribonucleic acid.

When the culture medium has contained thymidine for 2 hr., a few nuclei, but no mitotic figures, are notably labelled. This number increases with time and, after long contact, all mitotic figures and most intercinetic nuclei are seen to contain tritium-labelled thymidine. But a variable number of nuclei (up to 30 per cent), mainly in the inner part of the growth zone, are free of silver grains even after three days of cultivation in the presence of the nucleoside. As they are intermingled with labelled cells, the possibility that they are too far from the film for the tritium electrons to reach it can be ruled out. It can thus be assumed that up to that number of cells do not participate in the mitotic cycle and that no turnover of deoxyribonucleic acid occurs in such cells. Auto-absorption, however, is an important factor, because there are more silver grains over large flattened nuclei than over small round ones. The ratio between nuclear area and number of grains can be analysed.

The ratio of labelled to the total number of mitotic figures has been determined after exposure to thymidine in the cultures for various lengths of time. The results are shown in Fig. 2. They make it clear that the stage of synthesis of deoxyribonucleic acid, involving nuclear incorporation of thymidine in insoluble compounds, occurs mainly between the sixth and eleventh hours before onset of mitosis in chick fibroblasts *in vitro* at 37° C. Independent evidence based on quantitative Feulgen determinations shows that synthesis of deoxyribonucleic acid precedes mitosis in the same material by 7–8 hr. on an average[5]; thus, there is near coincidence between fixation of this nucleoside and polymerization to deoxyribonucleic acid.

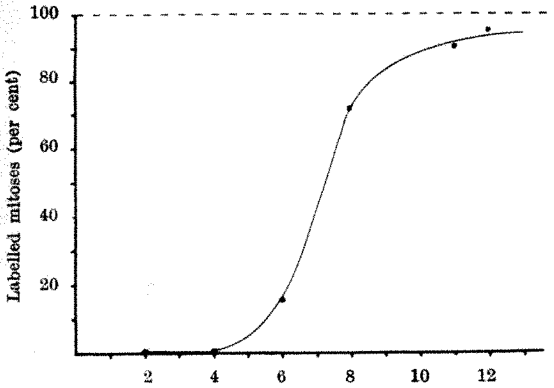

Fig. 2. Time relationship between thymidine labelling and mitosis

Counting the grains gives a fair estimate of the relative amount of thymidine present in structures of comparable thicknesses, such as the two chromosome groups of anaphases and telophases. The two always contain about the same number of grains. Deviation from equality in the two groups never exceeds what one would expect in a purely random process such as radioactivity. This is in accordance with the theory of equal division of deoxyribonucleic acid between the two daughter cells at mitosis, but not with the recent contrary findings of Plaut and Mazia[6] working on plant cells and using thymidine labelled with carbon-14 and consequently obtaining less accurate localization of the electron-emitting structure.

From these observations and others, to be published in detail elsewhere[5], it appears that tritium-labelled thymidine is a very useful tool for the cytological study of many aspects of the synthesis of deoxyribonucleic acid.

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Reduction of Low-Temperature Injury to Stored Apples by Modulation of Environmental Conditions

INVESTIGATION of the metabolism of the senescent apple fruit has largely been directed to the practical objective of improving storage technique. Observations have generally been made on fruit kept in a constant environment. There is, however, no inherent reason why an environment favourable at one stage of post-harvest life should be equally favourable when applied at another stage. A. J. M. Smith[1] reported experiments that led to the adoption of a 'dual temperature' method in the refrigerated carriage of South African plums to the United Kingdom. I have already reported that with Victoria plums a change of temperature to 18° C. for two days on the seventeenth day after the commencement of storage at 0° C. resulted in a considerable delay in the subsequent appearance of the low-temperature injury described as 'internal browning'[2].

A similar result has now been obtained with the apple fruit (variety, Bramley's Seedling), although the magnitude of the effect is less than with the plum. In Fig. 1 the amount of low-temperature injury, measured as the estimated percentage surface discoloured brown in 50 apples cut in half transversely to the stem-calyx axis, is plotted against a time-scale representing the period elapsing between the commencement of storage and the application of a warming treatment. The treatment consisted of raising the temperature of the fruit to 15° C. for 5 days after which it was returned to its original storage temperature of 0° C. All the apples were cut at the same date, 18 weeks after the commencement of storage. It will be seen that as the date of the treatment was advanced there was at first a progressive reduction in the extent and intensity of injury but that this was followed by a regular increase. The amount of injury when no warming treatment was given was comparable to that in samples which were warmed at the end of the experiment, five days before examination. The minimum injury occurred where warming was applied in the period 6–8 weeks after commencement of storage.

This picture was changed in a striking way when during the warming treatment the fruit was exposed to a current of carbon dioxide and air (Fig. 2). The amount of injury found after 18 weeks of storage was greatly reduced, the degree of reduction being greater when the concentration of carbon dioxide during warming was 20 per cent than when it was 10 per cent.

I have already suggested that the hypothesis put forward by Plank[3] that low-temperature injury may be due to the toxic effect of accumulating volatile metabolites is consistent with the effect of warming observed with plums[4].

Fidler[5] has shown that when carbon dioxide was allowed to accumulate to a concentration of 8 per cent during storage at 3° C. the output of total volatile substances from the apple was reduced. It would be interesting to see if temporary warming in an atmosphere containing carbon dioxide as described here can be shown to have an effect upon the production of total volatile substances. Work to this end is now proceeding.

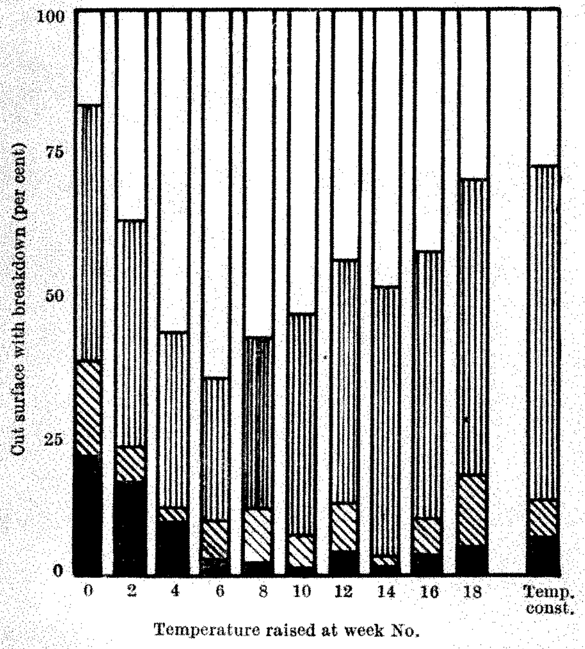

Fig. 1. Effect on occurrence of low-temperature breakdown of raising the temperature of apples (var. Bramley's Seedling) to 15° C. for five days at progressive intervals during storage at 0° C. (White, sound; vertical hatching, slight; oblique hatching, moderate; black, severe)

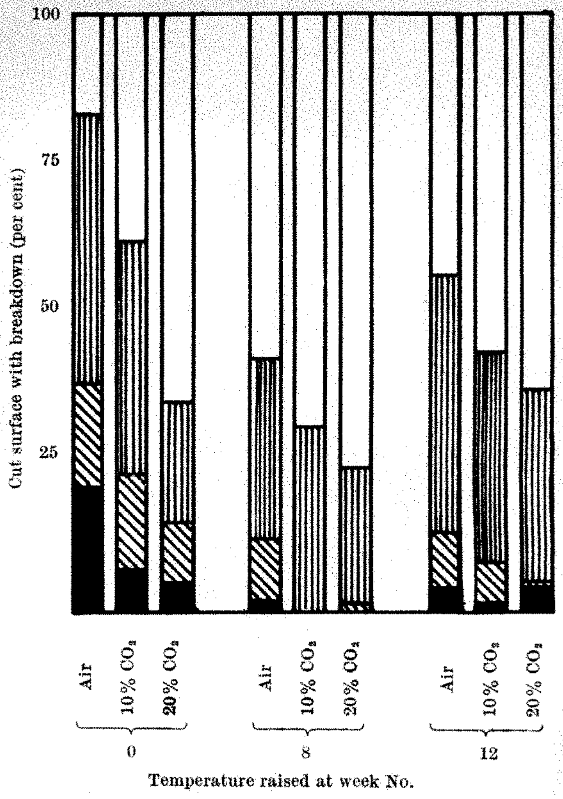

Fig. 2. Effect on occurrence of low-temperature breakdown of increasing the carbon dioxide content of the air in which apples (var. Bramley's Seedling) were kept for five days at 15° C. (White, sound; vertical hatching, slight; oblique hatching moderate; black, severe)

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A Staining Technique for detecting Ratoon Stunting Disease in Sugar Cane

Ratoon stunting, a virus disease of sugar cane, is difficult to diagnose since the macroscopic symptoms are ill defined. Several tests described for diagnosing virus diseases in plants, including one for sugar cane[1], were tried but gave inconsistent results. Attempts were therefore made to develop a colour reaction for detecting the presence of the virus. The investigations were prompted by reports on the use of 2,3,5-triphenyl tetrazolium chloride to detect viruses in plants[2] and on the use of the same substance to localize the site of reducing activity in sugar cane[3].

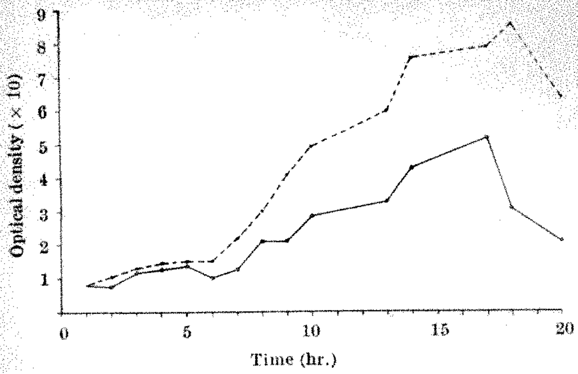

Fig. 1. Optical density of acetone extract. **Full** line, healthy; broken line, diseased

The test is based on the reduction of the soluble, colourless tetrazolium salt into the insoluble red formazan in the presence of viable tissues. It should be pointed out that little is known about the reducing mechanisms in the tetrazolium reaction. Furthermore, attention has been directed[4,5] to the photochemical properties of tetrazolium, a factor which demands carefully controlled conditions in experimentation.

The experimental procedure was as follows. Samples of cane tissue were taken from nodes of sugar-cane stalks by means of a cork borer cutting a plug 1 cm. in diameter. After sectioning the stalk at the level of the leaf scar, the plug was removed by boring vertically down into the lower internode, just inside the rind and opposite the bud. Slices, 0·5 mm. thick, were prepared by means of a hand microtome and the six sections immediately above the level of the leaf-trace bundles were selected. These were placed in 0·5 per cent solution of 2,3,5-triphenyl tetrazolium chloride and kept in an incubator, in darkness, at 35° C. The insoluble red formazan was extracted twice from the sections using each time 5 ml. of hot acetone. The optical density of the solution was determined by means of a Lumetron colorimeter, standardized with distilled water.

The change in colour was found to be more rapid with virus-infected than with corresponding virus-free tissue. The basal nodes of mature sugar cane stalks gave the best difference in colour intensity between healthy and diseased cane. Maximum difference was obtained when the four consecutive nodes above ground-level were sampled. When young canes were tested they reacted in the same way as young portions of mature cane, that is, colour development proceeded almost at the same speed in healthy and diseased tissue. Leaf punches taken from the mid-ribs also proved unsuitable for the test. Colour development being more rapid when the reaction is carried out in light, colour differentiation is better when the test is performed in darkness.

Cane tissue, when sampled in the internode, gave a minimum to no reaction. When sections were taken at the level of the leaf-trace bundles, reaction was too rapid in both infected and healthy tissue, and the large number of vascular bundles interfered with the development of a good colour pattern. The best zone for sampling was found to be just above the leaf-trace bundles, where the intermediate reaction gave a maximum difference in change in colour between healthy and diseased tissue.

The following sampling procedure was finally adopted. Six slices were obtained above the level of the leaf-trace bundles of the second and third nodes above ground-level. The twelve sections obtained were tested together for each stalk. The reaction was allowed to proceed for different lengths of time and the extraction carried out at intervals. The results are expressed graphically in Fig. 1. Although a difference in colour can be observed after 2 hr. when the reaction takes place in darkness, the best difference is obtained after, approximately, 9 hr. and is still very marked after 20 hr. It will be noted that there is a drop in both curves after seventeen to eighteen hours. It has been observed that the red colour fades and eventually disappears in the slices when left in the reagent, as well as in the acetone extract. It is therefore important to carry out the test under carefully controlled conditions.

More than 1,000 nodes were sampled from presumed healthy and diseased *M*.134/32 and *D*.109 canes growing in ratoon stunting field trials. Disease assessment by means of the colour test and macroscopic nodal symptoms[6] were in close agreement.

The method has its limitations in that it is applicable only to mature cane, and several varieties still have to be tested. The results obtained can be of only preliminary nature, and a more exhaustive study is being conducted.

Other tetrazolium salts, namely 3,3-dianisole-*bis*-4,4-(3,5-diphenyl)-tetrazolium chloride and 2-(*p*-iodophenyl)-3-(*p*-nitrophenyl)-5-phenyl tetrazolium chloride, were tested but did not show promise as colour indicators.

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Occurrence of a Blue-Green Alga in the Nodules of *Trifolium alexandrinum*

DURING a cytochemical study of nodule cells in Egyptian clover, *Trifolium alexandrinum*, it was observed that in addition to the rhizobial bacteria, a blue-green alga, identified as *Nostoc punctiforme*, occurred inside the nodules. So far as we are aware, blue-green algae have not been reported to be associated with nodule formation in legumes.

The alga, at first, occupies the intercellular spaces in the nodules (Fig. 1, 2) and gradually invades the cellular region, forming globose to subglobose colonies (Fig. 1, 1). The trichomes are few-celled, though many occur as individual cells. The characteristic blue-green pigment, double-walled akinetes, intercalary heterocysts and yellowish-brown coloration with iodine help to distinguish the alga from the associated bacteria (Fig. 1, 3). The alga could be successfully cultured in sterilized Erdschreiber soil solution. The alga occurs only in the nodules of *T. alexandrinum*, the other parts of the plant showing no such organism.

Nodules of both diploid and tetraploid *T. alexandrinum* showed the alga, as well as those of *T. alexandrinum* collected from different localities. The alga was, however, absent in the nodules of *T.*

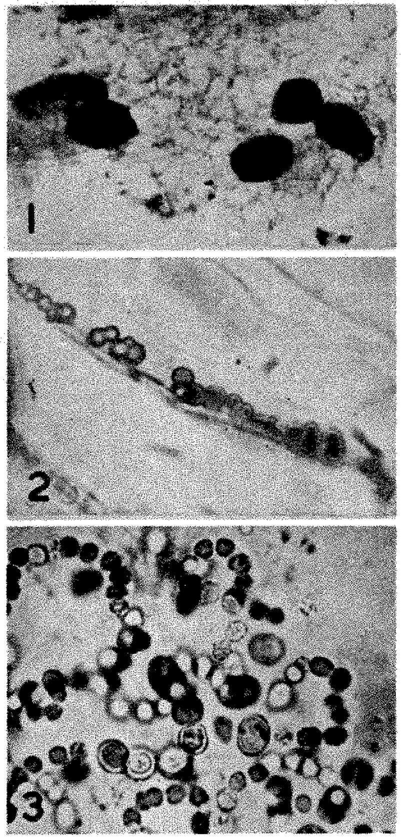

Fig. 1. (1) Colony of *Nostoc punctiforme* inside the root nodule. (2) Individual cells of the alga in the intercellular space inside the nodule. (3) *Nostoc punctiforme*, from culture, showing akinetes and heterocyst

pratense, *T. hybridum*, *Lupinus alba* and *Melilotus alba*, which were growing in the same fields as *T. alexandrinum* or in adjoining areas.

In some lower plants, blue-green algae, particularly those belonging to the genera *Nostoc* and *Anabaena*, have been reported to occur endophytically[1]. The occurrence of *N. punctiforme* in root nodules alone suggests that the relationship may not be a simple case of endophytism. Many blue-green algae are known to fix atmospheric nitrogen[2-4], and it is possible that *N. punctiforme* plays some such part. The reasons for the specific affinity of the alga to *T. alexandrinum* are also not clear. This legume is widely cultivated as a winter fodder in north India under irrigated conditions, and we are now studying the precise relationship between the alga and the leguminous nodule as well as the nitrogen-fixing ability of the alga.

We are indebted to Dr. M. S. Randhawa, Dr. B. P. Pal and Dr. S. M. Sikka for their interest in the study and encouragement. We are also grateful to Dr. M. S. Swaminathan for advice.

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Agar Double Diffusion Precipitation Reaction applied to the Study of *Asterococcus mycoides*

The agar double diffusion precipitation reaction has been found of value in this laboratory in research on the organism of contagious bovine pleuropneumonia, *Asterococcus mycoides*. Two techniques are used, a modification of Ouchterlony's[1] method described by Mansi[2] and a method described by Jennings and Malone[3]. The reactions observed, and the interpretation of the results obtained, with the bovine pleuropneumonia organism have been essentially similar to those described by these authors. Jennings and Malone's method has the advantage that a positive reaction can be seen in 2 hr., and that more distinct separation of lines of precipitation occurs as diffusion proceeds; but larger quantities of serum and antigen are required than for the method of Mansi.

Immune sera are produced in rabbits by intravenous injections of increasing doses of washed organisms grown in a culture medium containing no bovine antigens[4]. No reaction is produced between normal rabbit serum and infected bovine tissues or extracts of the organism, or between immune rabbit serum and normal bovine tissues. When immune serum is tested against material from infected tissues, such as pleural exudate or a saline extract of a lung lesion, a strong reaction is seen. Usually three lines of precipitation are apparent, demonstrating that the organism contains at least three soluble antigens. Cultures and extracts of the organism also give the same result. All strains of the organism studied here have produced the three lines, indicating no qualitative difference in the antigenic structure of different strains.

Most areas in tropical Africa where contagious bovine pleuropneumonia is enzootic are relatively isolated, and communications with laboratories are therefore often slow and unsatisfactory. In these circumstances a laboratory diagnosis on specimens obtained post-mortem is usually difficult or impossible through lack of suitable fresh material from the field, and reliance must be placed on serological tests of other animals in the affected herd. Consequently a technique which enables a suspected diagnosis of pleuropneumonia to be confirmed at the laboratory by the examination of preserved, or of partially decomposed and contaminated, material would be most useful. In order to investigate the value of the precipitation reaction in these conditions, two samples of unpreserved contaminated material from bovine lung lesions were kept at room temperature and tested at intervals. The reaction remained positive for up to 13 days, by which time the specimens were completely putrified. Cultural examination of the two samples in a suitable medium, containing thallium acetate and penicillin to suppress other bacteria, failed on and after the second and third days respectively, due to gross contamination. It has been found that 5 per cent formalin and 50 per cent glycerin do not destroy the antigen, and the test can be satisfactorily carried out on infected tissues preserved with these reagents.

The sera of cattle dying of infection with *Asterococcus mycoides*, when tested against immune rabbit sera, often give one or two lines of precipitation, demonstrating the presence of circulating antigens, probably absorbed from the extensive lesions and exudate which always contain a high concentration of diffusible antigens.

It is intended to use this method in investigating the antigenic composition of the organism of bovine pleuropneumonia, and its relationship to that of caprine pleuropneumonia and possibly other pleuropneumonia-like organisms.

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Incompatibility in *Theobroma cacao*

Knight and Rogers[1] postulated the existence of five incompatibility alleles, at a single locus, in the three self-incompatible but cross-compatible cacao genotypes studied by them. The five alleles differed in dominance, but two were equal; the same dominance sequence, $S_1 > S_2 = S_3 > S_4 > S_5$, was exhibited in both male and female parts of the flower. Their criterion of compatibility and incompatibility was the retention or fall, respectively, of hand-pollinated flowers guarded from insect visits.

I have used a different approach to the problem. Microtomed sections of pollinated ovaries have been microscopically examined. In all cases of self- and cross-incompatibility, a proportion of fertilized ovules shows non-fusion between the egg nucleus and first male gamete and between the polar nuclei and second male gamete; the remaining ovules show normal fusion. Three main types of self-incompatible tree are now recognized wherein the proportion of 'non-fusion' ovules is: (1) 25 per cent; (2) 50 per cent; (3) close to or actually 100 per cent. Compatible pollinations, on the other hand, give all normal ovules. *Theobroma cacao* L. provides, for the first time, an example of an incompatibility mechanism in the flowering plants which has non-fusion of gametes as its fundamental manifestation, the ratios of ovules wherein non-fusion and fusion of gametes take place bearing simple genetic ratios one to the other (1 : 3, 1 : 1, 1 : 0).

On a visit to the West African Cacao Research Institute in 1956, I was privileged to use some of the trees investigated by Knight and Rogers. Pollinated ovaries from guarded flowers were fixed, sectioned and examined.

All genotypes representing a combination of an allele and another recessive to it (for example, $S_{1\cdot 2}$, $S_{2\cdot 5}$, $S_{3\cdot 4}$) gave, on self-pollination, counts wherein the proportion of non-fusion ovules was 25 per cent. The $S_{2\cdot 3}$ genotype, a combination of alleles of equal dominance, gave 50 per cent non-fusion ovules on self-pollination. The $S_{5\cdot 5}$ genotype did not, however, give on selfing the expected 100 per cent non-fusion content; instead, it gave good 25 per cent counts, suggesting that, in fact, it is not homozygous, but is a combination of S_5 with a second allele recessive to it (say, S_6). The consequences of this assumption do not in any way invalidate the findings of Knight and Rogers.

Table 1. Percentage Ratios of 'Non-fusion' to Normal Ovules in Cacao Selfings and Crosses. Incompatible Combinations in Bold-face Type

Female	Male				
	$S_{1\cdot 2}$	$S_{2\cdot 3}$	$S_{2\cdot 5}$	$S_{3\cdot 4}$	$S_{5\cdot 6}$
$S_{1\cdot 2}$	**25**	0	0	0	0
$S_{2\cdot 3}$	0	**50**	**25**	**25**	0
$S_{2\cdot 5}$	0	**25**	**25**	0	0
$S_{3\cdot 4}$	0	**25**	0	**25**	0
$S_{5\cdot 6}$	0	0	0	0	**25**

Cross-pollinations between genotypes carrying the same dominant allele (for example, $S_{2\cdot 3} \times S_{2\cdot 5}$) also gave 25 per cent non-fusion ovules in the ovary. The cross, $S_{2\cdot 3} \times S_{3\cdot 4}$, found by Knight and Rogers to be incompatible, likewise gave 25 per cent non-fusion ovules.

All combinations that do not involve the same dominant allele (for example, $S_{1\cdot 2} \times S_{2\cdot 5}$, $S_{1\cdot 2} \times S_{3\cdot 4}$) and those that do not involve a duplication of alleles of equal dominance in the presence of the other (for example, $S_{2\cdot 5} \times S_{3\cdot 4}$) were found to give only normal ovules in the pollinated ovaries. Knight and Rogers found these combinations to be compatible.

The results are summarized in Table 1, which shows the percentage proportion of non-fusion ovules counted. The principal conclusions to be drawn from the results are: (1) that gametes carrying the same dominant allele are those that do not fuse in the embryo-sac; (2) that the fusion or non-fusion behaviour of gametes is determined by the S allele they carry interacting with the diploid tissues (for example, S_2 gametes fuse in $S_{1\cdot 2}$ tissues, but not in $S_{2\cdot 5}$ tissues), so that incompatibility or compatibility is ultimately determined by the diploid genotype and hence is sporophytically controlled; (3) the similarity of reciprocal pollinations.

From my observations on the incidence of compatibility and incompatibility in progenies arising from crosses between self-compatible and self-incompatible parents, the hypothesis put forward by Knight and Rogers, based on the operation of an allelic series at a single locus, appears inadequate. It seems necessary to postulate the existence of two independent loci, one (P,p) concerned with the production of an 'incompatibility precursor', and another (S), which imparts specificity to the precursor. The P,p locus shows simple dominance and recessivity, and acts before meiosis; the S locus shows allelomorphism and acts after meiosis. If either locus is inactive (pp and $S_{f.f}$, where the f indicates the presence of an amorph), full self-compatibility results. There will therefore be three main types of self-compatible tree: (1) $pp\ S_{a.b}$ (self-compatible by virtue of the non-production of the precursor); (2) $PP\ S_{f.f}$ (self-compatible by virtue of amorphism at the S locus); (3) $pp\ S_{f.f}$ (both loci inoperative). A cross between the first, believed to be representative of the Central-American self-compatible tree, and the second, thought to represent the Trinidad self-compatible, will produce offspring with both loci active, and hence all will be self-incompatible. This result has been obtained.

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A Chromatographic Method for studying Simple Compounds in Plants

MOST chromatographic methods of investigating simple compounds (for example, saccharides and amino-acids) and their distribution in plant tissues have involved preparing extracts either of the whole plant or of dissected portions.

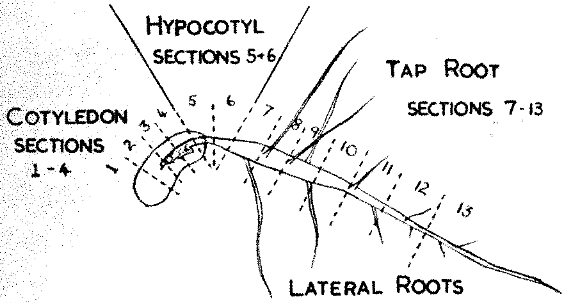

Fig. 1. Sectioned bean

I would like to indicate the possibilities of a less-elaborate technique to attain similar or more defined results. The method, comparable in principle to that of La Cour and Drew[1], is essentially to press the sap juices of the plant in question directly on to the chromatogram; instead of preparing water or alcohol extracts, concentrating and placing these on the chromatogram.

The plant studied in the initial experiments was a 14-days old seedling of the French bean *Phaseolus vulgaris*, var. Improved Canadian Wonder. This plant provided large amounts of sap, but other experiments with more woody plants also gave satisfactory results.

The beans were germinated for 14 days and then used immediately or stored at −20° C. until required.

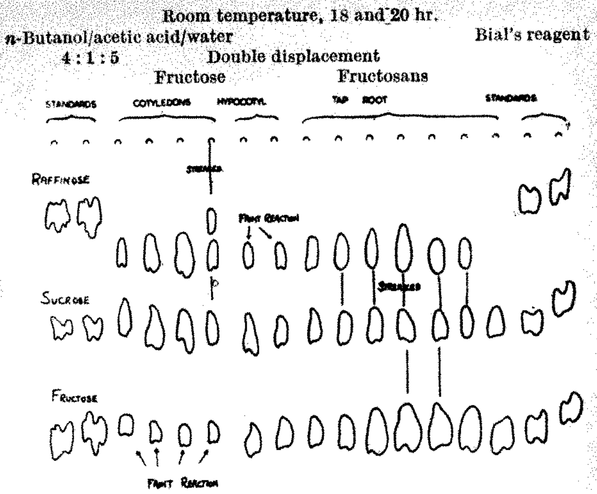

Fig. 3

(Stored beans were allowed to regain room temperature slowly before use.) The testa of the bean was removed and the plant divided into sections as shown in Fig. 1.

Each section was then placed at a marked position on the starting line of a paper chromatogram (Whatman No. 4, 22 in. × 18 in.), and its sap expressed by hand pressure exerted on a glass plate (4 in. × 6 in.) on top of the section. Underneath the chromatogram was another glass plate to prevent liquid loss and damage to the paper. When the sap had been absorbed by the paper and had spread to the desired spot size (¼ in. diam.), it was rapidly dried in a stream of hot air (30 sec.–1 min.). The process was repeated until most of the sap was removed from the section leaving only the skeleton of the section, which was discarded.

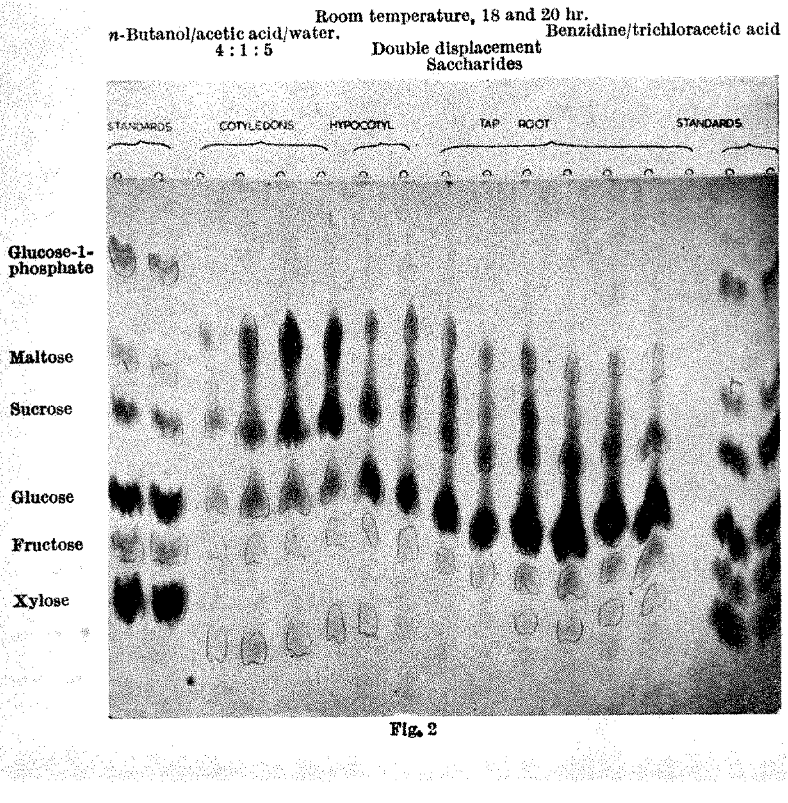

Fig. 2

Descending chromatography was then carried out using conventional techniques for the compounds under investigation.

By use of the appropriate series of sections, the sap components of a whole bean could be assembled on the paper in such a way as to indicate their distribution in the bean (Fig. 2). No detailed report on the findings will be attempted here; but, in summary, the results of the initial experiments showed that: (*a*) the method was applicable to such compounds as saccharides, including fructose and fructosans (Figs. 2 and 3), amino-acids and ultra-violet-absorbing substances; (*b*) there was an unequal distribution of these simple compounds between the cotyledons and the tap root. For example, fructose was found in the tap root but little was found in the cotyledons (Fig. 3). Proline was found in the cotyledons but not in the tap root, where a ninhydrin-reacting compound appeared to run to the same position; (*c*) the hypocotyl contained the smallest number of compounds.

This method may thus be of use in studying the distribution of simple compounds in the sap of whole or portioned plants during germination, and its application may also provide some information on translocation and other allied problems.

An objection to this method could be that the enzymes released by crushing are active in the time it takes to dry the sap and at the elevated temperatures of drying: this would complicate the picture observed. However, the sap is dried in a very short time, especially if an efficient hot-air dryer is used (30 sec. for the root section and 1–1½ min. for the cotyledon sections), thus minimizing enzyme action. In later experiments the area on which the sap was to be placed was impregnated with 5 µl. of a 0·01 *M* mercuric chloride solution[2] as an enzyme inhibitor and results were similar to those with spots submitted solely to heat treatment. It seems evident that enzyme action is so slight as to be negligible.

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Fluorescent Substances produced by Dermatophytes

The fluorescent substances formed by *Microsporum* species and *Trichophyton schoenleini* when attacking hair *in vivo* have not been identified; recently Wolf[1], on the basis of *in vitro* studies of the growth of *M. canis* and *M. gypseum* on hair, has produced evidence indicating that one of the substances is a pteridine. It is felt that this conclusion should be accepted with reserve for the following reasons.

(1) Wolf has produced no evidence to eliminate the possibility that the fluorescent products obtained could not also have been prepared from uninfected hair; Chattaway and Barlow[2] have shown that fluorescent materials can be extracted by water from normal hair, but that these have different chromatographic and electrophoretic properties from those formed during fungal attack *in vivo*.

(2) No comparison was made with fluorescent materials extracted from naturally infected hair. It is well known (for example, Vanbreuseghem[3]) that the mode of attack of hair *in vitro* by these fungi differs markedly from that seen *in vivo*. The metabolism of the organism is likely, therefore, also to differ, and any fluorescent products obtained during *in vitro* growth cannot be assumed to be identical with those formed *in vivo* unless direct comparison of properties is made.

(3) Chattaway and Barlow showed that aqueous extraction of hair damaged by fungi removed a complex mixture of substances, and treatment of such an extract with charcoal and methanol as described by Wolf would almost certainly not effect any great purification of the fluorescent material. Since the evidence for the material being a pteridine rests on absorption spectra data, any correlation of such data with fluorescent substances is at least very uncertain without further purification of the materials.

(4) Chemical examination by Davidson and Gregory[4] of aqueous extracts from naturally infected hair showed the presence of nitrogen, an aldehyde group and a phenolic ring; while Robinson, Figge and Bereston[5] concluded from infra-red analyses that the fluorescent material was a peptide. Chattaway and Barlow confirmed the findings of Davidson and Gregory but showed that the phenolic substance could be separated from the fluorescent substances by chromatography and that the fluorescence was quenched by bromine water. It is difficult to interpret these findings as supporting the presence of a pteridine.

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Streptomycin and Bacterial Respiration

There are many reports in the literature of effects of streptomycin on bacterial respiration[1]. Most of these involved the addition of streptomycin to non-growing suspensions of bacteria; but it seems likely that changes occurring during growth in the presence of streptomycin might ultimately prove of greater significance.

In the experiments described here, the effects on respiration of *Staphylococcus aureus* produced by exposure to dihydrostreptomycin during growth have been investigated.

Each experiment was performed as follows. Meat digest broth (50 ml. in a 250-ml. Erlenmeyer flask) was inoculated with *Staph. aureus* from an 18-hr. shaken culture in the same medium, to give a just-visible opacity, and the inoculated medium was incubated with continuous shaking for 2 hr. The density was then estimated absorptiometrically, and the culture was divided into two 25-ml. portions in 250-ml. flasks. The cultures at this stage contained staphylococci equivalent to about 1 mgm. dry wt. per ml. To one of these, dihydrostreptomycin in the required concentration was added (3 µgm.–50 µgm./ml.), and incubation of the flasks was continued, with shaking, for a further 2 hr. The cells were then harvested and washed three times with distilled water, by centrifugation. Suspensions were made in 0·1 *M* phosphate buffer, *p*H 7·3, and oxygen uptake with and without added substrate was measured for 30 min. by the conventional Warburg technique, no further dihydrostreptomycin being added at this stage. The dry weight of cells in the manometric experiments was 5 mgm./flask.

With succinate as substrate, the rate of oxygen uptake by cells which had been exposed to dihydrostreptomycin during growth was strikingly lower than that of the control cells. The decrease of oxygen uptake with glucose was, however, less marked and did not vary much with alteration of concentration of dihydrostreptomycin during growth. All figures are corrected for endogenous oxygen uptake of the respective cells, and are given to nearest 5 per cent.

Further experiments have shown that, under similar conditions, rate of uptake of oxygen with pyruvate is less affected than rate with succinate. For example, after exposure to 25 µgm. dihydro-

Table 1

No. of exp.	Oxygen uptake, dihydrostreptomycin-exposed cells with succinate (Control=100)	Oxygen uptake, dihydrostreptomycin-exposed cells with glucose (Control=100)	Di-hydrostreptomycin concentration during growth. (μgm./ml.)	Total growth of dihydrostreptomycin-exposed cultures on dry-weight basis (Control=100)
1	10	80	50	35
2	15	85	25	35
3	30	85	12	65
4	40	80	6	85
5	60	80	3	90

streptomycin/ml. during growth, rate of oxygen uptake with succinate was decreased by 85 per cent whereas with pyruvate the decrease was 20 per cent.

The effects described have not been called 'inhibition' of oxygen uptake, since it is possible that the underlying mechanism might be an altered balance of enzymes in the cells, due to differential effects of streptomycin on enzyme synthesis, and not a direct interference with oxidative enzymes already present. If the organisms are harvested less than 2 hr. after addition of dihydrostreptomycin, lesser degrees of reduction of oxygen uptake are found. With 25 μgm. dihydrostreptomycin/ml. present during growth, for example, the growth-curves of the dihydrostreptomycin and control cultures differ only slightly in the first ½ hr. of incubation, but thereafter diverge rapidly. The effects on oxygen uptake with succinate follow roughly the same pattern.

It is interesting to note that the streptomycin antagonist (2-heptyl-4-hydroxyquinoline-N-oxide) investigated by Lightbown and Jackson[2] strongly inhibits the oxidation of succinate if added to non-growing suspensions of *Staph. aureus*, whereas dihydrostreptomycin itself produces no measurable inhibition with this organism under these conditions.

Thanks are due to Mr. R. W. Warner for technical assistance.

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Inhibition of Blood Digestion in Mosquitoes by Cations, and Cation-Antibiotic Mixtures

DURING the course of some studies originally designed to evaluate the role of certain cations and anions in influencing the susceptibility of *Aedes aegypti* to infection with *Plasmodium gallinaceum*, it became apparent that the calcium fed to these mosquitoes was also consistently inhibiting digestion of the ingested blood meal in a fairly constant proportion of the mosquitoes. This report extends this observation somewhat, and deals with some preliminary experiments on the inhibitory effects of the cations calcium and magnesium, alone and in combination with the antibiotic oxytetracycline, on the process of blood digestion in the mosquito *A. aegypti*.

In these experiments, the salts, antibiotic, and salt and antibiotic mixtures were added in the appropriate concentrations to a 4 per cent sugar nutrient solution which is generally used in this laboratory as the maintenance diet for mosquitoes. The solutions were made available to the adult mosquitoes immediately after pupal emergence was completed, and the mosquitoes were then maintained on these solutions for the following 72 hr. At the end of this period the mosquitoes were allowed to gorge on normal chicks. Following the blood meal, the mosquitoes were allowed to continue to feed on the drug solutions until the experiments were terminated. Normally, in mosquitoes maintained at a constant laboratory temperature of 26·5° C. and a constant relative humidity of 75 per cent, as in this case, a blood meal will have been completely digested within 72 hr. At the end of this period the stomach will be entirely empty and contain no microscopically discernible trace of the blood meal. In these experiments, in order to emphasize the extent of inhibition of blood digestion, dissection of the mosquito and examination of the stomach was delayed until the fourth day following the blood meal. In those mosquitoes in which digestion has been inhibited the blood remains as a kind of darkened, amorphous mass, about one-third the size of the clot resulting from the original blood meal. Microscopically, intact red cells are no longer evident although the residue still retains the characteristic orange-reddish colour of hæmoglobin. Chemically, the residue gives a positive test for hæm by the benzidine reaction.

Table 1. THE EFFECT OF FEEDING CATIONS, AND CATION AND ANTIBIOTIC MIXTURES, ON BLOOD DIGESTION IN *Aedes aegypti*

Regimen	Mosquitoes containing blood residues	Total mosquitoes	Mosquitoes containing residues (per cent)
Sugar	0	160	0·0
0·002 *M* oxytetracycline	0	172	0·0
0·1 *M* calcium chloride	52	166	31·3
0·1 *M* calcium chloride + 0·002 *M* oxytetracycline	117	164	71·3
0·1 *M* magnesium chloride	2	162	1·2
0·1 *M* magnesium chloride + 0·002 *M* oxytetracycline	64	165	38·7

It is evident from the data presented in Table 1, which summarizes the results of several experiments, that calcium markedly inhibited digestion, since 31·3 per cent of the blood-fed mosquitoes still contained an undigested residue 96 hr. after the original feeding. At the same time, oxytetracycline alone had no apparent inhibitory effect, since none of the mosquitoes fed on that compound contained any discernible blood residues even when they were examined as early as 72 hr. after the blood meal. When it was fed to the mosquitoes in combination with calcium, however, oxytetracycline markedly increased the inhibitory effects of calcium and as a result the proportion of mosquitoes still containing considerable blood residues rose to 71·3 per cent of the total animals in the group. This potentiating effect of oxytetracycline was even more evident when it was fed in combination with magnesium. Thus, as shown in Table 1, magnesium alone had almost no inhibitory effect, but when it was fed together with oxytetracycline, 38·7 per cent of the mosquitoes contained undigested residues 96 hr. after the blood meal. It may be noted here that chloride, fed to the mosquitoes in 0·02 *M* concentrations of hydrochloric acid, either alone or with oxytetracycline, had no discernible effect.

It is of interest to note that when 0·058 *M* concentrations of the trisodium salt of ethylenediamine tetraacetic acid are added to the solutions of calcium and magnesium alone, or to the solutions of calcium and magnesium combined with oxytetracycline, so that these ions are in effect removed by the resulting chelation, their inhibitory effects are simultaneously eliminated and blood digestion proceeds normally. Thus, this fact lends further support to the assumption that these inhibitory effects are produced primarily by the cations, and that the antibiotic acts rather by potentiating and activating either the cations or the reaction between the cation and the particular enzyme system involved, in a manner not yet understood, but differing from the usual reaction between cation and antibiotic[1] in which the activity of the one or the other is either eliminated or inhibited. It has been observed, too, that those mosquitoes containing large, undigested residues nevertheless produce eggs in great numbers. Even though egg-laying is apparently delayed in such mosquitoes, as evidenced by the fact that unlike normal eggs these eggs become heavily pigmented while still in the body, the fact that eggs are produced in quantity indicates that there has been no interference with digestion or assimilation of the plasma fraction of the ingested blood meal, since it is well known that it is this fraction which the mosquito requires for egg laying. In view of this, and other data presented above, it appears reasonable to assume that only digestion of the hæmoglobin fraction, of all the fractions contained in the original blood meal, is affected by the cations, or cation and antibiotic mixtures.

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Response of the Adrenal Medulla of the Sheep Fœtus to Asphyxia

OCCLUSION or ligation of the umbilical cord of the fœtal lamb is followed by a rise in arterial blood pressure and changes in heart-rate[1-5]. These reactions, which have been attributed to asphyxia, can be first elicited after 80–90 days of pregnancy and become more pronounced in the mature fœtus. The magnitude of the reactions has been related to the development and maturation of the autonomic nervous system[5].

In the present experiments the output of adrenaline and noradrenaline from the adrenal gland has been studied in fœtal lambs of different ages from 80 days of pregnancy until about term (150 ± days). The fœtus was removed from the uterus under pentobarbitone sodium anæsthesia, but the umbilical cord and the placental circulation were retained until the induction of asphyxia. Venous effluent blood was collected from the left adrenal gland after heparin (1,000 I.U./kgm.) had been injected into both the maternal and fœtal circulations. The left splanchnic nerve was cut and, when necessary, the peripheral end stimulated from an induction coil. Asphyxia was induced by ligation of the umbilical cord; a mask placed over the mouth of the fœtus prevented distension of the lungs or respiratory exchange. The adrenaline and noradrenaline content of the blood and of the adrenal glands was estimated by the method of Vogt[6].

The resting level of adrenaline and noradrenaline secretion from the denervated adrenal medulla is normally very low[6]; this was confirmed for the fœtal lamb. After ligation of the umbilical cord, large amounts of the sympathomimetic amines appeared in the fœtal adrenal effluent blood. Both adrenaline and noradrenaline were released, but noradrenaline was invariably predominant, irrespective of the age of the fœtus (Fig. 1, *a*). This discharge from the fœtal adrenal medulla continued until the fœtal heart stopped which, in the majority of experiments, was about 10–15 min. after ligation of the umbilical cord.

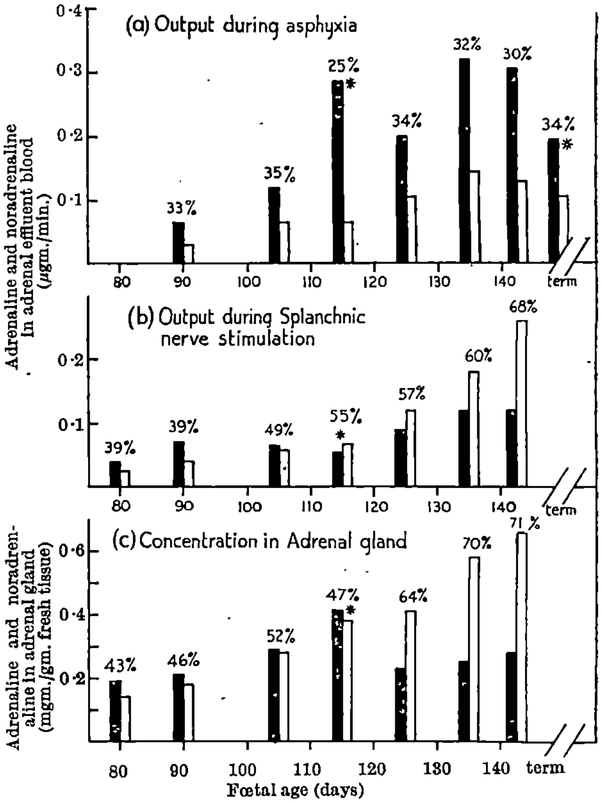

Fig. 1. Adrenaline and noradrenaline output and content of fœtal adrenal glands in the sheep. The percentage of adrenaline is given above each histogram. Black, noradrenaline; white, adrenaline. * One experiment: other figures are means of two or more experiments

The characteristically high concentration of noradrenaline in the fœtal adrenal blood during asphyxia is in marked contrast to the response obtained during stimulation of the left splanchnic nerve. With this stimulus the ratio of adrenaline to noradrenaline in the adrenal effluent blood corresponded to that in the gland. Thus when, in the last part of pregnancy, adrenaline became the major sympathomimetic amine in the adrenal gland of the fœtal lamb, it also became the dominant amine in the adrenal effluent blood during stimulation of the splanchnic nerve (Fig. 1, *b*, *c*).

The left splanchnic nerves were cut in the present experiments, and thus the response of the fœtal adrenal to asphyxia cannot be attributed to a reflex discharge similar to that reported in the adult[7,8]. Only a trace of sympathomimetic amines was detected in arterial blood samples taken after umbilical cord occlusion. It is therefore improbable that the right adrenal of the fœtus, which retained its splanchnic innervation, contributed to the high concentration of these amines in the effluent blood from the left gland. This sensitivity of the fœtal adrenal medulla to asphyxia may be particularly important in those species, such as the cat and dog[9,10] and the rabbit[11], in which the reflexes mediated by the autonomic nervous system are not as well developed at birth as those of the lamb.

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Effect of Two Extreme Temperatures on Growth and Tail-length of Mice

EACH of six mouse litters (taken from mice that had spent their pregnancy period in the cold environment of 50° ± 5° F.) was divided into two nearly equal groups *A* and *B* at weaning time. Group *A* was kept in the original cold environment and the other group, *B*, was transferred to the hot environment of 92° ± 1° F.

At the age of 7 weeks, that is, after four weeks in the hot room, all mice were weighed and the length of tail was measured between the tip of the tail and the point where the hair on the body ends, that is, the naked more or less hairless tail which was completely exposed to the environmental conditions.

Table 1 shows the mean body-weights of mice at weaning time and at 49 days old.

Table 1

Mice	Sex	Mean weight (gm.)	Max.	Min.
At 21 days	Males (19)	7·33 ± 1·60		
	Females (21)	7·47 ± 1·40		
Group *A**	Males (8)	20·33	24	13
	Females (11)	20·54	24	14
Group *B*†	Males (10)	15·10	20	11
	Females (8)	14·40	19	10

* After seven weeks in the cold environment.
† Three weeks in the cold environment, followed by four weeks in the hot environment.

At 49 days, the mean lengths of tail were: Group *A* (20 mice), 6·75 ± 0·65 cm.; Group *B* (18 mice), 7·92 ± 0·55 cm.

The results obtained showed that mice when raised in a cold environment grew normally, but when the environment was changed from the cold to a hot one, this growth was retarded. With regard to the effect on length of tail, it is obvious that the high temperature caused an increase in the length of tail as compared with the cold environment although both groups of mice were brothers and sisters from the same litters. This appears to be a reaction for increasing or decreasing the body surface area to facilitate either heat loss or heat conservation respectively.

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An Acid-fast Bacillus isolated from the Lungs of the Cape Hyrax, *Procavia capensis* (Pallas)

IN August 1954 a large epitheloid granuloma containing acid-fast bacilli was observed in a lung from Cape hyrax (locally known as 'dassie'). This particular animal had been received from New Bethesda, a small village in the north-eastern region of the Cape Province.

A further 86 'dassies' from the New Bethesda district were examined, and granulomatous lesions were found in the lungs of four animals. The infected animals all came from the same farm. Material from these lungs was injected intraperitoneally and subcutaneously into further 'dassies'. One of these animals developed a caseous inguinal lymph gland containing numerous acid-fast bacilli. This caseous material was planted on various culture media, and after four months one of us (G. B.) succeeded in isolating an acid-fast organism in pure culture on Dorset's egg medium.

Morphology and cultural characteristics. The isolated organism is a Gram-positive, acid-fast, non-motile, slender, straight or slightly curved rod, measuring approximately 1·5–2μ × 0·3–0·5μ. Much's granules are often observed. It is usually possible to differentiate microscopically the 'dassie bacillus' from the vole bacillus, particularly in artificial culture.

The organism grows slowly on ordinary mycobacterium media, although Dorset's egg medium is superior. The addition of 5 per cent glycerin does not benefit the organism. It grows better at 37° C. than at 26° C. Visible growth in primary culture usually occurs after 3–4 weeks incubation, whereas in subculture it may develop in approximately a week.

The colonies are of two types; one is small, round, raised, matt, regular, almost white; the other type is considerably larger, flat, irregular and with a raised centre. The differentiation is particularly marked after 2–3 months of incubation.

It survives without subculturing for at least a year. It is sensitive to streptomycin, rimifon and *p*-amino-salicylic acid.

Biological features. Saline suspensions of the culture were inoculated into 'dassies', rabbits, guinea pigs, white rats, white mice, and several varieties of veldt rodents. The lesions produced in these animals were very similar to those produced by the vole bacillus[1] (*Mycobacterium muris*, Wells, 1937). In view of this[2], series of *Mystromys albicandatus*, guinea pigs and white mice were inoculated with comparable doses of vole bacillus and 'dassie bacillus' respectively. The lesions, after intramuscular inoculation into *Mystromys* and guinea pigs, were of two types: local abscess formation and generalization. The lesions produced by the vole bacillus were far more severe than those produced by the 'dassie bacillus', but the animals invariably recovered. In white mice, however, the vole bacillus on intravenous inoculation produced a progressive fatal pneumonia. In contrast, those inoculated with 'dassie bacillus' developed an early generalized miliary infection which regressed. The animals still appeared healthy five months later.

In conclusion, the 'dassie' bacillus shares morphological, cultural and biological characteristics with the vole bacillus. Further studies are being undertaken to determine whether the 'dassie' bacillus should be classified as an almost non-virulent variant of the vole bacillus, or if it should be considered a new species.

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Microbial Growth Stimulants in Spleen

Previous studies have revealed that rabbit spleen contains unidentified, water-soluble substances that are growth stimulatory for *Escherichia coli*[1], and also that beef spleen yields heat-resistant, water-soluble extractives stimulatory for species of pathogenic fungi[2]. A blood agar medium incorporating aqueous spleen infusion was formulated for the isolation of pathogenic fungi at 37° C. [2]. The stimulatory effects of spleen extracts on the growth of micro-organisms in chemically defined culture media has been investigated by us.

We have found that bovine spleen contains an active growth-factor which is highly stimulatory for the growth of a variety of micro-organisms when tested in several chemically defined culture media. Some of the species include the yeasts, *Candida albicans*, *Cryptococcus neoformans* and *Saccharomyces cerevisiae*; the protozoa, *Ochromonas malhamensis* and *Tetrahymena pyriformis*; and the bacterium, *Lactobacillus casei*. A preliminary purification procedure of the spleen factor was accomplished by following photometrically the turbidimetric growth response of a vitamin-depleted strain of *C. albicans* in a chemically defined liquid culture medium.

One kgm. of fresh, de-encapsulated and de-fatted beef spleen was thoroughly ground and mixed with 2 l. of distilled water. The resulting mixture was infused at 50° C. for 1 hr., occasionally agitated, and then rapidly heated to 80° C. for 5 min. in order to coagulate heat-precipitable proteins. The hot mixture was filtered through a layer each of towelling, gauze and cotton. The filtrate was cooled to 10° C. to congeal any remaining fat, which was removed by filtration through paper. The latter filtrate was autoclaved at 121° C. (15 lb.) for 15 min. in order to produce additional protein coagulation. Autoclaving did not reduce the growth-stimulatory effect of the spleen infusion for *C. albicans*. One litre of aqueous crude spleen extract, which had a *p*H of 6·8, was lyophilized and 23·5 gm. of a tan amorphous powder was obtained. This powder was extracted with one litre of anhydrous methanol at 20° C. for 15 min. The methanol-insoluble residue was microbiologically inactive for *C. albicans* and therefore was discarded. The amber-coloured, methanol filtrate which contained the active principle was mixed in a separatory funnel with an equal volume of pentane (Eastman technical) at 20° C. and shaken gently and intermittently for 10 min. An inactive, white flocculent precipitate which formed in the lower methanol layer was discarded together with the inactive pentane layer. The methanol fraction was reduced in volume in an all-glass distillation apparatus *in vacuo* at 60° C. and then dried over a steam bath until dark brown solids weighing 9·36 gm. were obtained. These were dissolved in double-distilled water and dialysed for 2, 8, 12 and 36 hr. at 5° C. through transparent, seamless, cellulose dialyser tubing (Thomas 4465 A_2) in a stationary water bath of double-distilled water. The four separate dialysates were combined, then concentrated *in vacuo* at 60° C. and lyophilized, yielding 6·66 gm. of light brown, hygroscopic solids. When these solids were assayed in a chemically defined liquid medium with a vitamin-depleted strain of *C. albicans*, they produced characteristic dose response growth-curves which showed an average half-maximal value of 35 μgm./ml.

The active growth-factor is soluble in water, methanol, ethanol and other alcohols, but is insoluble in diethyl ether, chloroform and pentane. In aqueous solution, the factor is unaffected by boiling, freezing or by autoclaving at 121° C., the latter in the presence or absence of dilute hydrochloric acid. Dry solids are stable for at least one year when maintained in a desiccator at 5° C. The spleen factor is also stable in methanol solutions. Studies embracing the further purification and characterization of the stimulatory substance, as well as its relationship to known water-soluble vitamins, are in progress. These will be described in later publications.

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Amino-acid Composition of Sclero-protein of the Sponge *Hippospongia equina*

We have applied the method of paper partition chromatography to ascertain qualitatively the detailed amino-acid constitution of spongin, using the commercial unbleached honeycomb sponge, gathered in the eastern Mediterranean Sea. Our results differ in important respects from those of Low[1], who used this method to investigate the amino-acid constitution of the barium hydroxide hydrolysate of the sponge, *Spongia officinalis obliqua*, collected in the Gulf of Mexico.

We have examined both acid and alkaline hydrolysates of the sponge, previously washed with water and air dried. The acid hydrolysate was prepared by heating the sponge under reflux for 8 hr. with equal parts hydrochloric acid (6 *N*) and formic acid (85 per cent), while the alkaline hydrolysate was obtained by heating under reflux for 8 hr. with saturated barium hydroxide solution. The solvents and various location agents were all prepared according to Smith[2], while this author's dipping technique was also used. For final confirmation all the spots were extracted and run as one-way chromatograms against known standards.

The amino-acids identified in the acid and alkaline hydrolysates of spongin are given in Table 1. The relative intensity of the amino-acid spots is indicated by representing strong as + + + + and weak as +.

Tryptophan was confirmed with the Ehrlich reagent; tyrosine and histidine with the diazo reagent; iodinated tyrosines with ceric sulphate–

Table 1

	Alkaline hydrolysate	Acid hydrolysate	Relative intensity of amino-acid spot
Alanine	×	×	+++
γ-Aminobutyric acid	×		++
Arginine	×	×	+++
Aspartic acid	×	×	+++
Cystine	×		+
Glutamic acid	×	×	+++
Glycine	×	×	++
Histidine	×	×	++
Hydroxyproline	×	×	++++
Leucine–*iso*leucine	×	×	++++
Lysine	×		++
Ornithine	×		++
Phenylalanine	×	×	++++
Proline	×	×	++++
Serine	×		++
Threonine	×	×	++
Tryptophan	×		+
Tyrosine	×	×	++
3-Iodotyrosine		×	+
3 : 5-Diiodotyrosine	×		++
Valine	×	×	++

arsenious acid[3]. Two very faint spots which could not be identified appeared in the chromatograms of the acid hydrolysate after dipping in ninhydrin. Spot *A* was characterized by an R_F of 0·23 in butanol/acetic acid and 0·63 in phenol/ammonia: spot *B* gave values of 0·25 and 0·82 in the corresponding solvents. Spot *B* (see above) together with two other very faint spots *C* and *D* were also observed in chromatograms of the alkaline hydrolysate. Spot *C* had R_F values of 0·16 and 0·62 and spot *D* 0·35 and 0·73 respectively in butanol/acetic acid and phenol/ammonia.

All the amino-acids identified by earlier workers were confirmed except α-aminobutyric acid, dibromotyrosine and methionine found by Low[1]. No signs of these compounds could be detected, while oxidation of the valine spot with hydrogen peroxide failed to reveal any methionine. Contrary to Low's findings 3-iodotyrosine could not be detected in the alkaline hydrolysate, although it was identified in the acid hydrolysate. Considered together with the absence of 3 : 5-diiodotyrosine in the acid hydrolysate it is probable that the monoiodo-compound was present as an artefact.

We thank Mr. L. Nidditch, chairman, for laboratory facilities and the Brewing Industry Research Foundation for supplying quantities of ornithine and γ-aminobutyric acid.

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Fluorescence of the Crystalline Lens and Electroretinographic Sensitivity Determinations

It is generally assumed that the human lens acts like a colour filter in front of the retina, reducing the sensitivity in the short wave-length region of the spectrum. In isolated lenses, absorption depends both on wave-length and on the age of the subject. Comparison of sensory spectral sensitivities of normal and aphakic (lensless) eyes has yielded information on the absorption of the lens *in vivo*[1]. We have obtained comparable information, using the electroretinogram as an index when untrained subjects are tested.

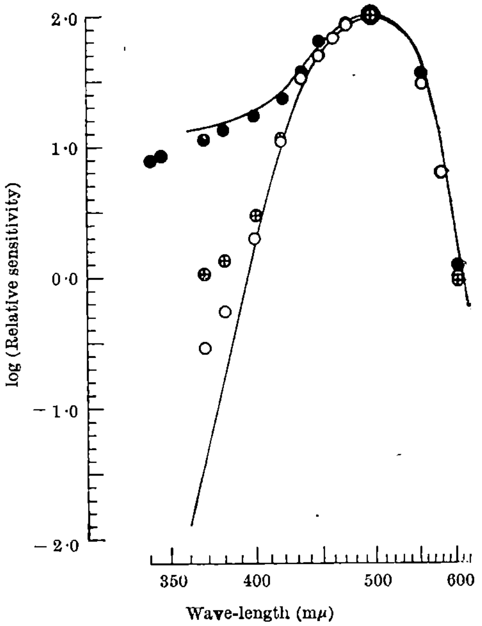

Fig. 1. Average spectral sensitivity of two aphakic eyes (filled circles), one normal eye, age 26 (open circles), and one normal eye, age 61 (crossed circles) as determined by measurement of energies producing scotopic *b*-waves of constant size (200 μV.). Spectrum of equal quantum intensity; values in terms of 497 mμ at 100 per cent. The curves represent spectral sensitivity of rod vision in an area 8° above the fovea in the normal (lower part) and aphakic (upper part) eye as determined psychophysically by Wald (ref. 1)

In order to lower the spectral limit from 400 to 341 mμ, a xenon high-pressure lamp and double-interference filters were used for stimulation. The filters were carefully selected to ensure both sufficient intensity and monochromasy (for details see ref. 2). A series of experiments was carried out on aphakic eyes of two subjects, 26 and 37 years old respectively, and on the normal eyes of two other subjects, 26 and 31 years old respectively. The average relative spectral sensitivities were calculated from the relative number of quanta eliciting *b*-waves of equal size, and their logarithms were plotted against wave-length; 497 mμ was chosen as reference standard. The results were compared with the curves for rod vision given by Wald[1] (Fig. 1).

As regards the visible part of the spectrum, there has been some discussion about the reason why sensitivity curves derived from measurements of scotopic *b*-waves are shifted towards the blue part of the spectrum[3]. Altogether, our electroretinographic determinations in the visible part of the spectrum from both normal and aphakic eyes, show rather close correspondence to Wald's curve. Peak spectral sensitivities were achieved at filter 497 mμ.

For the ultra-violet wave-length region, the values obtained from aphakic eyes fit the corresponding psychophysical curve fairly well. No differences were seen between the 26- and the 37-years-old subject respectively. However, for the young normal subject the ultra-violet sensitivity lies above Wald's curve. The corresponding values for the old normal eye are even higher. Since the absorption of the lens for short wave-lengths is known to increase with age[1,4], lower sensitivities would be expected in the older eye. When one observes a normal eye illuminated with ultra-violet light strong enough to cause a medium electroretinogram response, the lens appears as a whitish patch in a dark surround, that is, it fluoresces. The upper limit of the spectral region where fluorescence occurs lies at short wave-lengths in children and moves to longer wave-lengths with age[5]. It is tempting to relate these facts to the observed increase of spectral sensitivities, which also depends on age. Thus, fluorescence might account for the discrepancy between electroretinogram and sensory spectral sensitivity curves respectively.

This view is supported by further measurements relating response amplitude to stimulus intensity. The slopes of the curves for normal eyes are steeper in the ultra-violet than in the visible spectrum, thus showing why Wald's relative ultra-violet sensitivities for intact eyes are lower than those reported here. His values were obtained by absolute threshold determinations, whereas electroretinogram measurements require intensities much above the absolute threshold.

This work was supported by grants from the Deutsche Forschungsgemeinschaft towards the cost of apparatus. The support of this investigation by the Department of Ophthalmology, University of Heidelberg, which referred patients with lensless eyes to us, is gratefully acknowledged.

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Effect of a Raised Peripheral Temperature upon the Rate of Regeneration in a Mammalian Peripheral Nerve

It has recently been reported[1] that an environmental temperature close to freezing point inhibited nerve regeneration in the rat's caudal nerve after crush injury. In these experiments only the peripheral part of the nerve was cooled, the temperature of the cell body being unaltered (for details, see Gamble and Jha[2]).

Similar experiments have now been made upon ten rats kept at room temperature (21–22° C.) and upon six kept in heated cages (35° C.). In these conditions the body temperatures are the same, but the subcutaneous temperatures in the tail differ. In the animals kept at 21–22° C. the subcutaneous temperature in the tail at a level close to the nerve injury was found to lie between 27° C. and 30° C. In the animals kept at 35° C., subcutaneous temperatures in the tail ranged between 32° C. and 36° C. It is likely, however, that during much of their sojourn in the heated cages subcutaneous temperatures of these animals lay between 35° C. and body temperature (36–39° C.).

Where the caudal temperature lay between 27° and 30° C. only equivocal evidence of remyelination was found when survival lasted 15–19 days after nerve crush (five animals). Many fibres showed double, wavy osmophilic lines, suggestive of cylinders of rather variable calibre, separated longitudinally by gaps of variable extent. It seemed reasonable to suppose that these cylinders represented very early stages in the process of remyelination. It was not until after 21 days survival, however, that unequivocal evidence of remyelination was obtained (three specimens). Nodes of Ranvier were distributed evenly along the majority of the fibres, the internodal lengths being short and uniform in all fibres. This condition was found after only 12 days (one specimen) and 14 days (three specimens) where the subcutaneous temperature lay close to 35° C.; evenly spaced nodes of Ranvier at short intervals again provided unequivocal evidence of remyelination in the majority of the fibres. After less than 12 days in the heated cages, only equivocal evidence of remyelination was found.

It is concluded that raising the temperature of the tissues through which regenerating axons pass by some 5–10° C. (from 27–30° C. to 35–37° C.) considerably speeds the earlier stages in the remyelination of those fibres. Other work in progress in this Department suggests that this effect is continued into later maturation stages.

The lower temperatures involved in these experiments lie well within the range found both subcutaneously and more deeply in the distal parts of the limbs of man. A proximodistal temperature gradient in the limbs might be related to Sunderland's[3] findings that, in the longer human nerves, regeneration after injury is more rapid in the proximal than in the distal parts. It seems possible, at least, that human nerve injuries might respond to heat treatment of a very simple kind by acceleration of the growth and maturation of regenerating fibres.

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A Method for studying separately the Properties of the Innervated and Non-innervated Membrane of an isolated Single Electroplax of the Skate

The cellular unit of the electric organ of the skate (*Raja eglanteria*) is morphologically similar to that of *Electrophorus electricus*: both have rather large dimensions, although the electroplax of the skate is smaller and more irregular in shape; both have an innervated and a non-innervated membrane, the latter characterized by prominent digitations. There are, however, some differences of functional properties. The discharge of the organ in the intact animal has been studied by Albe-Fessard[1] and that of the individual electroplax by Brock *et al.*[2].

In view of the morphological similarity of the electroplax of the two species, it seemed worth while to try to adapt a new method recently developed for the single isolated electroplax of *Electrophorus* to the

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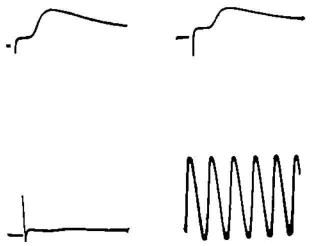

Fig. 1. Discharge of a single isolated electroplax from the skate (*Raja eglanteria*) before and after application of 0·1 μmole/ml. of *d*-tubocurarine chloride to the solution bathing the innervated membrane. From upper left to lower right: control; 1 and 4 min. after application of curare. Calibration: 5 msec., 100 mV.

corresponding unit of the skate[3–5]. This method consists in keeping a single isolated electroplax between a nylon sheet containing a window adaptable to the size and shape of the cell and a grid formed by nylon threads. The electroplax separates two pools of fluid, one of them bathing the innervated, the other the non-innervated face. Ion movements across the two types of membranes may be studied separately, and the electrical activity may be recorded with either extra- or intra-cellular electrodes. By-passing of ions has been excluded. Electrical activity remains unchanged for 6–8 hr. This method has now been adapted with minor modifications to the isolated single electroplax of the skate.

Fig. 1 shows the electrical activity recorded with extracellular electrodes and the effect of *d*-tubocurarine chloride (0·1 μmole/ml.) in the solution bathing the innervated site. The cell discharges in response to an electric stimulus with a latency period of about 3 msec. The amplitude of the response is about 30 mV. with a duration of 15–20 msec. Curare completely abolishes the response within 4 min.

The characteristics of the response are virtually the same as described by Brock *et al.*, thus confirming their finding. The advantage of the new preparation is the possibility to test the properties of the innervated membrane independently from those of the non-innervated membrane. Since it has been shown[5,6] that the two types of membranes of the electroplax of *Electrophorus* have different properties as to electric responsiveness, resting potential, ion movements and passive permeability, a study of the functionally different innervated membrane of the skate, now shown to be possible with the new method, is of obvious interest.

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Effect of Periodic Acid on Histochemical Aldehyde Blockades

SOME histochemical investigations still in progress required the use of an aldehyde blockade that would resist treatment with periodic acid and Schiff's reagent. Aldehyde groups were developed in sections of mouse tissues by oxidation with periodic acid reagent[1], by the Feulgen hydrolysis, or by carrying out these reactions successively on the same sections. Then, after blockading with hydroxylamine reagent[2], aniline hydrochloride[3], phenylhydrazine reagent[4], or 0·4 per cent w/v 1-dimethylcyclohexane-3 : 5 dione, the preparations were treated for 5 min. with the periodic acid reagent, which was followed by Schiff's reagent (E. Gurr, Ltd.) for 15 min.

Hydroxylamine blockade failed to resist treatment with periodic acid, and the sections stained with Schiff's reagent in the same manner as controls. By varying the time of initial treatment with periodic acid it was found that the staining of blockaded preparations could not be due to generation of additional aldehyde at sites where the initial oxidation might have been incomplete; hence, it seemed that periodic acid must be liberating aldehydes from aldoximes at the sites blockaded. Since there was no staining when 0·1 *N* hydrochloric acid was substituted for periodic acid after blockade, aldehyde liberation evidently was not due to acid hydrolysis alone. In some experiments with aldehydes developed by Feulgen hydrolysis, by treating sections with hydroxylamine and periodic acid alternately in series, the blockade could be broken down and reformed repeatedly.

Blockades with aniline and phenylhydrazine were resistant to periodic acid, except in the case of elastic membranes of blood vessels, which were stained strongly with Schiff's reagent. When 0·1 *N* hydrochloric acid was substituted for periodic acid after blockade, these membranes were stained just perceptibly. In all cases, this staining of elastica could be prevented by interposing a hydroxylamine blockade before Schiff's reagent.

1-Dimethylcyclohexane-3 : 5-dione did not block the reaction of aldehydes with Schiff's reagent at all sites; but where blockade was effective it was also resistant to periodic acid.

These results may be compared with those of Lillie[5], who found that 1 per cent periodic acid could liberate aldehydes at sites previously blocked with cyanide. However, his observation that blockades with aniline and phenylhydrazine were completely resistant to periodic acid apparently needs some qualification. Furthermore, it seems that when interpreting results of the periodic acid–Schiff reaction one must now envisage that some part of the staining may arise from the action of periodic acid on compounds having reactive groups analagous with the aldehyde condensation compounds that can be attacked by this reagent.

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A Quantitative Study of Stasigenesis in Fissipede Carnivores

In the course of quantitative evolutionary studies on the dentition of fissipede carnivores we[1] have recently published a paper utilizing two angular measurements, α measuring the relation of protoconid height and talonid length in lower M_1 and β the relation between total length and protocone height in upper P_4. Graphic representation on Cartesian co-ordinates of the two values thus obtained for a number of species shows that the relative position of the values of α and β has an important biological significance, since it reveals the general phylogenetic tendencies of the group and its constituent sub-groups, and is in close agreement with the qualitative findings of taxonomy.

We are now continuing the work utilizing linear measurements. In the lower jaw of the Fissipedia we distinguish three regions of different functional significance. P includes the premolar series up to the paraconid of M_1; C measures the small sector from here to the protoconid of the same tooth; and T includes the remainder of the molar series. The different types of specialization found in fissipede carnivores are reflected in the very diverse magnitudes of these three regions, and when plotted reveal a pattern of points representing the species concerned. These are distributed around a central zone with a regularity capable of calculation. The parameters of the three regions, expressed in percentages, have been plotted with triangular co-ordinates in Fig. 1.

This graph reveals some striking similarities with that obtained from the values of α and β, and, at the same time, some notable differences. The variations in the values of P, C and T show that the amplitude is smaller for P. The radiation of fissipede carnivores from the time of its inception involved variations in the regions C and T. Only two families, the Ursidae and Hyaenidae, show specialization involving variation in the value of P.

Palæontological research has shown that these two families are of comparatively recent origin, and that they were not differentiated in the initial phase of carnivore evolution from a basal form such as *Cynodictis*, which is considered as an ideal ancestor of the group (synthetotype) because of its generalized condition and its central position in the graph.

Progressive differentiation in accordance with the idea of cosmolysis propounded by Blanc[2] results in the belated appearance of types capable of filling new ecological niches. ('Cosmolysis' is a term proposed by A. C. Blanc to denote the process of demixture and segregation of characters in an originally homogeneous population leading to the production of progressive heterogeneity and distinct groups, with particular reference to the origin of the different races of man ('anthropolysis'), on the analogy of magmatic differentiation in the inorganic world.) This is where variations in the value of P became possible. This new formation of families started in the Pliocene, the period that represented the climax of fissipede evolution, after which it started on its stable phase of 'stasigenesis'[3].

This process is revealed quantitatively for the first time in our studies of the linear values of P, C and T.

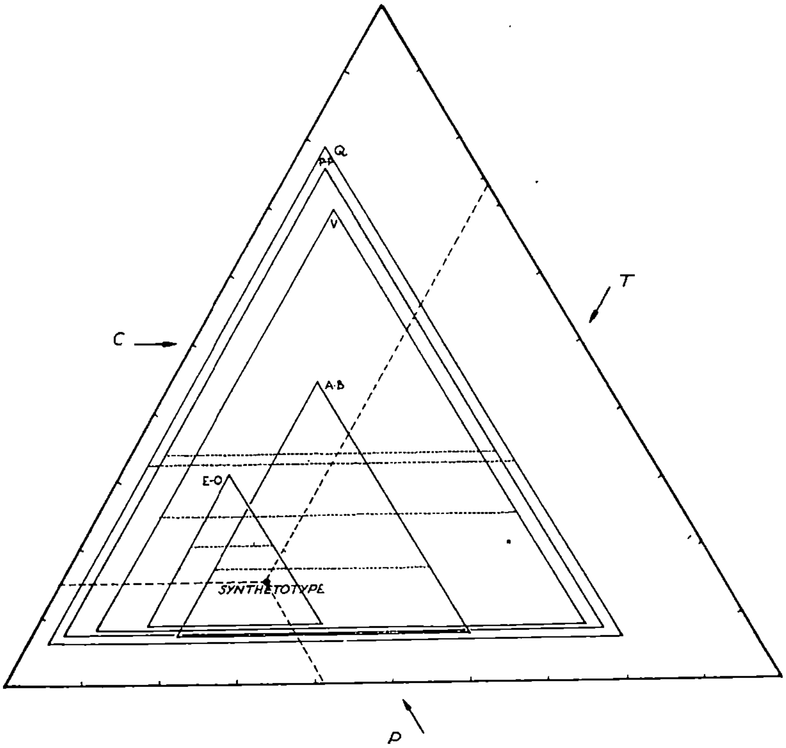

Fig. 1. Areas obtained by plotting on triangular co-ordinates of the measurements (expressed in percentages) of the lengths, P, premolar series to the paraconid of M_1; C, from the paraconid to the protoconid of M_1; and T, the remainder of the premolar series, in 133 species of living and fossil fissipede carnivores. The dotted lines represent the upper limits of the areas occupied by the different species. The broken lines are the co-ordinates of the synthetotype, *Cynodictis*. *E–O*, Eocene–Oligocene; *A–B*, Aquitanian–Burdigalian; *V*, Vindobonian; *P–P*, Pontian–Pliocene; *Q*, Quaternary

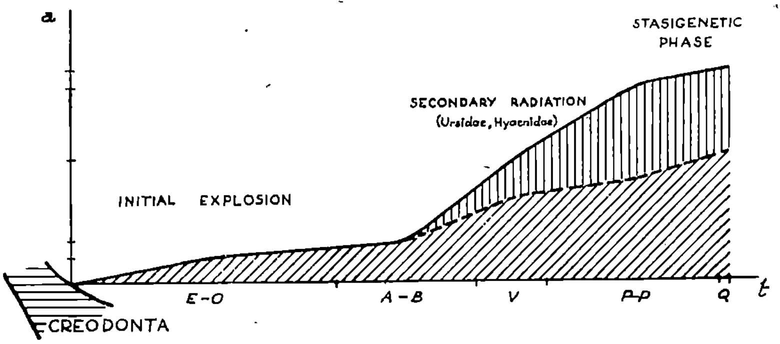

Fig. 2. Graph expressing the same data as Fig. 1, plotted on Cartesian co-ordinates. As ordinates, the amplitude of the variations expressing the increase in size of the areas of Fig. 1; as abscissæ, time expressed in absolute units. The broken line indicates the separation of the basal families from those of the Ursidae and Hyaenidae, the additive character of which is clearly shown

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The rate of increase in the area shown on the graph, representing fissipede evolution, changes in the Vindobonian, and the values obtained when represented as co-ordinates plotted against time provide a graphic expression of this phenomenon (Fig. 2).

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Induction of Triploidy in the South African Clawed Frog, *Xenopus laevis* (Daudin)

When amphibian eggs are exposed to a temperature shock a few minutes after fertilization, the second maturation division may be suppressed, and, by fusion of the haploid sperm with the diploid egg nucleus, triploid embryos may result[1,2]. In the earliest experiments of this type prolonged treatment with low temperatures (0° to +3° C.) was employed on eggs of *Triturus viridescens*[3], but exposure of freshly laid eggs to a hot shock varying from 35–37° C. for from five to fifty minutes was found to be equally effective in this species[4]. These techniques have since been employed successfully on several species of Urodela and Anura. To the list of triploids produced experimentally, *Xenopus laevis* has now been added. This Anuran species is particularly suitable for this research, since reproduction can be induced throughout the year under laboratory conditions, and the young are easily reared, reaching maturity in less than one year.

Mating and ovulation were induced by injection of chorionic gonadotrophin ('Ciba' *Op.* 776). The newly fertilized eggs, collected at 16–18° C., were submitted to a temperature shock in the range of 34–39·5° C. This treatment, lasting 5 min., was applied 1–10, 10–20 or 20–30 min. after oviposition. The mortality attributable to the heat treatment increased with increased temperature.

After about two days at 20–22° C. the larvæ hatched and were swimming freely 2–3 days later. On the eighth to tenth day after hatching the tail-tips were amputated and made into permanent whole preparations according to Baltzer's tail-tip technique[5].

To find the degree of ploidy, I counted the number of nucleoli per nucleus in 100 epidermal cells of each tail-tip, and, where possible, also determined the chromosome number. In this way, I was able to show that in this species, as in the frog and the axolotl[6], the maximum number of nucleoli per nucleus corresponds to the number of chromosome sets.

Triploid *Xenopus laevis* are best obtained from eggs treated within 10 min. of oviposition with a temperature of 36·1–36·5° C., when about 54 per cent of the analysable larvæ are triploid. Altogether 339 triploids have been produced. Other heteroploids and chromosome number mosaics also developed from eggs exposed to temperature shock.

Triploids have been reared to maturity, but final results concerning their growth and physiology are not as yet available. A triploid male, approximately 2½ years old when mated to a diploid female, showed greatly reduced fertility, while two other triploids of the same age, showing female characters, did not spawn after injections of large doses of hormone. Gallien[7], and Chang and Witschi[8], showed that the female is heterogametic in this species. It appears, therefore, that the triploid homogametic males can be fertile, while the heterogametic triploid females have failed so far to produce eggs.

I wish to thank Prof. R. Meier (Chemical Industry, Basle) for the chorionic gonadotrophin used in this experiment. I am very grateful to Dr. M. Fischberg for his advice and interest in this work.

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Epimorphic Regeneration during Hibernation

It has always been considered that certain factors must be present for normal epimorphic regeneration, and increase in temperature and certain metabolic activities are primary conditions which accompany regeneration.

An adult female tortoise of that species most commonly imported into Great Britain from north-west Africa and south-east Spain, *Testudo graeca graeca* L., was noted in the summer of 1954 to have a necrotic condition of the mental and first infralabial cephalic scales, this condition increasing to destruction of the larger part of the two dentary bones which constitute the distal part of the lower jaw. The tortoise lived through a spasmodic hibernation and was seriously handicapped the following summer, being prevented from normal mastication. The oral cavity was thus open to the exterior by this wound as the distal part of the lower jaw was now destroyed.

At the commencement of the second hibernation in 1956 the extent of the wound was some 4 mm. in length. While still in hibernation it was noticed that there had been closure of the ends of the wound. By the completion of hibernation two months later there was complete regeneration of the formerly affected parts of the lower jaw.

This example of epimorphic regeneration is of interest in that it occurred during hibernation and thus the temperature, oxygen and food levels were lower than those necessary for activity and voluntary response, the latter being associated with hibernation in poikilothermic animals. The total period occupied some twenty-three weeks, and of this time the pre-tissue regeneration stage took three quarters. This is approximately the time ratio for amphibian epimorphic regeneration.

Timothy J. Hunt

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FORTHCOMING EVENTS

Monday, January 27

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal Evening on "An Enquiry into the Specification of Transistors". Talk by Mr. F. F. Roberts.

Tuesday, January 28

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. W. Fillingham Brown, Mr. J. C. Wylie, Mr. G. E. G. Mattingly and Mr. J. Longwell: Formal Discussion on "The Disposal of Towns' Wastes".

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Symposium on "Long-Distance Propagation above 30 Mc./s.".

Women's Engineering Society, London Branch (at the Central Electricity Authority Headquarters, Winsley Street, London, W.1), at 6.45 p.m.—Mr. C. G. Barlow: "Food Instrumentation".

Wednesday, January 29

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Prof. A. R. Ubbelohde, F.R.S.: "The Marriage of Art and Science".

Institution of Electrical Engineers, Supply Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. L. Douglas and Mr. A. W. Stannett: "Laboratory and Field Tests on 132 kV. Condenser Bushings".

Institution of Mechanical Engineers, Education Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "To What Extent Should Students be Penalized for Bad English in National Certificate Examination Papers?"

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. I. Maddock: "Ultra-High-Speed Oscillography".

Thursday, January 30

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. L. H. Finlayson and Prof. O. Lowenstein, F.R.S.: "The Structure and Function of Abdominal Stretch Receptors in Insects"; Mr. E. J. Denton and Miss Mary Ann Walker: "The Visual Pigment of the Conger Eel".

Linnean Society of London (jointly with the Systematics Association, at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Meeting on "The Higher Taxonomic Group", opened by Mr. E. J. H. Corner, F.R.S., and Dr. A. J. Cain.

Friday, January 31

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Geochemical and Radiometric Methods of Surveying". Chairman: Sir William Pugh. Speakers: Mr. S. H. U. Bowie, Dr. W. Bullerwell, Dr. J. E. T. Horne and Mr. J. S. Webb.

Institution of Mechanical Engineers (General Meeting in conjunction with the Internal Combustion Engine Group, at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. W. Rizk: "Some Experimental Studies of the Mixing Processes and Flow Configuration in 2-Cycle Engine Scavenging".

Institution of Chemical Engineers, Graduates and Students Section (at Caxton Hall, Westminster, London, S.W.1), at 6.30 p.m.—Mr. P. W. Mason: "Instrumentation in the Chemical Industry".

Royal Institute of Chemistry, London Section (joint meeting with Brighton Technical College Chemical Society, at Brighton Technical College), at 7 p.m.—Mr. F. A. Paine: "Some Chemical Aspects of Packaging".

British Glaciological Society (joint meeting with the Cambridge University Meteorological Society, in the Geography Department, Downing Place, Cambridge), at 8.30 p.m.—Mr. G. Manley and Mr. C. D. Ovey: "Some Aspects of Climatic Change".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Lawrence Bragg, F.R.S.: "Gemstones".

Saturday, February 1

British Interplanetary Society (in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Dr. N. H. Langton: "Meteoric Hazards to Space Flight".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Demonstrator in Physics—The Registrar, The Manchester College of Science and Technology, Manchester 1 (January 31).

Assistant Physicist (with a good honours degree in physics) in the Physics Department of the Sheffield National Centre for Radiotherapy—The Secretary, Sheffield Regional Hospital Board, "Broom Cross", Tree Root Walk, Sheffield 10 (February 1).

Head of the Chemistry Department—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (February 7).

Mathematician (Assistant Experimental Officer grade), to work in the Agricultural Research Council statistical group dealing with a wide range of agricultural subjects—The Secretary, School of Agriculture, The University, Downing Street, Cambridge (February 7).

Assistant Lecturer or Lecturer in Pure Mathematics—The Registrar, The University, Nottingham (February 8).

Assistant Lecturer or Lecturer in Statistics—The Secretary, The University, Exeter (February 8).

Demonstrator (with a degree in agriculture) in Agriculture, for duties on the University Farms—The Registrar, The University, Leeds 2 (February 10).

Analyst (B.Sc., B.Sc.(Agr.), or equivalent, with emphasis on chemistry) at Yanco Experimental Farm, Department of Agriculture, New South Wales, for duties which include research and routine chemical work associated with rice-growing problems—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (February 12).

Senior Technician (A.I.M.L.T. or equivalent qualification, and preferably with experience in museum and histological techniques) in the Department of Anatomy, University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 12).

Assistant Lecturer (with an honours degree in psychology and additional training or experience in clinical psychology) in Clinical Psychology—The Registrar, The University, Manchester 13 (February 15).

Lecturer in Psychology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 15).

Research Assistant or Junior Fellow in Aeronautical Engineering—The Registrar and Secretary, The University, Bristol (February 15).

Research Biochemist (with a university honours degree in science, with biochemistry as a major subject, plus a knowledge of microbiology and some postgraduate research experience) at the Regional Pastoral Laboratory, Division of Animal Health and Production (C.S.I.R.O.), Armidale, N.S.W., Australia, to join a team of scientists investigating the chemical, biochemical, agronomic and nutritional aspects of a general programme concerned with the utilization and management of pastures—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 208/104 (February 15).

Scientific Officer (with a first- or second-class honours degree in physics, chemistry or chemical engineering) at the Water Pollution Research Laboratory (D.S.I.R.), Stevenage, Herts, to undertake (*a*) laboratory studies and theoretical consideration of settlement of flocculating and non-flocculating solid particles in quiescent and flowing aqueous media, and (*b*) laboratory and pilot plant studies of influence of design of sedimentation tanks on flow of liquid through such tanks and on settlement of suspended particles—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.3/8A (February 15).

U.S. Rubber Company Postgraduate Research Student (with a good honours degree including chemistry) to read for a higher degree, working on cationic polymerization under the direction of Dr. P. H. Plesch—The Registrar, University College of North Staffordshire, Keele, Staffs (February 22).

Lecturer in Statistics—The Secretary, The University, Aberdeen (February 24).

Assistant Lecturer or Lecturer (with special qualifications in mathematical statistics and some interest in industrial and engineering applications) in the Mathematics Department—Head of the Mathematics Department, Imperial College of Science and Technology, London, S.W.7 (February 28).

Chair of Geography tenable at the London School of Economics and Political Science—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 28).

Director of the Zoological Park, Auckland, New Zealand—New Zealand House, 415 Strand, London, W.C.2, or The Town Clerk, Town Hall, Auckland, New Zealand (February 28).

Lecturer or Assistant Lecturer in Psychology—The Registrar, The University, Hull (February 28).

Research Spectroscopists (2) (with a university degree of M.Sc. or Ph.D. in chemistry or physics, and preferably with some research experience in the general field of spectroscopy) in the Division of Industrial Chemistry (C.S.I.R.O.), Fisherman's Bend, Melbourne, Australia, to work on the following research topics: (*a*) development of the field of atomic absorption spectroscopy and its application to theoretical and applied problems, and (*b*) experimental and theoretical studies of electronic and vibrational spectra of co-ordination compounds in relation to structure—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 590/658 (February 28).

Wellcome Research Fellow in Zoology at the University College of Rhodesia and Nyasaland, to collaborate in work on the physiology of tsetse flies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 28).

Lecturer in the Department of Botany—The Secretary, The University, Edinburgh (March 1).

George Kelley Reader in Metallurgy—The Registrar, University Registry, Oxford (March 20).

Assistant Lecturer (Grade "B") to teach Organic and General Chemistry—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

Lecturer (preferably with qualifications or experience in chemical engineering and practical experience in radiochemical work) in the Nuclear Technology Section of the Department of Chemical Engineering—Prof. P. V. Danckwerts, Imperial College of Science and Technology, London, S.W.7.

Metallurgist, Chemist or Physicist (with an appropriate degree), for work in the Information Department dealing with every aspect of the recording and transmission of information on the extraction, manufacture and uses of non-ferrous metals and their alloys—The Secretary, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

sity College of

Research Chemists (organic chemists with physical chemistry interests, especially kinetics, or similar), for work on oxidation and ozonolytic reactions—The Director of Research, The British Rubber Producers' Research Association, 48–56 Tewin Road, Welwyn Garden City, Herts.

Senior Laboratory Technician (male, with previous experience as technician or steward in biology)—The Department of Zoology and Comparative Physiology, The University, Edgbaston, Birmingham 15.

Senior Lecturer in Physics; a Senior Lecturer in High Polymer Science; and a Lecturer in Chemical Technology and/or Chemical Engineering—The Clerk to the Governing Body, Borough Polytechnic, Borough Road, London, S.E.1.

Senior Scientific Officer (with a first- or second-class honours degree in physics, and postgraduate applied research experience), to join a team of chemists and chemical engineers making fundamental and applied research studies in the inorganic chemical field—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1663/34.

University Lecturer and University Demonstrators in Physics—Dr. F. B. Kipping, University Chemical Laboratory, Lensfield Road, Cambridge.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

Current Medical Research. (A reprint of articles in the Report of the Medical Research Council for the year 1955–56.) Pp. iii+56. (London: H.M. Stationery Office, 1957.) 2*s.* 6*d.* net. [2510

Bishop's Stortford College Natural History Society. Annual Report. (*Coturnix* 1956–57, June 1957.) Pp. 40. (Bishop's Stortford: Bishop's Stortford College Natural History Society, 1957.) [2510

Transactions of the Royal Society of Edinburgh. Vol. 63, Part 2 (No. 15): On Protopitys (Göppert); with a Description of a Fertile Specimen *Protopitys scotica* sp. nov. from the Calciferous Sandstone Series of Dunbartonshire. By John Walton. Pp. 333–340+3 plates. 6*s.* Vol. 63, Part 2 (No. 16): Cytological Studies of Melaniidae (Mollusca) with Special Reference to Parthenogenesis and Polyploidy. 1: Oögenesis of the Parthenogenetic Species of *Melanoides* (Prosobranchia-Gastropoda). By Dr. Joseph Jacob. Pp. 341–352+4 plates. 6*s.* (Edinburgh and London: Oliver and Boyd, Ltd., 1957.) [2510

Planning, Vol. 23, No. 415 (28 October 1957): Economics of Domestic Pets. Pp. 197–212. (London: Political and Economic Planning, 1957.) 2*s.* 6*d.* [2910

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Forestry Commission. Forest Record No. 34: Experiments on the Chemical Control of *Rhododendron ponticum*. By G. D. Holmes. Pp. 7. (London: H.M. Stationery Office, 1957.) 9*d.* net. [2910

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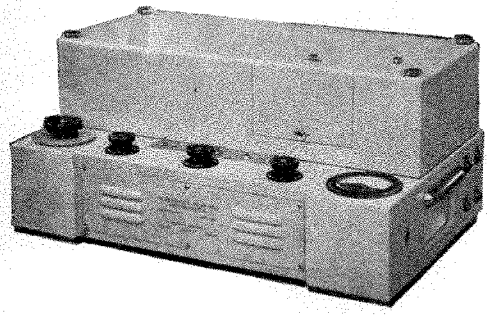

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The Graduate School in Mathematical Physics is intended for graduates holding a good honours degree in mathematics with subsidiary physics, who propose to take up work involving the practical application of mathematics to physical and similar problems. Candidates who are successful in the examination at the end of the course, will be awarded a Diploma in Mathematical Physics. The course lasts for one session (October to July). The fee is £58.

Application for admission to the course, starting in October, 1958, and requests for further information, should be made as soon as possible to the Registrar, University of Birmingham. In the case of candidates wishing to be considered for the advanced Course Studentships of the Department of Scientific and Industrial Research, it is desirable that application be made to the Registrar before February 15, 1958. In certain cases, a maintenance allowance with fees may be awarded by the university.

COLLEGE OF AERONAUTICS

The Board of Entry of the College invites applications from suitable candidates for the two-year course which begins in October, 1958, and ends in June, 1960. The course is intended for selected students of graduate standard. Candidates who do not possess a university degree may offer alternative evidence of educational attainment, for example, a good higher national certificate with a satisfactory record of apprenticeship or equivalent experience in industry. All applications are considered by the Board of Entry which may call candidates for interview. The College, a postgraduate institution, is devoted to the study of aeronautical science and engineering. The curriculum covers the five main subjects of aerodynamics, aircraft design, aircraft electrical engineering, aircraft propulsion, and aircraft economics and production. Instruction in the first year is designed to provide all students with a broad background of knowledge in all these subjects, with opportunity for limited specialization in two or three of them. In the second year students specialize more particularly, usually in one subject. The teaching in the syllabus is designed to fit students for a career in either aircraft or guided weapon engineering. Experiments in the air are an important part of the work, both in the first year when all students take part in them and in the second year when they are linked to the specialist work of the departments. Students who satisfactorily complete the course receive the Diploma of the College.

Further particulars and details of the procedure for enrolment may be obtained from the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

UNIVERSITY OF MANCHESTER

DIPLOMA IN BACTERIOLOGY

The course for the Diploma in Bacteriology requires full-time attendance in the Department of Bacteriology for one academic year (October-June). It is suitable for those who have qualified in medicine, veterinary medicine or other branches of science related to bacteriology. The course includes general and systematic bacteriology, bacterial chemistry, serology, immunology, virology, mycology and statistics. All candidates must present evidence of previous training approved by Senate as satisfactory for admission to the course and register as postgraduate students of the University.

Further particulars and forms of application may be obtained from the Secretary, Department of Bacteriology, York Place, Manchester, 13.

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Both courses take place at Imperial College, Prince Consort Road, South Kensington, London, S.W.7, from April 10-16. The courses are mainly for residential students but a limited number of non-residential students will be accepted. Applicants should normally be science graduates.

Applications to the Deputy Director (Ext. N), Department of Extra-Mural Studies, University of London, Malet Street, W.C.1, from whom further information may be obtained.

UNIVERSITY OF BRISTOL

DIPLOMA IN HORTICULTURAL SCIENCE

DIPLOMA IN PLANT PATHOLOGY (including ENTOMOLOGY) AND PROTECTION

The above postgraduate Diploma courses will be available during the Session 1958-9. Conducted in part at the Long Ashton Research Station, they are intended primarily for those with good honours degrees in science who seek careers in horticultural research, at home or overseas. The course in Plant Pathology and Protection permits specialization in any approved branch of the subject, including applied entomology.

The Horticultural Science course commences on September 15, the Plant Pathology course on September 29. Both courses extend over a full session of three terms ending in June or July, and include some additional practical work during the vacations.

Early application should be made to the Registrar, from whom full particulars may be obtained.

KING'S COLLEGE

(UNIVERSITY OF LONDON)

STRAND, LONDON, W.C.2

Applications for the B.Sc. Special degree course in Chemistry (commencing October, 1958) must reach the Sub-Dean of Science by January 31, 1958. All applicants (except those individually notified to the contrary) will be required to take a written examination in Chemistry at the College or at their school on Friday, February 21, 1958. Special examination arrangements may be made for applicants serving in H.M. Forces.

THE POLYTECHNIC

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Six lectures on "Modern Methods of Oxidation and Reduction in Organic Chemistry" will be given on Fridays at 7 p.m., commencing February 21, 1958. Fee for the course: 11s.

Application forms and further details may be obtained from the Head of the Department of Chemistry and Biology.

J. E. RICHARDSON,
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The Geological Survey Department invites applications from experienced and qualified Geologists for the following vacancies: one Economic Geologist; one Engineering Geologist; one Ground Water Geologist; one Petrologist cum Mineralogist; one Petroleum Geologist; one Photo-Geologist; one Geophysicist. Applicants must be bona fide graduates and have a minimum of five years' practical experience. Contracts will be for a minimum of three years. Salaries range from £165 to £220. Transport and accommodation provided. Passage both ways for self and family. Supplementary experience in related fields such as spectrography, X-ray diffraction, differential thermal analysis, geochemical prospecting, etc., will be an asset.

Write to Director, Geological Survey Department, 226/230 Mahabandoola Street, Rangoon, Union of Burma, within one month from the date of appearance of this advertisement.

WEST OF SCOTLAND AGRICULTURAL COLLEGE

BACTERIOLOGY

Applications are invited for the appointment of Head of the College Department of Bacteriology. Applicants should have an honours or higher degree in science with extensive experience of teaching, advisory work and research in agriculture and dairy bacteriology. Salary scale Grade I (Intermediate) (men), £1,460 rising to £2,000 (plus temporary addition £75 at minimum graduated thereafter). Appointment on July 1, 1958, or as soon thereafter as may be agreed.

Full particulars from the undersigned, with whom applications must be lodged by March 15, 1958.

N. B. BAIN,
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UNIVERSITY OF BRITISH COLUMBIA

DEPARTMENT OF PHYSICS

Applications are invited for appointments Lecturer, Assistant Professor, Postdoctorate Fell and Research Assistant in the Department Physics. The vacancies have been created by th rapid expansion of the university. They a mainly in the fields of nuclear physics, optic spectroscopy, solid state physics and geophys. Applicants should have an honours degree physics and, except in the case of Research Assis ants, a Ph.D. degree. They should not be mo than 30 years of age and should be available September, 1958. There are also Teaching Assi antships available to help students who wish pursue graduate work towards a Ph.D. degree.

Applicants wishing fuller information regardin any of these positions or awards should write t G. M. Shrum, Head, Department of Physics, University of British Columbia, Vancouver, B.C. Canada.

MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM

The Council of the Marine Biological Association, by arrangement with International Paint Limited, invite applications for the Researc Fellowship known as the International Paints Research Fellowship, to continue biological and chem cal research already in progress, including research with radioactive substances, at the Plymouth Laboratory, with a view to furthering knowledge of the effect of toxic substances on marine animals and plants. The appointment will be for a period of three years, subject to annual review, and the suitable applicant should be available to begin work on September 1, 1958. Salary will be conditioned by age and qualifications, and will approximate to scientific Civil Service scales. Applicants should preferably have had at least two years' postgraduate research experience, but recently graduated candidates would be considered. The post is appropriate both to biological and to chemical fields of research, but will be most suitably filled by a biochemist.

Forms of application may be obtained from the Secretary of the Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, Devon, and should be returned to him in quadruplicate not later than February 15, 1958.

UNIVERSITY OF EDINBURGH

DEPARTMENT OF BOTANY

Applications are invited for the post of Lecturer in the Department of Botany. Salary scale £1,150 by £50 to £1,350 by £75 to £1,650 pe annum, with placement according to qualifications and experience, together with superannuatio benefit and family allowance where applicable. The person appointed will be responsible for a large First-year Class, and should preferably have a special interest in Cytology/Genetics. The successful candidate will be expected to take up dut on September 1, 1958.

Further particulars may be obtained from th undersigned, with whom applications (six copies giving the names of two referees, should be lodge not later than March 1, 1958.

CHARLES H. STEWART,
Secretary to the University.

MARINE BIOLOGY STATION

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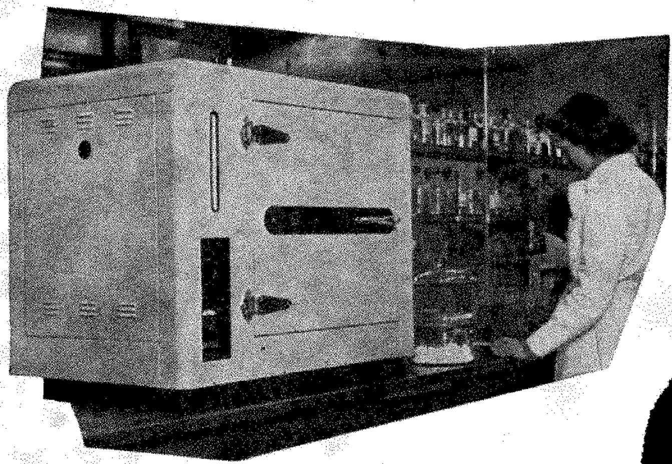

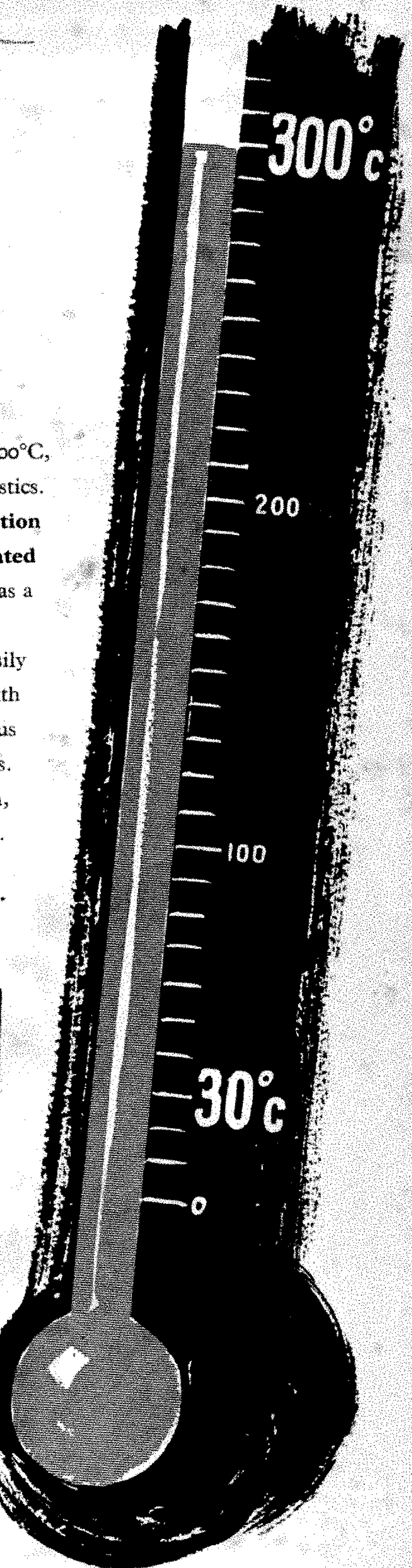

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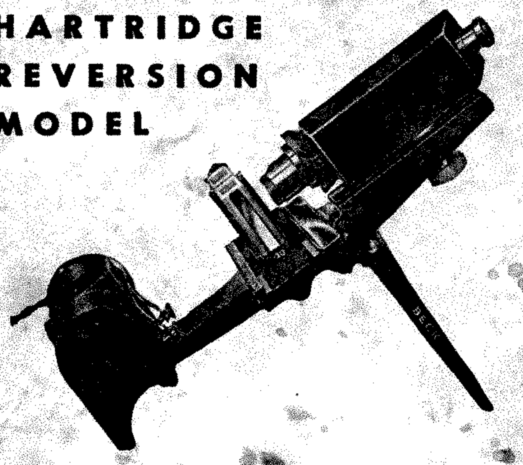

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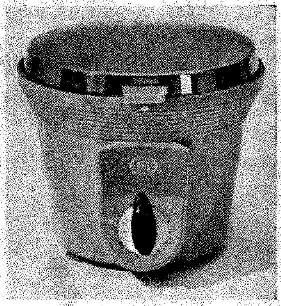

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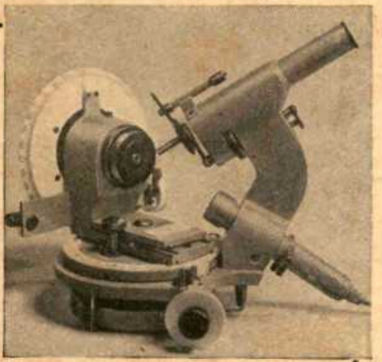

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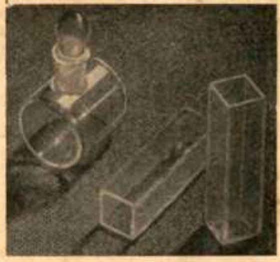

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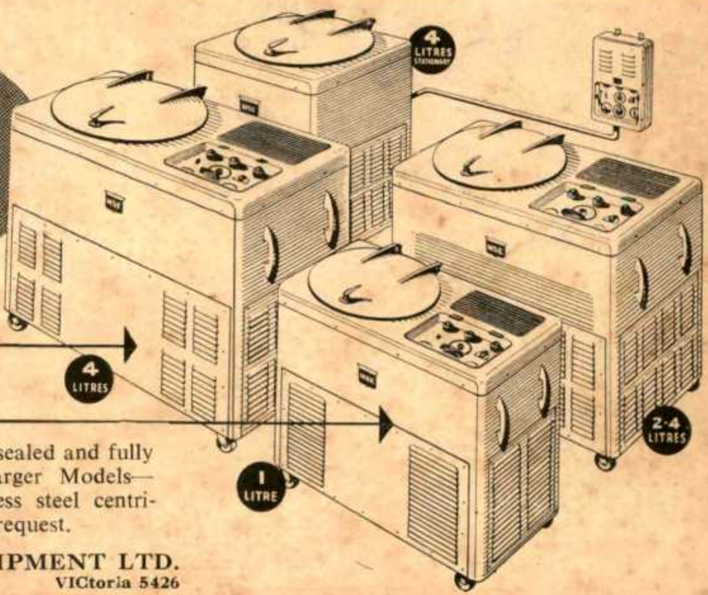

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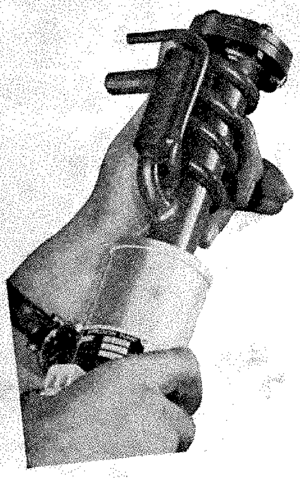

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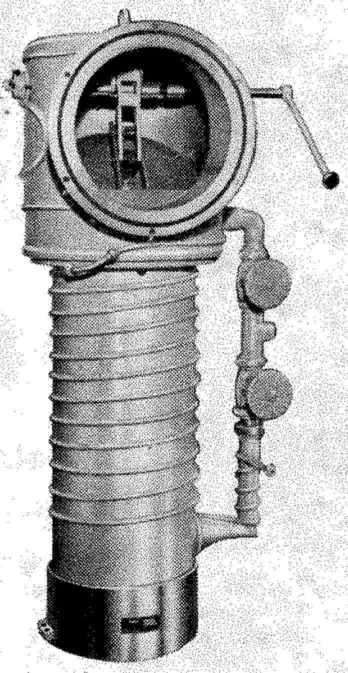

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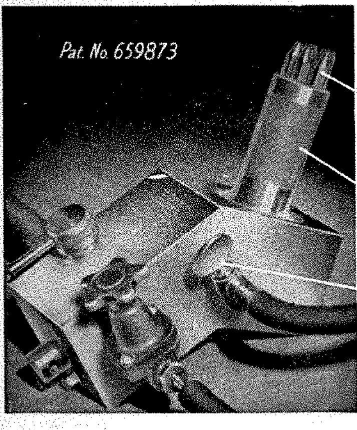

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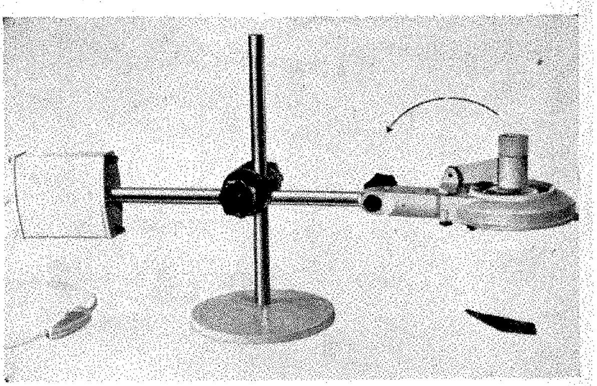

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BROADCASTING SERVICES AND EDUCATIONAL ACHIEVEMENTS

SOME three years ago, in March 1954, a Conference on Universities, Radio, Films and Television was sponsored by the Drama Department of the University of Bristol. In one of the papers contributed at this Conference, which were published for the University in 1956 (Butterworths Scientific Publications), Mr. E. Livesey, of the British Broadcasting Corporation, gave his definition of education: he suggested that it embraced the enlargement of horizons, the widening of experience and knowledge, both of the world outside the self and the nature of individual men, the awareness of the complexities of the world and of the human spirit, and through awareness the gradual acceptance of standards and ideals which have seemed to inspire the outstanding cultures and individuals both in the past and in the present. In short, it was in its effect on the uneducated section of the population that broadcasting had its greatest responsibilities and could make its greatest contributions. He also emphasized the great value in mass communication of the ability to interest a secondary audience as well as the primary one.

Mr. Livesey's remarks on the Third Programme audience, which he characterized as seekers and inquirers, as people with a certain attitude of mind or attitude to life rather than with a particular level of educational attainment, disposed of any idea of the Third Programme being a 'University on the Air', except perhaps in the sense in which the coffee-houses of the seventeenth and eighteenth centuries could be described as 'the penny universities', but he argued convincingly that the universities should take radio seriously. It was Dr. M. M. Lewis, director of the Institute of Education, University of Nottingham, who more specifically indicated the opportunities for the university, not simply in using mass media in its own internal teaching and in disseminating accurate knowledge about mass media and its relevance, but also in research. He stressed the importance of research on the conditions in which radio, cinema or television could become an effective medium, whether for the arts, as a means of communicating knowledge, or as an influence upon the attitudes of its audiences. He stressed also that it is important to ascertain if possible the relations between the components of each medium—the word as heard and the image as seen—and to understand the extent to which they reinforce or conflict with each other. Besides this almost entirely open field, there are the problems of the relations between these mass media and the written word, the effects of radio, film and television upon their audiences in the amount, quality and power of their reading.

It is even more apparent to-day than in 1954 that all this bears very closely, not simply upon education but also upon the whole fabric of public and social life. It may well provide, for example, the key to the social effects of equal opportunity to which Mr. W. James directed attention in a discussion at the Manchester Literary and Philosophical Society in March 1957. It bears equally on the problems of what may be described as cultural erosion, discussed by Mr. R. Hoggart in his book, "The Uses of Literacy", which have since found disturbing manifestations in other ways.

Perhaps the most disappointing feature of both the latest annual report of the British Broadcasting Corporation and of its Handbook for 1958* is that such problems are virtually ignored. The seriousness of such neglect is unmistakable to any thoughtful reader of Mr. Hoggart's book, as even his sub-title—"Aspects of Working-class Life with Special Reference to Publications and Entertainment"—might indicate. Writing with deep feeling and imaginative insight, Mr. Hoggart seeks to show that the under-educated in Britain—the three-quarters of the population whose schooling now ends at fifteen and whose distinguishing characteristic is rather lack of education than of money—are changing their traditional ways, and not for the better. Their freedom from poverty has exposed them to new and very deleterious influences, and while the gross prejudices and appetites are deliberately and even scientifically stimulated, the needs of the more serious-minded among them are neglected.

Mr. Hoggart achieves his purpose, and while he fails to offer much in the way of constructive suggestions and does not attempt to analyse the reasons why a minority resists this cultural erosion or to draw the distinction between this minority and the majority, both in its detail and in its comments his book displays the dangers in the present trends. It affords powerful support to Mr. Livesey's view that it is in the lesser educated section of the population that broadcasting has its greatest opportunities and responsibilities, and inevitably it arouses fresh doubts about commercial broadcasting. Once again the vital issue of the linking of power and responsibility is raised, and the reader may well reflect on the far-reaching consequences of the disappearance of independent newspapers and weeklies which contributed so much to sustain the creative minority on whom Mr. Hoggart relies to discharge a new and more difficult task, namely, that of waking the many from the hypnosis of immature emotional satisfaction.

Mr. Hoggart's study indicates sufficiently how much the responsible and constructive use of television and sound broadcasting could do to avert the dangers to which abuse of the mass-media—including the popular Press—expose us. He indicates, too, how this under-educated section of the community is losing its leaders and those best able to resist these blandishments. The implications and dangers of that process are set forth more fully, however, by Mr. James in his paper in *Manchester Memoirs* (98, 51; 1956–57) entitled "Social Effects of Equal Opportunity". Pointing out that although opportunity is still not equal and that serious-minded parents supply to their children incentives which are denied by those whose relaxations are the 'pools' and television, Mr. James emphasizes that one of the principal purposes of an educational system is to discover ability and encourage it. Men have always risen easily through the ranks of society in Britain; but to-day the selective process, abetted by the eagerness of industry to attract recruits of brains and character, is separating talent more efficiently than ever and leaving the great mass of the people, the base of the social pyramid, bereft of their natural leaders as never before.

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* BBC Handbook, 1958. Pp. 288. (London: British Broadcasting Corporation, 1957.) 5s.

Mr. James suggests that the thinking of society is done in groups, some functional and artificial like a trade union or a clique of a social club, some natural and spontaneous like the company which meets in a particular bar parlour or golf course. These groups are not isolated but knit together through individuals, and opinion may flow easily from one to another. Just as Mr. Hoggart stresses the needs for individuals and groups to assert their individuality and to think and feel for themselves and not in the mass, so Mr. James suggests that for this system of many inter-related groups to function healthily, each group should be in its own way self-sufficient, throwing up leaders of a quality sufficient for the level of the group. A healthy group should be able of itself to supply all the human material necessary for a happy administration of the leisure time of its younger members.

An inescapable result of a selective system of education is a drawing off of all men and women with the intelligence that goes with natural leadership from the groups at the base of the social pyramid and their transfer to groups higher in the social scale. Accordingly, the more this draining-off of talent ministers to the competitive capacities of the nation as a whole by ensuring the widest reserves of managerial and technical skill for manufacturing industry, commerce and administration, the more important it becomes to deal with the social consequences involved. Mr. James mentions, for example, the starving of the trade unions of leadership of high quality, and the probability, now that most of those who do not climb out of their class lack the talent to do so, that the future trade union leader will be less able than his predecessor. Power will still remain with the elected man who has risen from the shop floor, and in consequence there may be difficult problems of authority, as always occurs when leadership and power are divorced from trained intelligence. Mr. James makes his point provocatively by suggesting that on the political side we might easily slip into a State-managed trade union system, and that on the social side a great extension of welfare work will be required. Be that as it may, it is obviously important that the fullest and wisest use should be made of such media as broadcasting and television to stimulate leadership and sound thinking.

For this to be done there must be clear ideas as to the functions and limits of broadcasting. It is here that the report of the Royal Commission on (Canadian) Broadcasting, which Sir George Barnes has well described as "a classic statement on broadcasting", more deeply thought out, better argued and more clearly expressed than any British or American document on the subject that he had read, is so valuable. The Commission assumes that the content of a country's broadcast programmes is important to it because they have entered into the lives of the people and changed them in ways that are often unobtrusive and unnoticed. Their influence will grow rather than diminish and we must adapt them to our use, accommodate them to our purpose and weave them into the fabric of our lives, so that on balance they are agencies for good and not for evil.

If radio and television are not to dull sensibilities by endless repetition of the commonplace and tawdry, or become dehumanizing forces, making all men and women conform in thought, action and aspiration to the lowest common denominator of their kind, the Commission is clear that there must be regulation not only of technical matters but also of programme content and station performance. It believes that there must be some externally enforced standards of public interest to strengthen the instincts of public service that many private broadcasters feel. While advertising has a value and place in the broadcasting system, it is a legitimate exercise of public control to see that a limit is placed on the results of commercial pressures.

The Commission, after a cogent analysis of the effects of mass advertising on broadcasting programmes, points out that if audience-rating rules supreme, broadcasters will allow programme-planning to sink to the most boringly uniform and low level, and the responsibility of the broadcaster to lead his audience by making available fresh entertainment and experiences will be lost. While recommending the retention of private broadcasting, it concludes that free enterprise has failed to do as much as it could do in original programme production and the development of Canadian talent, not because of a lack of freedom but because of a lack of boldness. Accordingly, the Canadian Broadcasting Corporation should remain; but it should have its task more clearly defined, should know the limits beyond which it is not expected to go and should have the means and the power to discharge that task within those limits.

Neither in Canada nor in Britain is there room for the confusion and hesitancy which seem to characterize the last annual report of the British Broadcasting Corporation. It is true that the report claims that the B.B.C.'s policy is based on the conviction that sound radio has a vital part to play in an age of television broadcasting, and it is true also that if sound radio is to remain vigorous and useful, reappraisals are necessary from time to time to determine the proper shape and scope of the programmes. Nevertheless, in spite of the affirmation that the B.B.C. intends to remain firm in its purpose and mission to serve the cause of education and the arts, and also to serve the community as a whole, including the majorities and minorities which constitute the community, there are indications that audience-rating may affect unduly the balance and even the content of the programmes.

The report shows that in the current year the number of combined licences for receiving sound radio and television will for the first time equal the number of licences for sound alone ; but it does not discuss the relation between existing expenditures on sound and television broadcasting, the cost of which (excluding the external services) in 1956–57 was £11·6 million and £9·1 million, respectively. The report observes that, apart from the effect of any continued rise in costs, it is doubtful whether the income in view is sufficient to maintain the present services and to introduce essential progress in television to meet competition—which is seen as a burden rather than a challenge. The present estimates include nothing for major new developments, and neither the report nor the handbook refers to the challenge presented by these new opportunities.

It is in this respect that the report and handbook must be criticized. No attempt is made to present the Corporation's financial needs as an investment which could yield rich dividends to the nation both in education and in public policy. It should be clear to even a casual reader of the Fowler Report on Canadian Broadcasting that the comparatively small sums required to enable the British Broadcasting Corporation to embark on the developments both in television and in broadcasting required to enable it to maintain its high standards and to use to the full its present opportunities could do much to offset the dangers of which Mr. James and Mr. Hoggart have warned us so clearly. It is even possible that a useful contribution could be made to technical education at trifling cost. As it stands at present, however, there appears to be real danger of declining standards as well as of missed opportunities. Clearly the British Broadcasting Corporation needs all the support as well as the stimulus which informed and percipient opinion can bring, if the very real dangers which attend the mass media of communication in the world of to-day are to be avoided. It is idle to think that Britain can achieve the standards in technical education, for example, which are so highly desirable, under the domination of an under-educated society. The greatly increased expenditure on technical and technological education will not be forthcoming or wisely applied without the guidance of a creative minority which can stimulate the changes in broadcasting and television and in other spheres of communication that could minimize or largely avert the danger.

FRANKLIN, THE NEWTONIAN

Franklin and Newton

An Enquiry into Speculative Newtonian Experimental Science and Franklin's Work in Electricity as an Example Thereof. By Prof. I. Bernard Cohen. (Memoirs of the American Philosophical Society, Vol. 43.) Pp. xxvi+657. (Philadelphia: American Philosophical Society, 1956.) 6 dollars.

THERE must be many to whom the title of this book will seem paradoxical. How can Franklin, who is usually remembered in science to-day as the inventor of the lightning rod, stand comparison with Newton ?

In fact, of course, no simple comparison is intended, although the author takes the opportunity of contrasting the comparative neglect with which he feels Franklin's scientific work is treated by scientists to-day with the prestige which it enjoyed among his contemporaries and successors. Franklin was "the first person out of the nation" to be awarded the Copley Medal by the Royal Society, and on his election to the Society he was given special privileges in the matter of fees ; in Parliament he was compared to "our Boyle" and "our Newton".

Franklin, a man without mathematical training, was in no position to master the forbiddingly mathematical "Principia". Newton's "Opticks", on the other hand, was more accessible, for its proofs are based on experiments. More significantly, it is not a well-rounded work like the "Principia"; Newton appended a list of 'Queries', to which he added as edition succeeded edition, and these 'Queries' showed the eighteenth century the directions in which the master's thoughts had been travelling and were at once an invitation to further research and indications of profitable lines of attack.

Prof. I. B. Cohen feels that modern students of Newton have tended to neglect the "Opticks" in favour of the "Principia", and that the immense influence of the former work has therefore been obscured. To do this is to take a one-sided view of Newtonian science, a side to which Franklin could not contribute. "It is, in fact, the purpose of this monograph to show that Franklin was a Newtonian scientist by displaying the many-sided character of Newtonian science in Franklin's day and by analyzing Franklin's own contributions to science in Newtonian terms" (p. 83). So, for example, "Franklin's outstanding contribution to the theory of electrical action lay precisely in his clear grasp of the value of Newton's speculative ideas and in his understanding of the importance of following the spirit rather than the letter of what Newton said" (p. 107).

The work is divided into four parts. In the first, the author comments on the history of science in general and introduces his two main characters with a discussion of their personalities and reputations. Part 2 deals with Newton's two principle works, and it includes a detailed discussion, which is further elaborated in an appendix, of his use of hypothesis. It is amusing to reflect on the importance which has been attached to Newton's dictum, *hypotheses non fingo*, in spite of the passages in the "Principia" clearly marked "hypothesis" and in spite of the many speculative hypotheses in the "Opticks".

Part 3 contains first a carefully documented account of various works of the early eighteenth century which were inspired by Newton's experimental philosophy and which Franklin is likely to have studied, and then a general discussion of Franklin's own place in the current of Newtonian science. In the last and longest part we are given a detailed account of the investigations into electricity in the eighteenth century, in which Franklin played a central part, and the book ends with a bibliography of nearly fifty pages and an index.

In spite of the excellence of the individual sections of the work, which are written with the authority of one who already has many contributions in the field to his credit, it is doubtful whether the somewhat disjointed thesis is adequate for so massive a work. The author himself recognizes that individual readers may wish to study only parts of the book, and he provides a detailed table of contents expressly for their convenience. But in spite of this defect in the work as a whole, the full and careful treatment which the individual topics receive will earn for Prof. Cohen the gratitude of all whose interests lie in this field.

M. A. HOSKIN

BRUNONIAN DOCTRINE IN MEXICO

El Brownismo en México

Un estudio critico, seguido de la primera edición de la version castellana que hizo en México hacia 1800, el Doctor Don Luis José Montaña, de los "Elementos de Medicina" del Dr. Juan Brown. (Cultura Mexicana, No. 14.) Pp. ii+311. (México: Imprenta Universitaria, 1956.) n.p.

DR. J. J. IZQUIERDO, who is professor of physiology in the University of Mexico and a well-known historian of medicine, has edited the Spanish translation of John Brown's "Elementa Medicinae" (1780) from a manuscript written about 1800 by Luis José Montaña (1755–1820), one of the most distinguished pioneers of medical teaching in Mexico. As a preface to the translation, Dr. Izquierdo contributes an interesting essay entitled "El Brownismo en México", which is also the title of the book.

It is a little difficult to understand why the author, who has already performed such useful service by editing Montaña's commentary on the Hippocratic works under the title "El Hipocratismo en México" (1955), should now regard Brown's treatise as worthy of similar attention. The "Elementa Medicinae" is by no means a medical classic. It was never taken seriously in Great Britain, and almost every medical historian, whether in Britain or abroad, regards Brown as a figure for derision and not for praise. Nevertheless, although in his own day he was a mere charlatan in the eyes of most of his colleagues, Brown was highly esteemed by many of his students and patients, and was well known on the Continent, especially in Germany, where, at the University of Göttingen, a riot between the rival factions concerning his doctrine was quelled only by military force.

John Brown, a schoolmaster of Duns, Berwickshire, who turned his attention to medicine and was a graduate of St. Andrews and a student at Leyden, became a pupil and secretary in the house of the famous William Cullen of Edinburgh, and at a later stage the bitter opponent and rival of the patron to whom he owed so much. Brown has been fitly called the Paracelsus of Scotland, since he was regarded by some as a genius and by others as a complete charlatan. The 'system', to which he laid claim as his own although it dated from the time of Asclepiades, was ridiculous in its simplicity. In his view health, and even life itself, was a response to continuous stimulation by warmth, food, fresh air, etc. When the stimuli were withdrawn, death resulted. Disease was caused either by excess or by diminution of stimulation. Consequently there were only two kinds of diseases, the *sthenic*, caused by too much stimulation, and the *asthenic*, caused by two little, or by depressive factors. Treatment consisted of the use of sedatives (usually opium) for the former, and of stimulants (preferably alcohol) for the latter. Such a simple and easy scheme of medical practice could not fail to attract the attention of physicians of that time, many of whom were perplexed and bewildered by the complexities of iatro-physics and iatro-chemistry, the twin theories which viewed the human body as a machine or a test-tube, and which had been introduced in place of the age-long theory of the 'humours'. 'Brownism', demanding little study or thought, appealed strongly also to students who welcomed relief from the burden of examinations. But there was a redeeming feature of the new system. Perhaps Brown, in spite of all his failings and fallacies, did actually perform a useful service in directing attention to the importance of the biological, as opposed to the physico-chemical, aspect of medicine. His doctrine may have formed a bridge, however frail and slender, between the scholastic age and the age of medical science.

Accordingly, we need not be surprised to learn that Brownism exercised some beneficial influence upon medical education in Mexico, a progressive country which could lay claim to the first hospital (1523) and the first organized medical teaching (1580) in the American continent, as well as to the first medical journal of the western world (*Mercurio Volante*, 1772). It does seem strange that Brown's "Elementa Medicinae" was translated into Spanish only twenty years after it was written, while Harvey's "De Motu Cordis" appeared in a Spanish version only after a lapse of more than three hundred years (1936). The reason was that Brown's work, at the time of its appearance, seemed to offer an easy solution to nearly every problem in medical practice, whereas Harvey's treatise, though infinitely more significant, remained misunderstood and devoid of practical outcome for many years. It was, in fact, born far ahead of its time, whereas Brown's answer to a pressing need was eagerly grasped and widely applied as soon as it appeared.

Dr. Izquierdo has therefore been fully justified in adding this curious chapter to his former studies of the early progress of medical education in Mexico. We are too apt to forget that the early history of medicine in Latin America had important repercussions throughout the civilized world and that it is a subject well worthy of our attention. The present volume is a fitting sequel to the author's splendid work on "Montaña y los origines del movimiento social y cientifico de México", and a fine tribute to the ancient medical school. It also serves to remind us that the phenomenon of the 'Brunonian System', or as the writer calls it, 'Brownism', despite its absurd simplicity, helped to divert medical thought, in Mexico and elsewhere, away from the traditional and often sterile theories, and towards the beginnings of the scientific basis which lies at the root of all real progress in modern medicine.

DOUGLAS GUTHRIE

REPRODUCTION IN FUNGI

The Physiology of Reproduction in Fungi

By Dr. Lilian E. Hawker. (Cambridge Monographs on Experimental Biology, No. 6.) Pp. vi+128. (Cambridge: At the University Press, 1957.) 15*s*. net.

METHODS of reproduction in fungi have both a general and a special interest—general, inasmuch as reproduction is fundamentally important to all organisms, and special, for the following reasons. As a group, the Fungi exhibit a remarkable variety of reproductive mechanisms, the overall effects of which are to ensure the dispersal of the species to fresh habitats and its survival over periods when growth is not possible. The factors which control reproduction are thus of considerable practical interest in the case of the many fungi which bring about disease in higher plants. They are also of special interest to the fungal systematist, because reproductive mechanisms form the main basis for fungal classification. Furthermore, a large proportion of fungi can be grown under standardized cultural conditions and, as compared with most other plants, they offer great conveniences in ease of handling, in inexpensiveness of apparatus required and in the speed with which the life-cycle of many of them can be completed. It is not surprising, therefore, that much physiological work, dealing with reproduction and other activities, has been carried out with fungi, and it is a safe guess that, in the future, many of the more fundamental studies of growth and reproduction in plants will be based upon the same material.

Dr. Hawker's compact monograph gives an up-to-date and critical digest of the literature bearing on the subject. After a short introduction, in which the main reproductive types are briefly described, there follows an account of the growth of spores and spore-bearing structures. This chapter is important, as it is only when the succession of developmental stages is worked out with some precision that one can pose the physiological questions that are involved. This comes out very clearly with the more complicated fruit bodies, for example, of Basidiomycetes—as in Corner's detailed studies—but it is equally certain that there is an elaborate succession, on a more microscopic scale, of stages in the development of the simplest kind of reproductive structure, such as an oidiospore. The physiological work proper is discussed in four main chapters, the last of which deals with the intricate and still controversial problem of sex in fungi. A short final chapter considers the sporing behaviour of a number of fungi in the field, as interpreted in the light of experimental work in the laboratory. A list of some 350 selected references closes the monograph.

As the author ruefully remarks more than once, the physiological study of fungal reproduction has as yet barely progressed beyond the empirical stage. It deals almost entirely with the effects of environment —temperature, light, *p*H, quantity and quality of food supply, etc.—on sporulation. There is much diversity, as between one fungus and another, in the precise effects produced by any one environmental factor and very few generalizations have as yet emerged. This is not surprising, for it is the conditions inside the mycelium, as produced by the external environment, that control the onset, the amount and the kind of sporulation. The story, as it is unravelled, will undoubtedly be a biochemical one, with sequences of enzymatically and hormonally controlled reactions. There is already good evidence of the functioning of sex hormones in some of the lower fungi.

Sexual reproduction in fungi differs, in one very important respect, from that in higher plants. In the latter the key problem is: Why do diploid nuclei, after an indefinitely long series of mitotic divisions, suddenly undergo a reduction division, thereby giving rise to the reproductive cells? With fungi, the problem is the converse: Why do haploid nuclei, after a like series of mitotic divisions, suddenly become associated in pairs which, sooner or later, fuse to form a diploid nucleus, which in turn immediately reduces to the haploid condition? Clearly, any progress in either of these fields will have repercussions in the other.

The great merit of this book is that, though short, it covers the ground and, in particular, indicates where the many gaps in our knowledge lie. Its value to the research worker in mycology is obvious, for there are research problems, of a more general or a more special kind, to be picked from almost every page.

W. Brown

SOIL SCIENCE

The World of the Soil

By Sir E. John Russell. (The New Naturalist: a Survey of British Natural History.) Pp. xiv+237+26 plates. (London: William Collins (Sons) and Co., Ltd., 1957.) 25*s*. net.

THE "New Naturalist" has nearly fifty volumes to its credit in the ten years of its history. The excellent contributions made by these volumes in the various fields of science already constitute a tradition. The editors' choice of author for a book on soil science could scarcely have been more auspicious, for Sir John Russell is internationally known to agriculturalists and soil scientists as director of Rothamsted Experimental Station for thirty years and as author of "Soil Conditions and Plant Growth". This present volume will introduce him to a wider audience for whom study of the soil is an absorbing hobby.

The arrangement of the subject-matter recalls the separate departments of any soil research institute. Soil geology, soil physics and soil organic matter are briefly but adeptly handled in the opening chapters and are followed by a more lengthy treatment of soil microbiology and zoology. Chapters on soil fertility and soil survey complete the book. The whole is written so admirably that the impression gained is never of a vast catalogue of research but rather of a living story simply told. One-third of the book is devoted to the micro-flora and fauna, and here Sir John excels. A fascinating array of bacteria, fungi, mites, arthropods, nematodes as well as earthworms, slugs and snails are discussed. Since Darwin's study of the earthworm, published some seventy-five years ago, has recently been reprinted, the relevant pages of the book under review are particularly apposite, for we are treated to an authoritative appraisal of Darwin's experiments—one could almost wish for more. The mole, the pad-mark of which graces the dust cover, receives but short shrift from the author; yet there are hill pastures which will never see the plough where the mole is an active soil-former.

To the gardener in search of do's and don'ts, the chapters on soil fertility are probably the most interesting. The development of the modern fertilizer industry saw the birth of Rothamsted. The progress towards modern balanced fertilizers tailored to specific crops is a tale which cannot be told too often. Organic cranks are summarily dealt with: compost returns to the soil only what it has taken from it—should any element be lacking, composting will only perpetuate the trouble.

The final chapters deal with soil classification and soil survey; the soil is discussed in relation to the landscape and consideration is given to the uses to which the land can be put. This has been successfully done for southern Britain, but little is said of that large part of northern Britain once heather moor and now, due to the herculean labours of the crofters who reclaimed it, fertile and pleasant agricultural land. Such is Auchallater Farm in Glen Cluny (Plate XXII, which has both these places misspelt).

There are few printer's errors. On p. 144 the reference p. 000 is not helpful; Table 7, p. 94, has some curious arithmetic. The photographic illustrations are excellent as is also the drawing of the nematode (facing p. 114), but that of the crustaceans (p. 124) is lamentable, and Figure 9 (p. 136) cannot be regarded as useful. Very occasionally, too, the author nods: neutrality is stated to be pH 7·2; the meaning of the paragraph at the bottom of p. 145 is obscure; on p. 209, bilberry is said to be associated with wetter bogs, whereas it is an indicator of drier conditions. Crowberry could be substituted.

Altogether this book is one of "New Naturalist's" best. As a record of achievement for those who share Sir John's calling, it is heartening reading. The book, however, is intended for the lay reader. Apart from occasional OH's, NH_2's and COOH's, all terms are defined in the text. There is no glossary and none is needed. The words of a former proposer of a vote of thanks to Sir John can be quoted here: "The lecturer 'as been hintelligent, but not too hintelligent for us". P. C. DeKock

RED SEA FISHES

Fishes of the Red Sea and Southern Arabia

By Henry W. Fowler. Vol. 1: Branchiostomida to Polynemida. Pp. v+240. (Jerusalem: The Weizmann Science Press of Israel, 1956.) n.p.

THIS book and the two volumes expected to follow it will constitute the only compendious account of the fishes of the Red Sea since Klunzinger's of 1879. It is compiled, not by a man who has had special opportunities to study Red Sea fishes, but by a courteous, now very senior gentleman, who sits in a small upper room in the Academy of Sciences of Philadelphia, armed with a great facility in line drawing, a long experience and a very fine index to fish literature. The work is offered, not as a contribution to knowledge, but as a tool for those able to study the fauna.

As such we must be grateful for it, and ordinary standards of criticism should perhaps not be applied. Those who will approach the Red Sea fauna for the first time with this as their key should be warned, however, to use it very critically, and only for preliminary determinations. Many of the species extend over the whole Indo-Pacific area, and if Mr. Fowler had no Red Sea specimens at hand, nor a description of such to copy, he drew up a description from a specimen from perhaps Honolulu or the Philippines. He explicitly disclaims, therefore, any ability to contribute to the question of geographical variation or subspeciation.

The telegraphic style of the descriptions will probably be understood by readers whose first language is not English, but more care for punctuation would have helped here.

On nomenclature Mr. Fowler is pitiless. It seems regrettable that decisions made in such a careful work as that of Bigelow and Schroeder on the sharks and rays of the western North Atlantic should not have been taken as standard. They have carefully considered the arguments for and against the use of *Carcharhinus* for a large genus, the type of a family, of sharks. In the end, the decision had to be arbitrary, and in the interests of stability they gave it for *Carcharhinus*. So far as Mr. Fowler is concerned, this work was in vain. He uses *Galeolamna*.

It is significant that the work is published in Israel, largely in answer to the needs of the young scientists at work there. No doubt Mr. Fowler would join us in the hope that among them are some who will eventually put it out of date.

E. Trewavas

ADVANCES IN JUNGIAN PSYCHOLOGY

New Developments in Analytical Psychology

By Michael Fordham. Pp. xiv+214. (London: Routledge and Kegan Paul, Ltd., 1957.) 25*s*. net.

THIS book is by one of Jung's disciples and deals with the philosophy of his school. The author was a founder member of the Society of Analytical Psychology and is a Fellow in child psychiatry at the London Child Guidance Clinic.

No doubt enthusiastic Jungians will enjoy reading it but others will feel exasperated and frustrated by the loose thinking. For example, on p. 23 the author states, "Jung points out that the concept of conservation of energy is based on age-old archetypical forms and Pauli shows how Kepler's scientific discoveries are linked with symbolic doctrines of great antiquity". It is, of course, easy to do this sort of thing, and one can always find a myth to fill the bill, but there is not one iota of evidence to prove it. Again on p. 107 he states, "It is well known that children love fairy and folk tales and will concentrate on them for hours, demanding repetition of particular stories over and over again. This phenomenon can only be understood in terms of activity of archetypes within the psyche of the child". But this is untrue. It can be understood otherwise if we are willing to try. A child wants to hear a story re-told again and again either because it gives it pleasure or dispels anxiety, or both at once. We do not need to drag in hypothetical archetypes to explain it.

The author is best with his description of children's neuroses, as one might expect from his training, and in this field his work is more acceptable.

Clifford Allen

The Organization of British Central Government, 1914–1956

A Survey by a Study Group of the Royal Institute of Public Administration. Edited by D. N. Chester. Written by F. M. G. Willson. Pp. 458. (London: George Allen and Unwin, Ltd., 1957.) 32*s.* net.

THIS corporate work provides a detailed account of the structure of British Government and the changes which have occurred since the beginning of the First World War. After reviewing the general pattern, each of the major fields of Government is surveyed in turn: finance, trade and industry; law, justice and public order; social services; external affairs; defence; common services; and scientific research. For that last chapter alone the book is of great interest to the scientist. It brings together scattered information not easily available, some of it new or unfamiliar to most scientists, and provides a more penetrating survey of government scientific organization in the civilian field than is contained in the pamphlet issued under that title in 1951. It lifts the veil slightly on the work of the Committee of Civil Research and shows how much Lord Balfour did to establish the position of science in Government. The concluding chapters in the central co-ordination of Government and the handling of administrative change, besides providing a factual account of the present arrangements, including the way in which the Lord President of the Council came to assume major responsibility for the country's scientific effort, gives some first information about the Cabinet Machinery of Government Committee appointed in 1942.

The great value of these two chapters lies in the clear exposition of the various factors to be taken into account in determining the structure of Government, for example, in deciding on the number of ministries or the grouping of functions, and in doing so they indicate precisely what is involved in proposals to centralize or decentralize scientific activities, including research, among others. Essentially a work of reference, the book is provided with notes and a bibliography which will facilitate further inquiry in directions likely to throw more light on aspects of the organization of science in Government now being debated. The book is thoroughly up to date, recording, for example, the changes last April in responsibility for nuclear energy.

Organic Chemistry

Electronic Theory and Reaction Mechanism. By Rowland I. Reed and Dr. S. Horwood Tucker. Pp. viii+108. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1956.) 15*s.*

THE 'organic chemistry' of the title is restricted to those aspects of theory covered by the subtitle; there is no description of preparations and properties. The contents consist of nine chapters on the electronic theory and its application to organic reactions, and two on reaction mechanism. The chapters deal with: the atom, the origin of valence, acids and bases, atomic and molecular orbitals, intermolecular influence of atoms and groups on valency electrons, physical methods of measurement, physical evidence for conjugative electron shifts, interatomic distances, the hydrogen bond, reaction mechanism, and substitution reactions. The terminology and the theoretical contributions of Ingold and his school receive considerable notice. Mesomerism (resonance), hydrogen bonding and the other new theoretical developments which have extended and revolutionized our ideas on molecular structure are very clearly explained. The new knowledge leads to the formulation of helpful generalizations, affords a deeper understanding of reaction mechanism, and indicates a more logical classification of descriptive matter. To older chemists and university freshmen desirous of studying the application of the electronic theory to organic chemistry, this book is recommended.

G. Fowles

Statistical Tables for Biological, Agricultural and Medical Research

By Prof. Sir Ronald A. Fisher and Dr. Frank Yates. Fifth edition, revised and enlarged. Pp. x+138. (Edinburgh and London: Oliver and Boyd, Ltd., 1957.) 24*s.* net.

STATISTICIANS are well served in the matter of tables. The two standard sets, of which this is one (*Biometrika* Tables being the other), are beautifully printed and, by current standards, remarkably cheap. They run to new editions sufficiently frequently for continual additions and improvements to be possible.

This fifth edition of Fisher and Yates follows its predecessor of 1953 in general design, but incorporates several new tables and some extensions of former ones. Most of the material concerns variate-transformations, new tables being provided for 'logit' and complementary 'loglog' transformations, and the table of angular transformations is enlarged. A new table for the application of the product-ratio method in linkage investigations in genetics is also supplied.

Science and Human Life

Successes and Limitations. By Prof. J. A. V. Butler. Pp. viii+163. (London and New York: Pergamon Press, Ltd., 1957.) 15*s.* net.

THERE are quite a number of books of a popular, or semi-popular, type dealing with the urgent problems of the day thrown up by the advance of science and the tensions inseparable from human life. Prof. Butler has produced a handy little volume, in line with the general run of such works: it is interesting enough, but one may ask for whom exactly is it intended. The two sections, "Science and the Individual" and "Science and Human Society", cover adequately the fields suggested by their titles. But they contain very little beyond what can be garnered from ordinary contemporary reading. This result is not the author's fault; science *qua* science in everyday affairs is not what many people are worrying about. The difficulty is 'why' rather than 'how'; and having regard to Prof. Butler's point—manifestly correct—that intrinsic intelligence, apart from training and opportunities, has not increased greatly through the ages, the main need is for deeper philosophical insight at the point at which science ends, and faith or revelation may be said to begin.

The list of suggested books for further study contains several of a decidedly advanced character. On balance, they will conduct the reader into regions of thought not specifically scientific in the narrow sense (under Chapter 7 there is a misprint: 'Kaffka' should be 'Koffka'). But this may be all to the good, and Prof. Butler will have provided a sound introduction.

F. I. G. Rawlins

A NEW DEAL FOR AUSTRALIAN UNIVERSITIES

By Sir ERIC ASHBY

President and Vice-Chancellor, The Queen's University, Belfast;
formerly Chairman of the Professorial Board, University of Sydney

INTRODUCTION

On November 28, 1957, the Prime Minister of Australia, Mr. Menzies, announced in the House of Representatives in Canberra that the Commonwealth Government proposed, subject to co-operation from the States, to raise Commonwealth expenditure on the State universities from about £6,000,000 in the triennium 1955–57 to £22,000,000 in the triennium 1958–60. This is support on a scale beyond the dreams of Australian academic men a few years ago. It represents an act of statesmanship on the part of the Commonwealth Government. More than this, it provides at long last an opportunity for Australia's intellectual development to keep pace with her dramatic political and economic development.

The circumstances which led up to this historic announcement are as follows. In Australia, education is a responsibility of the States, not the Commonwealth. After the War, the cost of higher education increased steeply in Australia, just as it did in Britain. The States increased their grants to the universities by 123 per cent (although their revenue increased by only 77 per cent); nevertheless, these increases were insufficient to meet the universities' needs. The Commonwealth had come to the financial help of the State universities during and after the War to enable them to give higher education to large numbers of ex-servicemen; and in 1950 Commonwealth help was stabilized in a formula whereby the Commonwealth gives to each State, for its universities, £1 for every £3 of revenue the universities receive from State grants and fees. The Commonwealth commitment is limited to a ceiling of grant in any one year. Capital grants for buildings and equipment have not normally been provided by the Commonwealth Government.

There have been signs for some time that this machinery would soon become quite inadequate to finance the universities of Australia. The urgent demand for graduates, the unprecedented pressure of young people wanting higher education, the frustration among academic men in many university departments, have together precipitated a situation which could be resolved only by a drastic review of the whole of Australian higher education. This review has now been published*. In December 1956 Mr. Menzies asked a Committee of five, under the leadership of the chairman of the University Grants Committee in Britain (Sir Keith Murray), to inquire into such matters as "the role of the university in the Australian community; the extension and co-ordination of university facilities; technological education at university level; and the financial needs of universities and appropriate means of providing for these needs". The other members of the Committee were Sir Ian Clunies Ross, formerly a professor in Sydney and now chairman of the Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.); Sir Charles Morris, vice-chancellor of the University of Leeds and sometime chairman of the Committee of Vice-Chancellors and Principals; Mr. A. J. Reid, chancellor of the University of Western Australia and formerly head of the State Treasury; and Mr. J. C. Richards, assistant general manager of the Broken Hill Proprietary Co. (B.H.P.). The Committee worked for three months, and has produced what Mr. Menzies described in his speech as a "brilliant and provocative report".

SUMMARY OF THE REPORT

The Background

The report begins with a lucid and restrained chapter on the role of universities in the community. It then goes on to describe the economic and educational setting of Australian universities: a population of 10 million increasing at a rate of 2½ per cent per annum and likely to reach 12 million by 1967; capital investment at the level of some £1,500 million in a year; primary industries with an output of more than £1,000 million; and international responsibilities under the Colombo Plan, the South-East Asia Treaty Organization, and the South Pacific Commission. All these activities need to have behind them healthy and adequately financed universities. The need for teachers is so desperate that in one State bursaries are offered to children "at the tender age of eleven plus if their parents express an inclination for them to become school teachers". The shortage of graduates is not confined to scientists and technologists: there is an unsatisfied demand also for graduates in arts, law and medicine.

There is no lack of recruits for these occupations. The school population increased from 1·1 million in 1946 to 1·8 million in 1956; but there is a severe wastage of talent at secondary school level through early leaving. In 1954, only 9·4 per cent of seventeen-year-old children were receiving any sort of full-time education. Nevertheless, some of the universities are, on British standards, large. A list of them, with their 1957 enrolments, is given in Table 1.

In 1956 the total recurrent income of all the universities was about £11·78 million, of which 79·5 per cent was provided by State and Commonwealth grants and 15·6 per cent came from fees.

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* Report of the Committee on Australian Universities. (Commonwealth Government Printer, Canberra, Australia, 1957.)

Table 1

University and foundation date	Enrolment, 1957*
Sydney (1850)	7,407
Melbourne (1853)	6,341
Adelaide (1874)	3,331
Tasmania (1890)	750
Queensland (1909)	3,519
Western Australia (1911)	1,661
Australian National University (1946)	67
N.S.W. University of Technology (1949)	4,288
New England (1954)	591
Canberra University College (1930)	216
Newcastle University College (1951)†	—

* The enrolments are full-course equivalents, calculated as follows: full-course student = 1, part-course student = ½, external student = ¼. Some full courses at the N.S.W. University of Technology are designed for part-time students. The gross enrolment for 1957 was 36,465.

† Enrolments included under New South Wales University of Technology, of which it is a branch.

Present State of the Universities

Some departments in the larger universities are in a state of chronic congestion. First-year classes of more than 1,000 are not uncommon, and failure-rates are alarmingly high. For example, 30 per cent of holders of Commonwealth scholarships (of which 11,536 were awarded in 1955) fail to graduate. It is commonly believed that students come to the universities inadequately prepared and not sufficiently mature to benefit from university teaching; and of course the size of elementary classes makes any tutorial tuition in the first year very difficult. It has been an Australian tradition to admit all qualified applicants to universities and not to exercise any machinery of selection. The Committee realized the great practical difficulties in the way of limiting entry or raising matriculation standards, and it recommends that Australian universities should equip themselves to deal with the increasing flood of students coming to them, rather than protect themselves against the flood by putting up barriers to entry.

The Committee commented adversely not only on the high failure rate (which it describes as a "national extravagance which can ill be afforded") but also on the very low ratio of honours to pass degrees and the very meagre development of postgraduate work. The pattern of a large undergraduate department is illustrated by the Department of History in the University of Sydney in 1956. History i had an enrolment of 768; History ii, 332; History iii, 119; and History iv (the honours year), 11; and for this total enrolment of more than 1,200 students there is a full-time academic staff of ten. Accommodation in many departments is "bursting at the seams". Halls of residence (most of which in Australian universities take the form of 'colleges' under church endowments, but which do not impose religious tests on their residents) are quite inadequate. This is particularly serious because of the considerable Asian student-population now to be found in Australian universities and because about half the population of Australia lives away from the big metropolitan centres. Academic staffs were reported by the Committee to be disheartened not only by enormous elementary classes and small honours schools, but also by other difficulties. Their salary scales were low by comparison with those of other professional men (the Prime Minister alleviated this difficulty by including in his announcement a substantial lift in salary-scales). The superannuation system does not allow of easy migration of staff between universities and C.S.I.R.O., or even between all universities. In most universities the staff have no adequate common room or meeting place. For years there has not been enough money for libraries, equipment and technical assistance; and the high cost of travel is an obstacle to the sort of inter-university conferences and meetings which would be a great stimulus to academic men.

Problems Ahead

To these old difficulties, which many academics have endured heroically and successfully overcome, formidable new difficulties will shortly be added. Numbers in the 15–19 year age-group actually fell between 1947 and 1952. They rose by 16·4 per cent during 1952–57. Between 1957 and 1962 they are expected to rise by 36·4 per cent. Enrolments in universities are expected to increase from 36,465 in 1957 to 70,785 in 1965. A first-year chemistry class, which to-day has an enrolment of 1,400, may in ten years time have to deal with an enrolment of 3,000. Sydney expects by 1965 to have a student population of 27,000 (17,000 in the University of Sydney and 10,000 in the New South Wales University of Technology).

The Committee's Proposals

The Committee deals calmly and firmly with these alarming expectations. The main need is for money. Following the Committee's recommendations, the Commonwealth Government has offered to contribute over the triennium 1958–60 more than £9 million toward a proposed capital programme of £15 million; emergency grants totalling £4½ million to enable universities to dispose of their most severe embarrassments before 1961; a contribution towards a substantial increase in salaries; and £600,000 towards the extension of residential accommodation in colleges. In addition, the Committee recommends, and the Government accepts, that the Commonwealth contribution for running expenses should be raised by 10 per cent per annum for the triennium 1958–60.

But the Committee has not confined its comments to finance. It suggests that consideration should be given to some sort of close link between the Australian National University, which is a purely postgraduate institution, and Canberra University College, which prepares undergraduates for Melbourne degrees. It is in favour of a second Victorian university in Melbourne and it foresees the need for the expansion of the New South Wales University of Technology to include a second medical school in Sydney, and indeed to become a second full-range university, which might appropriately be called the University of New South Wales.

Of particular interest are the Committee's very frank comments on policy-making in Australian universities. The governing bodies of the State universities are comprised (as they are in the Scottish and modern English universities) predominantly of laymen, with some representation from the teaching staff. The body of professors (commonly called the Professorial Board) is charged, as it is elsewhere, with a good deal of responsibility over academic matters. But by an accident of history, the vice-chancellor in most universities is not chairman of the body of professors, nor is he their spokesman and protagonist before the governing body. These responsibilities fall to a chairman of the Professorial Board who is elected by the professors. Accordingly, the vice-chancellor finds himself immobilized in the performance of what should be one of his chief functions: to maintain the delicate balance between the lay governing body and the academic staff, and to prevent any suspicion of an employer–employee relationship arising between them. It may well be that the chairman of the Professorial Board performs this function adequately, but (as the Committee says) "this position tends almost automatically . . . to place the vice-chancellor in some other camp" (that is, other than the academic camp). "There comes to arise . . . not a natural unity of governing body and academic, but a natural disunity".

One consequence of this anomalous position of vice-chancellors is that outside their universities, too, they find it difficult to formulate nation-wide policy on academic matters. Consequently, there is a lack of cohesion between universities. This, and the absence of a common initiative, are criticized by the Committee as weaknesses which must be overcome if Australian universities are to discharge their present and future responsibilities.

An Australian University Grants Committee

The Committee's chief long-term recommendation is that an Australian University Grants Committee should be set up, with a full-time chairman, two lay members and five academic members. The Committee emphasizes that the members should not be representatives of Commonwealth, States or universities, but should serve solely in their personal capacities. It should be set up informally, not by statute, and attached to the Prime Minister's Department. Its business should be to advise the Prime Minister on the contributions which the Commonwealth should make to States toward the support of universities, and directly toward the support of the two university institutions under Commonwealth control. The Committee hopes that the States would be willing to seek advice from the proposed University Grants Committee in respect of their local university problems. The proposed Committee would work very much as its prototype does in Britain, by visiting universities and preparing a recommendation for the Commonwealth Government. The Committee believes that financial grants should be made at three-yearly intervals, not five-yearly intervals as in Britain.

Finally, the report reminds its readers that the provision of money and the setting up of a University Grants Committee will not of themselves solve Australia's problems of higher education. The Committee, if it is set up, will have to rely on the Australian universities, through their Vice-Chancellors' Committee, to formulate a national policy for the development of higher education and to take the initiative in putting their views before the proposed University Grants Committee. The Committee would (as in Britain) deal directly with each university over its own programme of development. But it would also have to be in frequent consultation with the Australian Vice-Chancellors' Committee on matters of national policy.

COMMENTARY

To anyone familiar with Australian universities, this report is a masterpiece of discernment, and the Prime Minister's quick response to it is very gratifying. The older Australian universities have a great tradition of scholarship. The intellectual capacities of Australian youth are as high as those of young people anywhere in the Commonwealth. Already in her brief history Australia has made very distinguished contributions to science, scholarship and world affairs. But in recent years her universities have been taxed hopelessly beyond their capacities. The trouble is due partly to the peculiarly Australian conception of democracy which regards the right to attend a university as something in the same category as the right to drive a vehicle on the public highway. But public enthusiasm for enjoying the benefits of higher education has not been matched by public enthusiasm for paying for them. So the universities have had to open their doors to students inadequately prepared to enter and in numbers for which no proper provision had been made; the outcome has been a decade of mass-education, lectures in duplicate, practical classes without enough demonstrators, shortages of equipment, heavy examination failures, and no energy left over for research.

Mr. Menzies's announcement, and his promise that a body having the functions of a University Grants Committee will be set up, disperses most of the clouds in the academic sky. But not all. It still remains to be shown whether a university organized on the Scottish pattern can carry a student population of 14,000–17,000 (as Sydney contemplates) without a breakdown in the machinery of administration. You cannot double the size even of a football team without changing the rules of the game. It is a matter of judgment, of course; but one cannot observe these large Australian universities without wondering whether they should not either re-organize their administration on the American model (with permanent deans and much more decentralization of business into faculty offices), or limit numbers to (say) 8,000 and encourage the foundation of new institutions.

In the long view (not as a way to meet the present emergency) there is something to be said for dispersing the enormous and amorphous elementary classes into colleges somewhat resembling the American junior college. In a country without a strong sixth-form tradition in its schools and with such a widely dispersed population, the educational climate might prove congenial to colleges in the country and in the suburbs of big cities, where young students under personal supervision could cover the intermediate year in basic arts and sciences. Such an arrangement as this would reduce the numbers in the universities; it would provide them with more mature students; and it would enable them to preserve their Scottish pattern of organization.

However, the Committee was wise not to make any revolutionary or unfamiliar proposals in this report. For there is no time to be lost, and the only way Australian universities can prepare for the macro-bulge which is coming is by a vigorous programme of development on conventional lines which the vast majority of academic people will approve. The Murray Committee has made a decisive contribution to Australian higher education; in doing so it has put not only Australians, but also all other academic men in the Commonwealth, in its debt.

SYNTHESIS OF RIBONUCLEIC ACID

By Dr. A. M. MICHELSON

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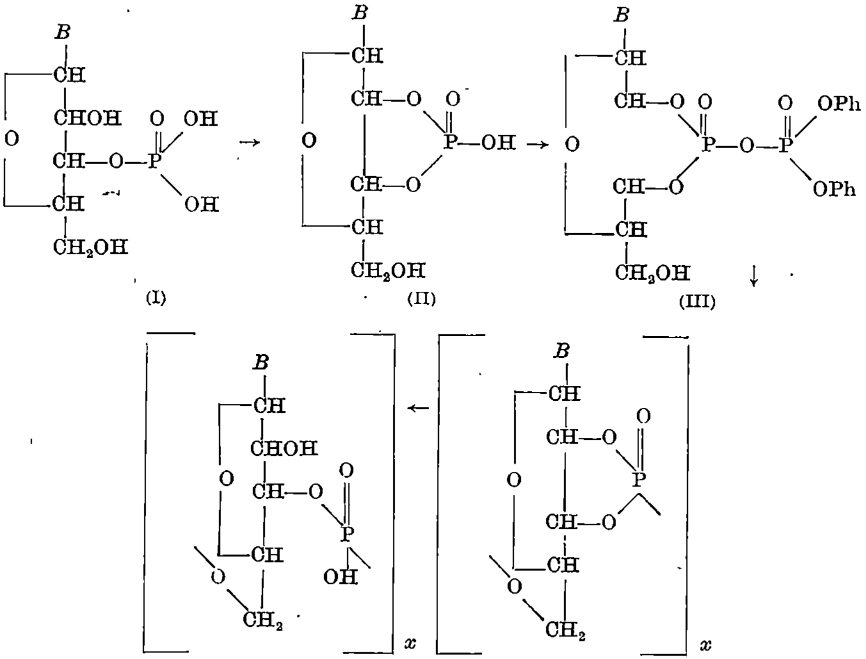
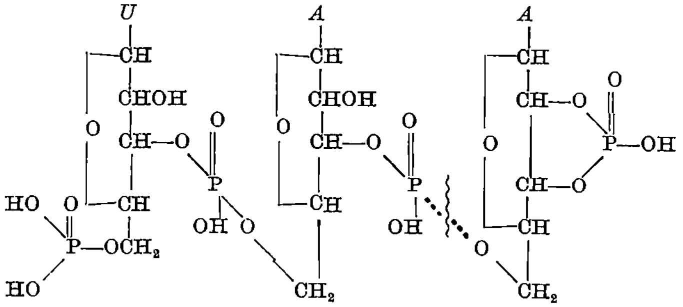
WHILE classical methods have been applied with some success to the synthesis of small polynucleotide derivatives such as dithymidine dinucleotide[1] and adenosine-2′-uridine-5′-phosphate[2] such methods give low yields and require protected nucleoside and nucleotide derivatives. The fully esterified mixed anhydride method has proved successful for di(nucleoside-5′)-phosphates[3], but when applied to the synthesis of a naturally occurring type of internucleotide linkage is unsatisfactory[1]. An extension of this method to the use of nucleoside phosphite anhydrides has been described[3]; but again, yields are low and the method offers little hope for the synthesis of higher oligonucleotides. A preliminary publication by Khorana[4] describes the use of carbodiimide and toluene-*p*-sulphonyl chloride in the synthesis of deoxydinucleotides from thymidine-5′-phosphate.

In view of the difficulties attending the use and removal of protecting groups in the ribonucleotide series, the possibility of polymerization of the readily available 2′(3′)-monoribonucleotides has been examined. It has been found that these nucleotides are easily converted to the nucleoside-2′-3′-cyclic phosphates[5], which are then polymerized quantitatively, by the action of tetraphenylpyrophosphate at room temperature. A number of such polymers have been prepared, including polyadenylic acid, polyuridylic acid and polymers containing adenylic and uridylic acids in various proportions. By using uridine-2′ : 3′-cyclic phosphate-5′-phosphate in the presence of excess adenosine-2′ : 3′-cyclic phosphate, polymers of adenylic acid terminating with uridine-5′-phosphate at the head and adenosine-2′ : 3′-cyclic phosphate at the tail (V) have been synthesized. In addition, by reaction of a mixture of four mononucleotides—adenosine-2′(3′)-phosphate, guanosine-2′(3′)-phosphate, uridine-2′(3′)-phosphate and cytidine-2′(3′)-phosphate—a synthetic 'ribonucleic acid' has been prepared.





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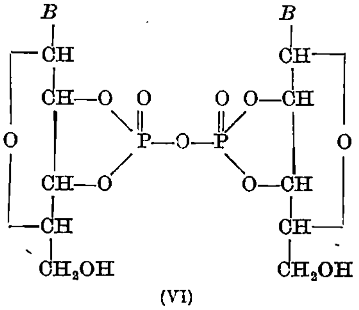

(VI)

In practice, a solution of the mono tri-*n*-octylammonium or mono tri-*n*-decylammonium nucleotide (I) is treated with tetraphenyl pyrophosphate[6] or diphenyl phosphorochloridate[7] and tri-*n*-butylamine to give the cyclic phosphate (II) quantitatively, which is then made to react *in situ* with a further mole of tetraphenylpyrophosphate (added directly or formed in the reaction medium by addition of diphenyl phosphorochloridate). Rapid polymerization, with the evolution of heat, then occurs, presumably through an unstable pyrophosphate (III), which then reacts, either directly or via the dinucleoside pyrophosphate (VI), with the primary hydroxyl groups to give ultimately a mixture of polymers (IV) with 2′(3′) : 5′-phosphate linkages and a tail 2′ : 3′-cyclic phosphate. Precipitation from the reaction mixture gives the crude product, which can be fractionated roughly into oligonucleotides of various molecular weights by acid precipitation, or better, by dialysis against water, 0·5 *M* ammonium chloride and 2 *M* sodium chloride solutions. Representative dialysis results are given in Table 1.

Table 1

	Dialysis of crude polymers against		
	Water	2 *M* sodium chloride	Dialysis residue (per cent)
Commercial ribonucleic acid (from yeast)	14·8	29·8	55·4
'Synthetic ribonucleic acid'	18·5	43·3	38·2
Polyuridylic acid	31·8	45·7	22·5
Polyadenylic acid	24·9	45·5	29·6
Polyadenylicuridylic acid	19·8	46·6	33·6

The properties of these polymers are consonant with the general structure ascribed to natural oligonucleotides[8] with the exception that, as expected, only some 50–60 per cent of the internucleotide linkages are 3′-5′, the remainder being 2′-5′. (While this is perhaps unfortunate from a purely æsthetic view, the possible chemotherapeutic value of such compounds may be significant.) Thus mild acid treatment opens the terminal cyclic phosphate to give oligonucleotides with tail units containing a 2′(3′)-phosphate. More vigorous acid degradation gives either purines and/or pyrimidine-2′(3′)-phosphates, depending on the polymer. The polymers are completely degraded by 0·1 *N* sodium hydroxide at 37° for 24 hr. to the respective 2′(3′)-mononucleotides (and to uridine-2′(3′) : 5′-diphosphate in the case of P5′UP5′AP5′AP—abbreviations as in ref. 1) only. Treatment with rattlesnake venom gives the expected nucleosides, and, after prolonged treatment, the nucleoside-2′(3′) : 5′-diphosphate (that is, the tail nucleotide) in small amount[9]. Estimation of the relative amounts of nucleoside and nucleoside-2′(3′) : 5′-diphosphate gave an estimate of the average molecular size. Thus the unfractionated initial products gave results varying from 4·2 to 7·8 nucleotides as the average chain-length. Preliminary work indicates that under the conditions employed the molecular species vary from 2 to approximately 10 nucleotides in length. While the reaction can undoubtedly be improved it does not seem likely that extremely large polymers with molecular weights of the order 50,000–10^6 will be synthesized in this manner unless an anhydride which is effective in aqueous solutions is used.

While the polyadenylic acid was resistant to the action of ribonuclease, some 50–60 per cent of the internucleotide linkages of polyuridylic acid were cleaved. This figure is aproximate as only a proportion of the material appears as uridine-3′-phosphate, the remainder appearing as di-, tri- and possibly tetra-nucleotides (paper chromatography) containing 2′-5′-internucleotide linkages exclusively. Considerable variation has been observed, and it is likely that under suitable conditions a higher proportion of 3′-5′-linkages would be formed[10,11].

It is clear from the extensive work of Sir Alexander Todd and his collaborators[12] that, under the conditions employed, the nucleoside-2′ : 3′-cyclic phosphates would be polymerized by the action of any acid anhydride where the weaker acid of the anhydride is stronger than the cyclic phosphate. It was therefore of interest to examine the action of an anhydride such as that derived from diphenyl phosphoric acid and benzyl phosphorous acid[13]. When adenosine-2′ : 3′-cyclic phosphate was treated with diphenyl phosphoric–benzyl phosphorous anhydride[13], approximately 50 per cent of the adenylic acid was converted to polymers containing a 5′-benzyl phosphite group at the head and a cyclic 2′ : 3′-phosphate at the tail. The remaining 50 per cent was isolated as adenosine-2′ : 3′-cyclic phosphate-5′-benzyl phosphite, identified by its conversion to adenosine-2′(3′) : 5′-diphosphate[14] via adenosine-2′ : 3′-cyclic phosphate-5′-benzyl phosphate and adenosine-2′ : 3′-cyclic phosphate-5′-phosphate.

By using dilute solutions of the nucleoside-2′ : 3′-cyclic phosphates and allowing the reaction to proceed for a limited time, products containing relatively large amounts of smaller oligonucleotides were obtained. Dr. L. A. Heppel of the National Institutes of Health, Bethesda, Maryland, has examined such products from adenosine-2′ : 3′-cyclic phosphate and has tentatively identified AP5′A2′ : 3′P, AP5′AP5′A2′ : 3′P and AP5′AP5′AP5′A2′ : 3′P by comparison with authentic specimens. Treatment of AP5′A2′ : 3′P with dilute acid gave AP5′AP from which the terminal 2′(3′)-phosphate was removed by the action of prostate monoesterase to give a mixture of A2′P5′A and A3′P5′A. Spleen phosphodiesterase split approximately 50 per cent of the AP5′AP to AP, the remaining A2′P5′AP being resistant to enzymatic cleavage.

It is hoped to extend the work to the synthesis of dinucleoside phosphates and the alkyl esters of the 2′- and 3′-nucleotides.

Thanks are due to Dr. L. A. Heppel for the results mentioned, to Dr. A. K. Mills for interest and encouragement and to the Directors of Arthur Guinness Son and Co. (Dublin), Ltd., for permission to publish this work.

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BIOCHEMICAL FUNCTIONING OF VITAMIN B_{12}

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THE chemical structure is now known not only of vitamin B_{12} itself but also of many natural and biosynthetic analogues and products of its chemical modification. It is therefore possible to begin to consider such problems as the linkage between the vitamin and peptides or proteins (the intrinsic factor, for example) and the nature of the molecular groupings that may be involved in its biochemical functioning. The 'nucleotide' has two points of attachment to the porphyrin-like 'planar group'. One is through a chain of seven atoms between ring *D* and the phosphorus: the other is by a co-ordinate link between the cobalt and N3 of the benziminazole. It is this second link that is broken in the formation of the purple dicyanocobalamin with alkaline cyanide, leaving the nucleotide part hanging loose, as it were, from its long chain with considerable freedom of movement; this, incidentally, may well be what prevents the dicyano compound from crystallizing. It appears that this link can also be broken by thiocyanate[1], and there is some evidence that linkage with B_{12}-binding proteins also extrudes the nucleotide in this fashion. Thus the two complexes, between vitamin B_{12} and intrinsic factor and the sow's whey factor, respectively, have both been shown to retain the —CN group, and they both fail to react with alkaline cyanide to add a second —CN: this suggests that the position is already occupied, by a group not readily displaced by cyanide[2,3].

Most of the vitamin B_{12} present in animal or bacterial cells appears to be 'bound', presumably to proteins, so that one probably should consider such a complex, rather than the free vitamin, as the biologically functional unit. It is already becoming clear, however, that any one of various slight modifications to the vitamin structure can interfere with its linkage to a highly specific binding factor. This suggests multipoint attachment, such as has been envisaged between enzymes and their substrates[4], involving both the nucleotide and the planar group. The cobalt might well be joined to a nitrogen atom of a histidine residue[5], and one can envisage the nucleotide, on the end of its flexible chain, being free to wrap itself around part of the protein molecule so that, for example, oppositely charged and suitably situated sites on the two molecules are in juxtaposition. It would not then be surprising if the absence of one or both of the methyl groups from the dimethyl benziminazole, or their replacement by other relatively non-polar groups (even by chlorine), made little difference to the biological activity, as indeed it does[6]. This part of the molecule probably represents, as it were, just the end of a line of hooks, by which the vitamin attaches itself to its appropriate biological environment. For the same reason, perhaps, in microbiological systems synthesizing cobalamins, this part of the molecule is freely replaceable by almost any substituted benziminazole one cares to add to the medium or (with a more limited range of organisms) by one of several purines[7]. Reverting to the biological activity of analogues, one may note that even a hydroxyl group on the benzene ring is enough to depress activity considerably, and that exchange of benzene for the more basic pyrimidine ring (to give a purine type analogue) almost entirely destroys activity except for the less specific assay organisms[6]. It is justifiable to conclude that the low activity of the purine analogues is due to their inability to link effectively with specific proteins, because the adenine-containing pseudo-vitamin B_{12} does not interfere (even when it is present in large excess) with the binding of vitamin B_{12} by intrinsic factor or with the uptake of the vitamin from the gut[8,8a].

It seems likely that the highly activated β-position on ring *B* must also be involved in binding to specific proteins. It is this position that is attacked when the vitamin is subjected to mild oxidation by halogens or by oxygen and alkali. The adjacent acetamide chain is then modified and cyclized to yield a lactam or lactone ring fused to ring *B*; these compounds are also biologically inert[9].

Having thus dismissed a good deal of the molecule to accommodate the protein, one is left wondering which parts are left to function in promoting enzyme reactions. A likely answer seems to be the labile amide groups. There are three of these, one much more labile than the others, and they are almost certainly those on the three propionamide chains: it is perhaps significant that these chains protrude from the planar group on the side opposite to the —CN group, that is, on the side where the binding protein is probably located. Thus at least one would be in a position to interact with a substrate molecule anchored in turn to the protein.

These amide groups can be successively hydrolysed with dilute acid or alkali, and the resulting mono-, di- and tri-carboxylic acids are not merely inert towards the B_{12}-requiring mutant of *Escherichia coli*, but they show some anti-vitamin activity. This appears to be enhanced when the acids are converted into substituted amides by reaction with methylamine, aniline, etc. (conveniently with dicyclohexyl carbodiimide as condensing agent)[10,11]. One may deduce that these substituted amides can compete successfully with the vitamin for binding sites on the specific protein (which some other analogues cannot do) but that they are unable then to fulfil its biochemical functions[8a].

The precise nature of these functions is still something of a mystery. So many, indeed, have been attributed to vitamin B_{12} that most or all of them must be indirect, and the problem is to discover what reaction or reactions are directly B_{12}-dependent and so fundamental that they could have an over-riding effect upon the others. Most investigators have, wisely perhaps, kept to their own corners of the field, and few have attempted much by way of integration. One can, however, discern four totally different hypotheses that have been tentatively proposed.

Dubnoff in early *in vitro* experiments detected an effect of a vitamin B_{12} concentrate upon the reduction of —S—S— linkages to sulphydryl groups. This was taken up by Bacon Chow, who pointed to the low serum glutathione-levels in B_{12} deficiency states, quickly raised to normal by the vitamin, and linked this with a possible effect in maintaining —SH enzymes in the reduced, active state. Since important glycolytic enzymes are in this group, the connexion between vitamin B_{12} and carbohydrate metabolism could thus be explained[12]. The established function of the vitamin in promoting the *de novo* synthesis of the methyl group of methionine from one-carbon precursors in a higher oxidation state must involve at least two steps. Since a folic acid derivative is probably responsible for the actual transfer to homocysteine of a one-carbon unit, it seemed reasonable to postulate that vitamin B_{12} reduces this to $—CH_3$ and perhaps also homocystine to homocysteine[13]. The trivalent cobalt in the vitamin can indeed be reduced reversibly to the divalent state, in which it could serve as a reducing agent, and although the redox potential seems well outside the physiological range, linkage to protein might change it in the required direction. However, there are difficulties; for one thing vitamin B_{12} sheds its cyanide group on reduction and probably also the ability to link with protein. Also, recent experiments appear to disprove any effect on the reduction of homocystine[14].

In lactobacilli, vitamin B_{12} can be replaced by thymidine or other deoxyribosides. The assumption that their synthesis is controlled by the vitamin has recently been confirmed. Further, tracer experiments suggest that the synthesis of deoxyribose is the B_{12}-dependent step. Although these phenomena could not be demonstrated with other species of micro-organisms, it was widely assumed that vitamin B_{12} was concerned in the synthesis of deoxyribonucleic acids, and possibly of ribonucleic acids also, in animals and humans. This was supported by the dramatic increase in red cells and growth of epithelium (relief of sore tongue) on treatment of pernicious anæmia cases. By analogy with the methylation of homocysteine, vitamin B_{12} was supposed to bring about methylation of uracil to thymine (possibly at the nucleoside-level) and so to make available this constituent of deoxyribonucleic acid required for cell division[13]. This hypothesis has also run into difficulties. Doubt has been thrown upon some evidence cited in its support. More directly, recent tracer experiments by Connor Johnson and his colleagues have failed to show any effect of vitamin B_{12} upon the rate of synthesis of either deoxyribonucleic or ribonucleic acid from any of several likely precursors by pigs or chicks[15].

A number of observations have indicated that cyanocobalamin is involved in protein metabolism. Other experiments did not support this as a major role, and until recently there was a tendency to regard any such effects as secondary. Several independent studies have, however, given indications of diminished concentrations of different enzymes (transmethylase, ribonuclease and dehydrogenases[16–18]) in the tissues of B_{12}-deficient animals. Wagle and Connor Johnson have recently reported that the incorporation of carbon-14 labelled serine or glucose into liver protein of pigs or rats is markedly diminished when the animals are deprived of the vitamin[19]. They have also demonstrated large *in vitro* effects in experiments with liver and spleen microsome fractions from normal and deficient animals. The incorporation of labelled amino-acids was about four times as great in the '$+B_{12}$' preparations; moreover, the '$-B_{12}$' ones could be brought up to nearly the normal level by addition of the vitamin[20]. This is the most dramatic effect yet demonstrated in an isolated enzyme system. However, other workers have criticized the experimental conditions and are not yet ready to concede proof of a *direct* effect upon protein synthesis.

A complication in advanced pernicious anæmia is degeneration of the spinal cord, and this condition can be arrested only by vitamin B_{12}, whereas folic acid can bring about hæmatological remission, at least temporarily. Niewig and his colleagues were forced to the conclusion that this implied a control of protein synthesis by vitamin B_{12}, because the protein turnover rate is high in the nerve axons involved in these degenerative changes[21]. Being wedded to the nucleic acid hypothesis, they explained this as an indirect effect, whereby ribonucleic acid functions as a template for protein synthesis, the synthesis of the necessary ribonucleic acid being the B_{12}-dependent step. However, it would be more logical to cite this evidence in support of a direct effect of the vitamin upon protein synthesis. This hypothesis can explain better than most the over-riding effect of cyanocobalamin upon a number of metabolic processes, if it functions by controlling synthesis of the protein moieties of enzymes.

Wokes and Picard[22], noting increased thiocyanate excretion in dietary vitamin B_{12} deficiency, diminished by administration of the vitamin, have put forward a hypothesis based on the supposed lability of the cyanide group and competition of hydroxocobalamin and the enzyme rhodanese for cyanide.

One may now inquire which of these hypotheses accords best with the picture of a vitamin B_{12}-protein complex with its labile amides poised for action. Although no precise mechanism can be envisaged as yet, the likely answer seems to be the protein-synthesis hypothesis, as indeed its latest exponent, Dr. Connor Johnson, has suggested[23]. It is perhaps relevant that an enzyme, recently detected in liver, catalyses the exchange of ammonia from protein amide groups for aliphatic amines, including the ε amine group of lysine[24].

The end of the story is not yet in sight, but there are reasonable hopes that we may soon know more about the mode of action of vitamin B_{12} than we do about some other vitamins discovered much earlier.

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MANAGEMENT AND RESEARCH

THE theme of the annual conference of the British Institute of Management, which was attended by 620 top managers during November 6–8 at Bournemouth, was set in the opening address by the Right Hon. Viscount Monckton of Brenchley. Introducing research as a signpost to better management, Lord Monckton showed that as a nation we are devoting roughly two per cent of our national income to research of all kinds. This appears to be a similar proportion to that for the United States, but our research effort seems to be more dominated by defence requirements, particularly in the fields of aircraft, electronics and atomic energy, than is that of the United States. Partly, if not wholly for this reason, a larger share of the financial burden in Great Britain is carried on the shoulders of the Government. The expenditure of the United Kingdom Government on research and development in the year 1955–56 amounted to more than £200 million, of which only about one-sixth was accounted for by expenditure on civil research. Lord Monckton paid tribute to the important contribution to industrial efficiency which is made by the research activities of business undertakings within their own organizations —activities entailing expenditure many times greater than that of the Government on industrial research— and also raised the basic question of whether, in principle, the consumer of the current products of industry should be called upon to cover the cost of research designed to produce better and cheaper articles for his successors, or whether such ventures should be properly financed by the shareholder by way of lower dividends or by the direct provision of new capital.

Giving pointers for future research, Lord Monckton suggested that "it might be worth while for some internal research to be done on the actual effects upon particular branches of business of changes in rates of purchase tax". Research of this kind might yield results of value in shaping the processes of national economic policy in such a way that full regard is paid to its more remote and long-distance consequences as well as its immediate and direct effects. Another field would be research into "the true causes of breakdowns in employer–workers relations".

The remainder of the Conference was a model of how large national conferences should be organized to give all participants opportunities of obtaining information and discussing matters in which they are particularly concerned or interested. In twenty-five sectional meetings topics ranged from electronic data processing to market research; from operational research to case-studies of successful new companies; from economic research to means of evaluating performance in the sales force; from the use made by industry of research organizations to budgetary control.

One of the liveliest of these sectional meetings was concerned with psychological factors in group relations. The speaker was Dr. A. T. M. Wilson, of the Tavistock Institute of Human Relations, who indicated the main types of investigations which have been made into group relations. By the use of experimental discussion groups, two styles of group leadership were contrasted: the highly directed and the 'actively integrative'. The investigator concluded that the integrative style leads to a more appropriate group atmosphere, to greater group satisfaction with the performance of members, and to greater member satisfaction with group solutions of problems.

Another type of research into group relations has been the descriptive analysis of group relations exemplified by the studies of Woodward and her colleagues with Manchester dock workers, and Scott and his colleagues at the University of Liverpool on the effects of changing methods of steel manufacture on the social structure and group relations in a mill. Similar work has been done by Trent and Bamforth, who, in a study of the longwall system of mining, have presented one of the most detailed analyses yet available of group relations in a production system; Burns has recently examined cliques and cabals in industrial firms, while Mackenzie has discussed the relationship between production and inspection groups.

Studies of the kinds described are adding to our knowledge of group relations in actual working situations beyond the superficial level at which they have often been described and considered in the past. More important, they illustrate how knowledge can be deepened by the use of a systematic framework derived from the social sciences. The full value of such studies will not be easy to assess until it is possible to see their results in the new generations of managers whose training has in part been based on discussion of such research and its implications.

A different kind of study has been made with the experimental reorganization of working groups in actual industrial situations. One of the best-known is that of Rice, who, in an Indian textile factory, had an opportunity to initiate an experiment in complete reorganization of a working team, first in an automatic and later in an ordinary weaving shed. With the agreement of management and trade unions, and with the collaboration of the workers concerned, he was able to reconsider the whole basis of dividing up the activities needed to service the working looms. In the automatic weaving shed he reduced the twelve categories of job to three and completely altered the supervisory pattern. The results were to increase efficiency by about fifteen per cent. A completely reorganized managerial system emerged.

One extremely important finding of this work can be expressed as follows: the technological character of a particular production system does not completely determine the structure of the working team by which any such system is operated. The studies which Rice has published demonstrate the possibility that there may be much to be gained from a consideration, first, of the objectives of a particular production team and, secondly, various possible forms of team structure.

Studies of communication in small working groups have also been made and clearly showed that communications are particularly vulnerable to the creation of informal procedures, and the creation of 'by-pass channels', and that the existence of informal procedures can serve as a signal to the investigator to look for discontent originating in circumstances perhaps quite unrelated to communications themselves.

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There have been many experimental training conferences in group relations, and these have varied patterns of component activities. Wilson also described the use of groups; theory sessions: role-playing; and short projects to illustrate the project method of teaching.

In the ensuing discussion it was made clear by management representatives that useful research findings in group relations would continue to be unused until their interpreters were able to free themselves from unnatural jargon and obscurantism.

Confusions about productivity and profits were analysed by R. J. Brech (Unilever Ltd.), who showed that productivity is of little value in assessing the current operations of a firm.

Productivity is simply an arithmetic ratio expressing a technical concept. It describes the relative change in output from a given change in input. If output goes up or down more than proportionately with the increase or decline in input, then productivity increases or declines. As a technical concept it has its value, since once it is known, changes in output can be predicted for given changes in input. But from a management point of view, such a concept has little significance. A manager, if he is to run his business intelligently, has to use economic concepts rather than technical ones. The difference between an economic and technical concept is still not fully appreciated by the business community. The essence of business is the ability and willingness to take a risk, and profits are the legitimate return for risk-taking. Profits are based on relative prices and costs—on economic considerations and not technical ones.

How far does the concept of productivity help the manager to maximize his profits? Productivity ratios can be (and perhaps should be) worked out for all significant factors of production used in any particular process—labour, materials, machinery, floor space and so on. But the ratios themselves are of little value, since they cannot be compared against a standard. A more significant feature is the change and the rate of change in the ratios over time. But when all these ratios and changes in ratios have been worked out, how do they help the manager to maximize his profits? If the manager can legitimately assume that relative prices are unchanged, then an increase in productivity of any factor of production will mean a decline in cost per unit of output. Productivity as a concept is only helpful as a step in calculating changes in costs; and even then it can be misleading since it turns attention away from the real problem confronting management—namely, the provision and use of proper information.

The basic information necessary for taking management decisions is the normal accounting and statistical data, and these should be designed in such a way that they can be used for most, if not all, management decisions. Unfortunately, most accounting data are usually presented in such a form and so late as to be of little value to the manager in taking current decisions or in looking to the future. Accountants have had to concentrate much more on form and presentation of data rather than on the content and on the concepts on which the data are based. A manager, however, is an 'operational economist': all his decisions are basically those connected with economic problems in the sense that they are concerned with relative prices. Any accounting information intended to help management to take the right decisions must be based on economic principles.

A sectional meeting which attracted considerable interest was one concerned with a woman's approach to management. The speaker was Elizabeth Barling (John Lewis Partnership), who suggested that in some civilizations men enjoy much more freedom than women. In Western countries, however, men enjoy considerably less freedom and are inured to considerably more discipline.

Most men have wives and families to support and think about. Most career women either have husbands who have jobs or are unmarried and, economically, have only themselves to think about. Men have to play safer, so far as their jobs are concerned, than women. Women will not stay in jobs they do not enjoy. Men mostly will—if security and perhaps pensions depend on their doing so. Creativity is essentially a product of freedom. Staying in a job that is disliked or playing safe in a job that is disliked are not the conditions in which creativity flourishes. If women are less inured to discipline—and if industry wants their ideas—then industry must recognize that their creativity may depend on conditions of freedom and do what it can to foster those conditions.

It is incompetence in dealings with people that holds British industry back. How to get people to work effectively together? Where to find an incentive that really lasts? How to remove the traditional suspicions and fears that prevent workers from going all out to increase national productivity and their own standard of living? How to turn not just virtues but the weaknesses in human nature to good account in the interest of the firm and of the country? These are the real problems of to-day and women have a part to play in their solution.

The implications of budgetary control for financial research were considered by A. E. Tunley (Harris Lebus Ltd.). The kind of research into the completed budget would raise such questions as:

(1) Is the estimated profit up or down compared with previous years, and is this in keeping with the trend in industry generally and in the particular industry in which the organization operates? Does the profit appear in general to reflect a comparable achievement to that of its chief competitors?

(2) Does the estimated profit in relation to the estimated capital employed show an improvement or a deterioration over previous periods, and do these variations reflect a general trend in the industry or are they peculiar to the organization? If not, are they temporary and a part of a deliberate policy of long-term improvement?

(3) Of equal importance in testing the efficiency of an organization is to see that the rate of profit earned on profits retained in the business is at least equal to the profitability of the original capital—the true test of the growth of a company.

A change in the profitability of capital employed can arise from several causes, and it is desirable to investigate which of these operated. It may be that costs as budgeted have increased, and it is not thought possible to pass this on to customers. It is important to consider why costs have increased and whether the increase is avoidable. Various ratios and indices of measurement will lead to further investigations, such as:

(i) the elements of manufacturing, distribution and selling costs expressed in terms of a suitable unit which eliminates the price element (that is, a productivity unit or a selling unit) to indicate trends by comparisons with previous years.

(ii) comparisons of labour efficiency as projected in the budget compared with past records.

A fall in profitability of capital employed could be due to a slowing down in turnover in capital. A breakdown of the elements of capital employed in relation to volumes of sales should give a lead as to where the slow-down is occurring. The fall in profit in total and in relation to capital employed may be due to a fall in turnover. If, however, the problem has remained intractable, and the shrinkage in turnover seems to be progressive over a long term, it must mean that there is either a developing shrinkage in the market for the company's products or that the company itself is becoming progressively uncompetitive.

If the problem is the former one, then the company must consider some more profitable use of capital.

If the problem seems to be one of competition, the company must discover whether the reason is price—which may be due to: inefficiency in direct cost; too high an overhead burden; an attempt to obtain too high a margin.

All these tests—and others—applied to the trend of an organization's figures in the final budget will indicate how a business is progressing in relation to its own standards. The question still remains whether it is improving its position in relation to its competitors and in relation to industry generally; whether it is better or less than average; whether it is showing sound incipient strengths that could well be exploited. It is difficult to establish these facts unless there is some established method of comparison between firms. These take the form of detailed exchange of cost information on a common costing method or financial ratios.

The part the universities could play in management research was discussed by Prof. N. C. Hunt (University of Edinburgh), who suggested that many apparent personality problems in industry are, in fact, organizational problems. Given that organization, people would react similarly however well trained and well chosen they might be. They create situations in which workers who have been educated to be active, independent adults with real abilities are required to behave more and more like infants—dependent, subordinate and passive—even though they may be well paid for it and well treated. This must tend to frustrations which in turn lead to an increase of aggression and a reduction of efficiency. In this situation managers are asked to do the impossible. Whether they are autocratic or democratic, optimum results are persistently elusive.

Much could be gained by researchers going into businesses without a detailed frame of reference to investigate a particular problem. Free to follow their own devices they might well stumble upon important discoveries which might have been missed had a definite course been set. University researchers must keep themselves free to tackle problems in their own way, however 'practical' these problems may be. The business world would do well to make it possible for them to investigate problems which are not obviously practical and which may seem irrelevant.

Research in management must be a co-operative venture between the universities and the business community. It cannot be undertaken on any scale by business men immersed in the day-to-day problems of management. Neither can it be done by academics confined to laboratories and libraries.

Besides the sectional meetings, twenty-six discussion groups were arranged concerned with subjects varying from management ratios in the small firm to research in labour turnover; from research into industrial markets to ways in which management can be kept informed of scientific development and research findings. The groups led to extensive shaping of experience which should prove to be of considerable value to British industry.

The Conference was also addressed by Dr. A. King, deputy director of the European Productivity Agency, who illustrated the value of research as an investment.

T. H. HAWKINS

OBITUARIES

Sir Ernest Kennaway, F.R.S.

THROUGH the death of Sir Ernest Kennaway, which took place on January 1 (peacefully in his sleep, at St. Bartholomew's Hospital), cancer research in Britain has lost its *doyen*, and experimental pathology one of its greatest figures.

Ernest Laurence Kennaway was born on May 23, 1881, the son of Laurence James Kennaway, of Exeter. As a scholar of New College, Oxford, he took a first-class in the final honours school of natural science in 1903. Proceeding to the Middlesex Hospital with a university scholarship, he graduated B.M., B.Ch., in 1907, and D.M. in 1911. After working for short periods at the Lister Institute and at University College, London, he then successively became demonstrator of physiology at St. Thomas's Hospital (1908), Hulme research student at Brasenose College, Oxford (1909), and demonstrator of physiology at Guy's Hospital (1909–14). In 1911, he was awarded a Radcliffe travelling fellowship by the University of Oxford, and studied at Heidelberg and at Munich. In 1915, he obtained the D.Sc. of the University of London.

He joined the staff of the Cancer Hospital in London as physiological chemist in 1921, and in due course became director of its Research Institute (now the Chester Beatty Research Institute), in succession to Dr. Archibald Leitch; and was also elected professor of experimental pathology in the University of London. He retired from the staff of the Royal Cancer Hospital in 1946, becoming professor emeritus, and continued his researches at St. Bartholomew's Hospital. In a long life he accumulated many honours—the William Julius Mickle fellowship of the University of London, the first award of the Anna Fuller Memorial Prize (jointly), the Garton Prize of the British Empire Cancer Campaign, the Walker Prize of the Royal College of Surgeons of England, the Baly Medal of the Royal College of Physicians of London, the Osler Memorial Medal of the University of Oxford, and an honorary fellowship of New College —among others. He was elected Fellow of the Royal Society in 1934 (and a Royal Medallist in 1941), and of the Royal College of Physicians in 1937, and received the honour of knighthood in 1947.

In the period from about 1910 to 1920, Kennaway was the author of a whole series of papers, on a great diversity of topics, which unmistakably revealed the breadth of his knowledge and interests in chemistry, physiology and pathology, and gave a taste of things to come. Certainly, however, it is upon his massive achievements in the sphere of malignant disease that his name and fame are based and will endure. In the early 'twenties, great efforts were under way to elucidate the nature of the cancer-producing agent in tar and pitch, following the successful induction of cancer through application of coal-tar to the rabbit skin by Yamagiwa and Ichikawa (1915), and in the mouse by Tsutsui (1918). Between 1921 and 1926, Bloch in Zurich had found that the active substance was concentrated in the higher boiling fractions as a neutral compound probably belonging to the class of cyclic hydrocarbons. In 1924–25, Kennaway succeeded in producing carcinogenic tars by the pyrolysis of many organic materials, and by leading acetylene and isoprene with hydrogen through heated tubes. The tars obtained at successively higher temperatures showed an ascending potency, and the results could be explained by assuming that acetylene was a common decomposition product, and that the carcinogenic material was built up from it. In all this work, Kennaway ever acknowledged the value of Berthelot's classical paper of 1866, describing for the first time the production from acetylene of these very kinds of molecule.

We are fortunate, indeed, that he left his own characteristic account of these and later developments (*Brit. Med. J.*, 2, 749; 1955), setting forth their history, and making clear the essential part played by others at the Cancer Hospital—W. V. Mayneord's examination of the fluorescence spectra of the carcinogenic tars, and the discovery of their special qualities (1927); the development of this clue by I. Hieger ;—the discovery that 1 : 2-benzanthracene gave a spectrum similar to that of the carcinogenic mixtures; and J. W. Cook's studies of the benzanthracene homologues. About this time, Clar had just published methods for the synthesis of certain benzanthracene hydrocarbons. These compounds were tested by Kennaway and Hieger (1929–30), who soon observed positive results with 1 : 2 : 5 : 6-dibenzanthracene: this was the first pure compound manifesting pronounced carcinogenic properties, and one cannot forget the satisfaction and modest pride which Kennaway obtained from the fact. The fluorescence spectrum—in Kennaway's words "the single thread that led all through this labyrinth"—was also used in the concentration of the agent from coal-tar pitch, culminating in the isolation of a hydrocarbon which showed the characteristic spectrum and which proved to be highly carcinogenic. Its properties suggested one of the two benzpyrenes, and these were synthesized by J. W. Cook and C. L. Hewett, who were then able to prove the identity of one of the compounds (3 : 4-benzpyrene), and the substance from pitch. All these, and many other results which Kennaway alone inspired, are embodied in numerous papers (many of them classics) in the scientific literature at home and abroad, and, most notably, in a celebrated series which appeared in the *Proceedings of the Royal Society* during 1932–42. What undoubtedly emerged from almost thirty years of brilliant work was a satisfying and indeed beautiful correlation between chemical constitution and biological action, whereby the carcinogenic sub-classes of polynuclear hydrocarbons could clearly be related to the parent substance phenanthrene, in a system suggesting dependence upon certain optimal features of molecular size, shape, substitution and reactivity. But we must not minimize another result—namely, the profound practical influence which was exerted upon the whole of cancer research, and indeed biology at large, from the mere availability of these potent carcinogens, so rendering possible, and catalysing, numerous other investigations, and additions to knowledge, which could not have been attained without them.

No imagination is needed to see how this career demanded a patient sense of purpose over so many years. In certain ways Kennaway possessed a unique combination of qualities—in his intellectual aptitudes, his chemical sympathy and knowledge, and in his unrivalled skill in applying them to physiology and pathology. Apart from his modern scientific bent, he was also a true naturalist, believing greatly in field work and epidemiology. His standards of scientific evidence were rigorous and severe, to the point of austerity. His experimental methods were simple, practical and decisive, and a delight to watch in execution. He was much less interested in hypotheses and explanations, and although his own work had lain almost entirely in the chemistry of carcinogenesis, he remained completely open and free to accept any other mechanism or interpretation—provided only that the facts were ascertained, and not an instant before. Added to all these gifts, he was a master of scientific expression, and of English construction.

We have lost a great discoverer and scientific worthy. Among his personal attributes two things prevailed. First, his profound agnosticism. Secondly, a superb fortitude, which enabled him to triumph over disability, illness and accident, and to continue his researches long after his official retirement and almost to the day of his death. Of course, he had many other interests, and many human concerns which he did not parade and which, contrariwise, he often tried to conceal. It is idle to pretend that Kennaway was easy, or that he could readily apply to ordinary judgments the quality of detachment he brought to his special field. But for how many can anything of the kind be claimed ? Although he could be subjective and quixotic even more than most of us, these foibles were mere additions—often endearing—to the fascination of an already complex human character, and had no real bearing on the solid worth of his permanent achievement.

No appreciation could be complete which failed to refer to a factor at all times apparent to those who worked with him—the part played by Lady Kennaway in every aspect of his life and contribution. Not in any small measure due to his helpmeet, he wrote a vast chapter in cancer research and chemical pathology, which nothing can diminish, or take away.

A. Haddow

Dr. A. J. Ewins, F.R.S.

Dr. Arthur James Ewins died after a long illness on December 24, aged seventy-five. He will long be remembered for his discovery of several important chemotherapeutic remedies.

Ewins was born in 1882 at Norwood, the son of Joseph Ewins, who was a signalman on the London and South-Eastern Railway. A scholarship took him to Alleyn's School, Dulwich. Leaving at the age of seventeen, he obtained a position as technician at the Wellcome Laboratories, Herne Hill, working under Dr. (later Prof.) G. Barger. By evening studies at Chelsea Polytechnic, he graduated with honours in 1906, and was promoted to the staff of the Wellcome Laboratories. Soon he began to co-operate with Dr. (later Sir) Henry Dale in work on acetylcholine, other choline esters, and the ergot alkaloids, and this formed the basis of a long and valued friendship between them. When Dale entered the service of the Medical Research Committee (later Council) in 1914, Ewins did the same, and worked with him in the production of 'Salvarsan' and other drugs formerly made in Germany and by then no longer available. Early in 1917 he was offered an attractive appointment with May and Baker, Ltd., which he accepted; and he continued with this firm for the rest of his scientific life, becoming the head of its chemical research department and director of research.

Ewins's main interest was in chemotherapy. After much work on the organic arsenicals, he turned his attention to other fields. In the middle 1930's Dr. E. M. Lourie and Prof. Warrington Yorke, of Liverpool, had discovered that synthalin was very active in killing trypanosomes *in vitro*. Following development work by the late Dr. Harold King at the National Institute for Medical Research, Ewins took up this lead and synthesized a long series of diamidine compounds, of which the most active, pentamidine, has proved of great value in combating sleeping sickness in Africa. One intramuscular injection is enough to protect a man against this infection for six months, and this procedure has been applied to millions of people in tropical Africa to safeguard them against this dangerous disease. Another member of the same series—phenamidine—is widely used for curing babesiasis (redwater) of cattle and dogs. These drugs are also active against kala-azar.

The work for which Ewins is best known was his discovery of the famous '*M* & *B* 693', or sulphapyridine as it was later named. After prontosil had been prepared by Domagk and Mietsch in 1933 as a cure for streptococcal infections, the French workers, Trefouel and Bovet, showed that the antibacterial activity resided in the simple structure—*p*-aminobenzene sulphonamide, or sulphanilamide. The early attempts to obtain greater and wider activity by modification of this structure were not very successful until in 1937 Ewins and Phillips inserted a pyridine group in the sulphonamide radical. This compound was tested by Sir Lionel Whitby and found to be very active in curing mice experimentally infected with pneumococci. The new compound was quickly applied to human infections and proved to be brilliantly successful, and for the first time in medical history lobar pneumonia could be cured by a simple drug. Later, sulphapyridine was supplanted by other more active and less toxic compounds (including sulphathiazole synthesized by Ewins and Newbery), but the inspiration of its discovery will long be remembered. In 1943, Ewins was elected to the Royal Society. He continued to direct the research organization which he had built up until his retirement in March 1952.

Ewins was a simple and modest man, but he knew his own mind, and once he had made a decision he persevered with determination. He was well liked and well respected. Besides his scientific work, his chief pleasures were working in his garden, reading and motoring. He leaves a son and a daughter.

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NEWS and VIEWS

The United Kingdom Atomic Energy Authority

MR. W. R. J. COOK, deputy director of the Atomic Weapons Research Establishment, Aldermaston, has been made a full-time member of the Atomic Energy Authority. This new appointment makes it possible to progress towards certain alterations in the structure of the Authority. Three full-time members of the Authority have hitherto each had three types of responsibility. First, they have had executive control of one or more of the Authority's establishments. Second, they have been responsible for formulating policy on, and for broad oversight of, the subjects constituting their own special fields (research, production and engineering, and weapons). Third, they have had to join with their colleagues in considering and deciding jointly on the general policies to be pursued by the Authority. The purpose of the alterations which are being made is to free these members from their executive duties, and thus enable them to devote more time to their other responsibilities. Sir John Cockcroft, who has since the setting up of the Authority held the posts of member for scientific research and director of the Atomic Energy Research Establishment, Harwell, will be succeeded in the latter post by Dr. B. F. J. Schonland (the present deputy director).

Mr. Cook will be responsible at Board-level for policy questions concerning the Authority's production factories and the engineering aspects of the Authority's work. Since Sir Leonard Owen was appointed managing director of the Industrial Group in September 1957, he has had executive charge of the establishments in that Group. Sir William Penney will continue to be member for weapons research and development and, pending the appointment of a new director of the Atomic Weapons Research Establishment, he will continue to hold that post also. The duties of Sir Donald Perrott, member for finance and administration, and of Mr. W. Strath, member for external relations and commercial policy, are unchanged. Mr. Cook and Dr. Schonland will take up their new appointments on February 17.

National Research Council of Canada:
Dr. J. B. Collip, C.B.E., F.R.S.

THE retirement is announced of Dr. J. B. Collip from the directorship of the Division of Medical Research of the National Research Council of Canada. He has held this appointment since 1947 when the new Division of Medical Research superseded the old Advisory Committee on Medical Research, of which Dr. Collip had also been chairman since 1941. Dr. Collip, of course, is best known for his work in purifying the early preparations of insulin and thus playing a leading part in making this hormone available for general clinical use. Dr.

Collip, however, has many other claims to the respect and admiration of the scientific world. His work with extracts of pancreas seemed to whet his appetite for hormones, and he next attacked the parathyroid gland which at that time was something of a mystery as an endocrine organ, and he succeeded where others had failed in obtaining a reproducibly active preparation. Next he worked on the newly recognized hormones of the anterior pituitary lobe, gonadotrophin, thyrotrophin and adrenocorticotrophic hormone, with a brief but productive excursion to the placenta. From the latter organ he prepared both œstrogenic and gonadotrophic extracts upon which he worked for some time in 1930 at the National Institute for Medical Research in London. Since the beginning of the Second World War his time has been taken up very largely by organizational work, partly in connexion with his appointment to the National Research Council but also as dean of medicine at the University of Western Ontario, a position which he still holds. No one meeting Dr. Collip could fail to be aware of his active and forceful mind or of the keen intelligence with which he dissects the various parts of a problem, and it is fitting at this moment to pay tribute to his services to medical science generally and to the National Research Council of Canada in particular.

Prof. R. F. Farquharson, M.B.E.

The recent appointment of Prof. Ray Fletcher Farquharson as vice-president (medical) of the National Research Council of Canada, in succession to Dr. J. B. Collip, is one which is regarded with much pleasure and satisfaction by physicians and scientists alike throughout Canada. Born in Claude, Ontario, Dr. Farquharson graduated from the University of Toronto Medical School in 1922, and after six additional years of postgraduate training in internal medicine in Toronto and in Boston he was appointed to the staff of the University of Toronto as demonstrator in medicine and began to practise as a medical consultant. In both his university and professional work he was eminently successful and he rose rapidly in academic rank. In 1935 he was appointed assistant professor of medicine in charge of therapeutics and in 1947 he succeeded Prof. Duncan Graham as the Sir John and Lady Eaton professor of medicine and head of the Department of Medicine in the University of Toronto and as physician-in-chief to the Toronto General Hospital—posts which he still holds. During the Second World War he was on active service with the Canadian Armed Forces, serving with the rank of wing-commander as consultant in medicine to the Royal Canadian Air Force, and from 1948 until 1951 he was a member of the Defence Research Board of Canada. He is a Charter Fellow of the Royal College of Physicians and Surgeons of Canada and, in addition to serving on its Council for many years, was president of the College during 1945–47. He has been associated with the National Research Council of Canada since 1945, first as a member of the Division of Medical Research and then as a full member of Council. With his recent appointment as vice-president (medical) he will be in charge of all the medical activities of the Council. In spite of his many other activities, he has found time to carry out and publish an impressive amount of clinical research; his work on calcium metabolism, pernicious anæmia, Simmonds' disease and anorexia nervosa is particularly well known. Widely recognized throughout Great Britain and the United States as well as in his own country as an outstanding physician, a first-rate investigator, an enthusiastic teacher and an able administrator, and held in the highest esteem and affection by his colleagues and patients, he brings to his new post a fund of ability and experience which augurs well for medical research in Canada.

Applied Mathematics in Durham: Prof. K. Stewartson

Dr. Keith Stewartson, reader in applied mathematics in the University of Bristol, has been elected to the newly created chair of applied mathematics in the University of Durham. Dr. Stewartson was a Wrangler in Part 2 of the Mathematical Tripos in Cambridge in 1944 and then had his studies interrupted by two years national service in the Ministry of Supply. He returned to Cambridge in 1946 to read for Part 3 of the Mathematical Tripos, in which he gained a mark of distinction in the following year and the Mayhew Prize. He then took up research in fluid mechanics and was awarded the Rayleigh Prize in 1949 for an essay on supersonic flow. He took his Ph.D. in 1949 and was at the same time appointed lecturer in the University of Bristol. He became reader in 1954 on his return from a year's leave of absence spent as a research fellow at the California Institute of Technology.

Dr. Stewartson's contributions to fluid mechanics have come under the headings of supersonic flow, magneto-hydrodynamics, boundary layer theory and rotating fluids, and of these perhaps the last two are the more important. In earlier work on boundary layers he showed (as did Illingworth simultaneously) that under certain special, but not unrepresentative, conditions it is possible to correlate the flow in compressible boundary layers, and he has also concerned himself with the phenomenon of separation, both shock-induced and in incompressible flow. His work on the mechanics of rotating fluids has comprised contributions to inviscid theory in such problems as the motion of a sphere along the axis of a rotating fluid, and to viscous theory in such problems as the flow between two rotating coaxial disks and the discussion of almost solid rotations.

University of Durham Computing Laboratory

The Computing Laboratory of the University of Durham was officially opened on January 21 by Sir George Thomson, who spoke of the wide field of application of electronic computers, not only as an aid in scientific calculation, but also in the study of the humanities by the analysis of literary style. The Laboratory has recently installed the Ferranti 'Pegasus' computer 'Ferdinand' (FERranti DIgital Numerical Analyser Newcastle and Durham). The cost of the machine has been met by a grant from the University Grants Committee and by contributions from firms in the north-east of England. 'Ferdinand' was demonstrated to representatives of many firms after the official opening and naming ceremonies. The machine will be used for research work by university departments and will also be available for hire by industrial and commercial concerns.

Royal Photographic Society Award

The Royal Photographic Society of Great Britain has awarded its Silver Progress Medal for 1957, the Society's highest award, to Dr. Edwin H. Land, president of the Polaroid Corporation, Cambridge, Massachusetts, for his outstanding contributions towards the development of synthetic polarizers for light (for example, 'Polaroid'); of stereoscopic photography using polarized light one-step photography ('Land' camera); of the ultra-violet colour-translation microscope; and of the use of plastics and colloids in optics. Honorary Fellowship of the Royal Photographic Society has been conferred upon Dr. John I. Crabtree (Research Laboratories, Eastman Kodak Co.), who has been responsible for major developments in the practice of processing black-and-white still- and motion-pictures; and also upon Dr. E. H. Land.

Pooling Scientific Resources in the Western World

In a written answer given on January 21 in the House of Commons to a question regarding the Government's policy as to the pooling of scientific knowledge in the interests of international peace and co-operation, Mr. R. A. Butler re-affirmed that the Government is in favour of pooling scientific resources. He added that discussions with other members of the North Atlantic Treaty Organization and the Organization for European Economic Co-operation are proceeding with the view of promoting this continuing co-operation. The most important recent step towards scientific co-operation in the government field has been the joint decision of the North Atlantic Treaty Organization to establish a Science Committee and to appoint a Science Adviser to the Secretary-General.

Technical and Technological Education in Scotland

Replying on January 21 to a question in the House of Commons regarding the expansion of scientific and technological education in Scotland, the Joint Under-Secretary of State for Scotland, Mr. N. Macpherson, said that projects to the value of £7,300,000 have already been approved by the Secretary of State. He added that further projects to the value of £1,200,000 are being considered and it is expected to receive shortly a scheme for the remaining £1,500,000. Every opportunity is being taken by means of conferences and other forms of publicity to encourage employers and young workers to make full use of the facilities available.

National Science Foundation Grants for Research Reactors

Two major grants for research reactors are to be made by the National Science Foundation, namely, a 300,000 dollar grant to the State College of Washington, at Pullman; and a 150,000 dollar grant to the University of Virginia, at Charlottesville. The reactor facility to be constructed at the State College of Washington will be a swimming-pool type, heterogeneous reactor using enriched fuel elements and moderated by water. The reactor will have twelve beam ports, a thermal column, and at a power level of 100 kW. will provide a core flux of about 10^{12} neutrons/cm.^{2}/sec. The project is under the direction of Harold W. Dodgen, of the Department of Chemistry. The proposed facility is near seven other institutions of higher learning and is expected to contribute to the development of a regional programme in reactor research and training in nuclear technology. The project is also being assisted by the U.S. Atomic Energy Commission. The research reactor at the University of Virginia will also be of a swimming-pool type. The School of Engineering is participating in the design and construction of the reactor, thereby making possible appreciable savings in cost. The project is under the direction of Lawrence R. Quarles, dean of the School of Engineering. The staff has been actively planning research with nuclear radiation in the fields of biology, chemistry, engineering, medicine and physics. Nuclear fuel for both reactors will be provided by the United States Atomic Energy Commission.

The Midwestern Universities Research Association

The National Science Foundation has awarded a grant of 160,000 dollars to the Midwestern Universities Research Association, Madison, Wisconsin, for the support of basic research entitled "High Energy Accelerator Studies". The research is under the direction of Keith R. Symon, of the University of Wisconsin. Since 1953, scientists of the Association have been investigating methods of accelerating particles to energies of billions of electron volts. They discovered that a machine based on the principle of a fixed-field-alternating gradient was feasible, and a model was built to demonstrate this principle. The basic theory of accelerators was also developed to a point in advance of anything that had thus far been achieved. The work was facilitated by the use of high-speed computing machines, which were used to carry out analyses not otherwise possible. With the new grant, which supplements funds received from the U.S. Atomic Energy Commission, the Midwestern Universities Research Association expects to continue those studies of new ways of producing high-energy collisions involving beams of protons. It will continue to investigate the orbits and accelerating field configurations for the intersecting-beam method of producing 'effective' energies of tens of billions of electron volts. Theoretical studies will be made of the temporary 'stacking' of orbiting particles. Because the feasibility of an intersecting-beam accelerator depends on the intensity in the beam, it is planned to build a new pilot model to test the theoretical calculations that have been made on beam intensity. The model will operate at 50 million eV. and be so built that counter-circulating beams of particles can be studied. The radiation effects and the spurious interaction of these circulating beams will also be investigated.

History of Libraries

In his inaugural lecture, "The Golden Chain: a Study in the History of Libraries", at University College, London, on November 21, Prof. R. Irwin suggested that the history of libraries is essentially concerned with the conquest of space and time by the art of recording communications, and involves not only the history of scholarship in its narrower sense, but also of human civilization, culture and literacy. Moreover, he pointed out that the genealogy of scholarship and letters is as complex as any family tree. Books have their ancestry and descendants, and a book is a kind of reincarnation of the author that gradually gathers to itself an independent life of its own. An author's literary offspring are always the result of a marriage between his own mind and the communicated experience of other minds, in the main received through the medium of books, so that the conception and birth of the new book commonly occurs in the author's library or, for a scientist, in his laboratory. Prof. Irwin suggested that a library can be defined as a community in which reader and writer meet, to which both contribute something of value, mutually forging the links of the chain as it passes from mind to mind and from generation to generation. At the centre of this community is the librarian, with his two main duties of preserving for future readers the books in his care and of caring for the needs of every member of that community and for the chain of recorded tradition which is continually being corrected, strengthened, extended and passed onwards.

Indian Ephemeris and Nautical Almanack (1958)

THE publication of the first issue of the Indian Ephemeris and Nautical Almanack (pp. xviii+392. Delhi: Manager of Publications, 1957. Rs. 12) marks an important step in the plans for the development of astronomical studies in India. The preparation of such a work was first recommended by the Planning Committee for the development of astronomy and astrophysics set up in 1945 under the chairmanship of the late Prof. M. Saha. In 1952, the Government of India appointed a Calendar Reform Committee with the object of unifying the diverse indigenous calendars (see *Nature*, 178, 402; 1956). This Committee recommended that an Indian Ephemeris and Nautical Almanac for each year should be compiled and issued by the Government. The work was started by the Council of Scientific and Industrial Research under the Ministry of Natural Resources and Scientific Research, but it has now been taken over by the Indian Meteorological Department under the Ministry of Communications, and a Nautical Almanack Section has been set up at the Regional Meteorological Section, Alipore, Calcutta. At the end there is a section on Indian astronomy, added in accordance with the recommendation of the Calendar Reform Committee. The work of compiling and publishing the present issue has been under the supervision of Sri N. C. Lahiri, who has also been responsible for the introduction, dealing with the history and development of astronomy in India from about 1350 B.C.

Vacuum Drying Oven

THE Gardiner precision vacuum oven, developed by S. D. Gardiner in the laboratories of Tate and Lyle for the determination of the loss in weight on heating sugar syrups and molasses, is now in production by Griffin and George, Ltd., Ealing Road, Alperton, Wembley, Middlesex, from whom particulars of it may be obtained. In this oven the sample is taken into solution and distributed over aluminium powder. It is then heated in a vacuum while a current of dry air or inert gas is taken over its surface. Suitable arrangements for heating the specimen are incorporated. The oven will be suitable for use with various types of materials, including those of a labile nature.

Developmental Potentialities of Fern Leaf Primordia

E. G. CUTTER (*Annals of Botany*, N.S., 21, 343; 1957) has noted that when young visible primordia, which are not yet determined as leaves, on inactive apices of *Dryopteris aristata* are isolated by four shallow incisions, they undergo regression and disappear; but if the adaxial incision is afterwards deepened, some of the primordia are stimulated into a renewal of growth. About three-quarters of this number developed as buds, the rest as leaves, some of which were of radial symmetry; others became dorsiventral, but were sometimes abnormally orientated. Such primordia usually underwent a phase of radial symmetry during development. Subsequent deepening of the abaxial or radial shallow incisions was usually without effect. In a discussion of the problems of leaf determination, symmetry and orientation, it is suggested that, in specimens where the isolated primordia developed as leaves, the experimental treatments have merely fortuitously reproduced the regulative effects normally exercised by the shoot apex and adjacent primordia. There may be specific relationships between the size and growth capacity of the primordium and that of the shoot apex on which it is formed. Three phases in the development of a leaf primordium of this species can now be distinguished: inception as a growth centre, determination as a foliar organ of limited growth, and development as an organ of dorsiventral symmetry. Under normal growth conditions, radial leaf development is never observed, but when growth is unusually slow it may become manifest. In other species the temporal relationships between these phases of development may differ, so that they cannot be differentiated by experimental means.

Second International Symposium on Freezing and Drying

THE Institute of Biology is arranging a symposium on freezing and drying to discuss progress in this field since the first symposium held in 1951. The meeting is to be held in the Beveridge Hall, Senate House, London, W.C.1, on April 1 and 2. Some twenty speakers, including workers from France, Japan, Kenya, the United States and the U.S.S.R., have accepted invitations. The symposium will be open to the public. Further information can be obtained from the Institute of Biology, 41 Queen's Gate, London, S.W.7.

"Structure of Brain Ganglioside"

WITH reference to the communication under this title by Dr. Samuel Bogoch published in *Nature* of July 27 (180, 197; 1957), Dr. J. Folch-Pi, director of scientific research, McLean Hospital (Harvard Medical School), Waverley, Mass., states that Dr. Bogoch should have mentioned that most of this work was carried out at the McLean Hospital Laboratories, and that it was supported by the American Cancer Society (Grant *BCH*-11 *et seq.*).

University News: London

THE British Steel Producers' Conference and the British Constructional Steelwork Association have offered £6,000 a year to the Imperial College of Science and Technology, London, for the establishment of a readership in structural steelwork in the Department of Civil Engineering and the provision of a number of bursaries for postgraduate study in that subject.

Nottingham

THE title of reader in applied mathematics has been conferred on Mr. John Edward Adkins.

The Night Sky in February

FULL moon occurs on Feb. 4d. 08h. 05m U.T., and new moon on February 18d. 15h. 38m. The following conjunctions with the Moon take place: Feb. 9d. 14h., Jupiter 2° N.; Feb. 13d. 09h., Saturn 2° S.;

Feb. 14d. 12h., Mars 5° S. In addition to these conjunctions with the Moon, Mercury is in conjunction with Venus on Feb. 7d. 07h., Mercury being 9·6° S. Mercury is too close to the Sun for normal observation. Venus is a morning star, visible low in the south-east before sunrise. It rises at 6h. 25m. and 4h. 55m. on February 15 and 28, respectively. Mars rises at 5h. 20m., 5h. 10m. and 4h. 55m. at the beginning, middle and end of the month, respectively; it is visible in the south-east before sunrise. Jupiter rises at 0h. 10m., 23h. 15m. and 22h. 25m. on February 1, 15 and 28, respectively; it is east of Spica, and is stationary on February 16. The stellar magnitude of Jupiter is − 1·8, its distance from the Earth on February 15 being 460 million miles. Saturn rises at 4h. 45m., 3h. 55m. and 3h. 10m. at the beginning, middle and end of the month, respectively; it is near θ Ophiuchi. It has a stellar magnitude of + 0·8 and a distance of 980 million miles from the Earth on February 15. There are no occultations of stars brighter than magnitude 6 visible at Greenwich.

Announcements

Mr. R. R. Blackwood, general manager of the Dunlop Rubber Co. of Australia, formerly professor of mechanical engineering in the University of Melbourne, has been appointed chairman of the interim Council of the new University of Victoria. It is also expected that he will be the first chancellor of the University when it becomes established (see p. 300 of this issue).

Dr. J. A. Fraser Roberts, director of the Medical Research Council Clinical Genetics Research Unit, Institute of Child Health, The Hospital for Sick Children, Great Ormond Street, London, W.C.1, has been elected president of the Royal Anthropological Institute for the years 1957–59.

Dr. M. C. R. Symons, lecturer in chemistry in the University of Southampton, has been appointed visiting associate professor in the Department of Chemistry at the University of British Columbia for the period January 1–June 30.

The following appointments in the Ontario Research Foundation have been announced: Dr. A. E. R. Westman to be director of research of the Foundation, Dr. H. B. Marshall to be director, Department of Chemistry, and Dr. S. G. Reid to be an assistant director in that Department.

The Fifteenth International Horticultural Congress will be held in Nice during April 11–18, under the presidency of M. Henri Queuille. The theme will be "Science in the Service of Horticultural Techniques". Further information can be obtained from M. le Secrétaire général du XV^{e} Congrès International d'Horticulture, 84 rue de Grenelle, Paris 7^{e}.

The fifth Easter School in Agricultural Science will be a symposium and colloquium on "The Nutrition of the Legumes". It will be held at the University of Nottingham School of Agriculture, Sutton Bonington, near Loughborough, Leicestershire, during April 14–17. Further information can be obtained from the conference secretary, Mr. E. A. N. Greenwood, at the above address.

The first international symposium organized by the International Collegium for Neuro-Psychopharmacology will be held in Rome during September 9–12. In addition to organized symposia, there will be certain sessions devoted to original communications. Those interested in presenting papers should send a 250-word abstract before March 31 to Dr. P. B. Bradley, Department of Experimental Psychiatry, The Medical School, Birmingham 15, from whom further particulars may be obtained.

The Radiation Research Visiting Club is holding a meeting in Cambridge on March 20 and 21 on the theme of the action of high-energy radiation on solids. Further details may be obtained from Dr. A. J. Swallow, Tube Investments Research Laboratories, Hinxton Hall, nr. Saffron Walden, Essex.

The South-Eastern Union of Scientific Societies is organizing a conference on conserving wild life and amenities in the south-east of England, to be held at the Zoological Society of London, Regent's Park, N.W., on April 12, under the chairmanship of the Earl of Cranbrook. Each member society is being invited to nominate two delegates to attend the discussions, which, it is hoped, will lead to the formation of Naturalists' Trusts for each county represented.

The second symposium of the Reticuloendothelial Society (New England Institute for Medical Research, Ridgefield, Connecticut) will be held in Rapallo, during August 29–31. It is intended to discuss the subject under three main headings—the reticuloendothelial system and steroids; the reticuloendothelial system and immunity, including antibody immunity and properdin, and tumour immunity; and the reticuloendothelial system and radiation. As in the first symposium, which was held in France at Gif-sur-Yvette in 1956, attendance at the symposium will be limited. Proposed titles of papers from intending participants should be sent, accompanied by a brief summary in English, before March 15, to Dr. Alberto Marmont, Clinica Medica Universitaria, Viale Benedetto XV, Genoa, Italy, to whom inquiries may be addressed.

The Medical Research Council states that in future all requests for compounds in the Steroid Reference Collection should be addressed to Dr. W. Klyne at the Postgraduate Medical School, Ducane Road, London, W.12, and not to the National Institute for Medical Research at Mill Hill. As a result of generous gifts from two industrial firms, larger supplies of œstriol and 16-epi-œstriol (Organon Laboratories) and very limited supplies of racemic aldosterone (Ciba AG, Basel) are now available; these materials are intended for chemical reference purposes, and not for clinical work.

The authors of the first article on "Controlled Release of Thermonuclear Energy", entitled "Production of High Temperatures and Nuclear Reactions in a Gas Discharge" (*Nature*, January 25, p. 217), wish to add the following acknowledgments: (1) investigations leading up to the present results have been constantly encouraged and supported by Sir John Cockcroft, Sir George Thomson and the late Lord Cherwell; (2) invaluable assistance has been given by their colleagues at Harwell and at the Research Laboratory of the Associated Electrical Industries, Ltd., Aldermaston; (3) the erection and maintenance of ZETA has been under the control of J. T. D. Mitchell, of the Engineering Division.

TECHNICAL EDUCATION IN THE U.S.S.R.

AN impressive account indicating the importance attached to technical education in the Soviet Union has been given by C. E. Simmonds in a publication of the Society for Cultural Relations with the U.S.S.R.*.

Compared with a total of 200,000 in Russia in 1913, it is claimed that there are now more than 5 million specialists with a higher or secondary education; about 280,000 specialists with higher education qualified in 1955 and entered various branches of the national economy. Each year about 60,000 'professional engineers' and 70,000 lower grade engineers are being produced; to support their activities the aim is to train two, four or more technicians with secondary schooling for every college-trained specialist. The U.S.S.R. has some 3,000 scientific research institutes, experimental stations and laboratories, and more than 900 institutions of higher education. It has 4,000 technical and other specialized secondary schools.

The system is in many ways simpler than that to be found in Britain, where qualifications depend on State examinations or the requirements of the City and Guilds of London Institute, the specialized professional institutes, the trade unions and industry itself. In the Soviet Union the minimum educational period provided is the seven-year school (seven to fourteen); ten-year secondary education (seven to seventeen) is now established in the large towns, and is to become universal by 1960. Secondary qualifications can also be gained in specialized secondary schools, or *tekhnikums*, which also train secondary school leavers as technicians, or at evening classes. Each trade has its nationally-determined 'technical minimum' and a range of grades of skill with corresponding rates of pay; there is thus a constant incentive to study.

Many workers study in the evening after work; others attend full-time short courses of training or re-training, others (up to the age of thirty-five) win places in the higher technical institutes. The Labour Reserve Ministry has a complex network of schools, and courses for training skilled workers are being increasingly used in factories where automatic processes have been introduced. The Moscow automatic ball-bearing factory is described as "the most advanced production unit of its kind in the world". It turns out 900,000 ball-races and 600,000 roller bearings a year, with a total staff of 178 divided between two shifts. It took six months to design this factory and eighteen months to build it. Some 2,000 or 3,000 designers, including many from centralized research and development agencies, were involved in its planning. The experimental Research Institute for Metal Cutting Machines in Moscow has a staff of more than a thousand scientific workers. The Ordjonikidze machine tool factory has 400 designers and draughtsmen. One Moscow factory employing 4,000 workers has more than forty full-time teachers in its own technical school. The Red Proletariat Works, in Moscow, turns out small universal lathes at the rate of 12,000 a year, using only 1,000 workers. This lathe line took eighteen months to design and build.

To produce a sufficiency of scientists and technologists, Soviet educationists insist that technical education must be broadly based. The aim of the ten-year school is to turn out boys and girls, with a certificate including Russian language and literature (in addition to the native language in the non-Russian Republics) as well as mathematics and physics as compulsory subjects (the standard of the certificate is rather above that of the General Certificate of Education, Ordinary Level), with a good knowledge of basic scientific principles and some conception of their application in industry and agriculture, with practical experience of tools and machines, and, above all, with an interest in the world around them and a willingness to use their hands and brain creatively and adapt themselves quickly to whatever job they choose on leaving school.

The new syllabuses adopted in the past few years include practical handwork and nature study in the first four classes. The course is the same for all pupils, girls and boys, without selection or streaming. The children are encouraged to link up all the subjects they study with what is going on in the community to which they belong, the industrial and agricultural processes, the local climate and geography. In classes 5–7 there are two periods of wood and metal work per week. Practical work in agriculture (linked with biology studies) and electrical technology (linked with physics) also begins at this stage. The main elements of electro-magnetism and its practical application are taught in class 7. Practical work in electro-technology begins in class 7, and continues in the next three classes. Pupils learn how to wire up simple circuits and later they deal with complex apparatus like meters and dynamos. In class 8 engineering and machine study is introduced as the third practical subject, with two periods a week allotted. The work involves theoretical and practical study of various tools and mechanisms, such as parts of cranes, lathes, drills and jacks. The pupils' knowledge is gradually built up from understanding the principles and functions of the parts, to grasping the working of complex machines such as the car and the tractor, which is a main feature in the ninth-year syllabus. Visits to factories, and periods of practical work at some enterprises, are an integral part of school work, more especially if the school has a factory acting as patron, helping with the supply of equipment, lecturers and workshop instructors. The visits take the form of excursions carefully planned and followed up. At some schools, pupils from upper forms go to work at a factory once a week during school time. They work under careful supervision in machine-repair shops, electrical laboratories and tool-rooms.

Simmonds's paper also contains an account of the Labour Reserve Scheme for training skilled workers which was set up in 1940; between 1946 and 1954 more than 5 million skilled workers were trained in a variety of trades in the Labour Reserves Schools.

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* Technical Education in the U.S.S.R. By C. E. Simmonds. Pp. 36. (London: Society for Cultural Relations with the U.S.S.R., 1957.) 2*s*. 6*d*.

With the extension of ten-year schooling, it was decided, in 1954, to open a new type of two-year technical college, called a *tekhnicheskoye uchilishche*, intended for entrants who had already completed the ten-year school. Two hundred and sixty-one were opened in 1954, and by 1956 the number had grown to four hundred and forty, spread throughout the U.S.S.R. They are designed to train workers and junior technicians for highly skilled and responsible work, to take charge of machinery in rolling mills and mines, or to control automated processes and operate measuring instruments. Steam and diesel engineers, electricians and laboratory workers are being trained for agriculture. Entrance is open to young men and women from the ages of seventeen to twenty-five, local people being given preference in any given area.

Besides the products of the Labour Reserve Colleges, the aim of the sixth Five Year Plan (1956–1960) is to supply 550,000 skilled workers with secondary education from the new two-year technical colleges. The trade and railway schools will train 520,000 workers, the mining and building schools 1,180,000, and the agricultural mechanization schools 1,090,000. New schools are to be developed in Siberia, and more than a thousand million roubles are to be allocated by the Labour Reserve Organization for new schools, buildings, workshops and hostels. The schools vary from excellent to poor, the shortage of teachers and instructors, text-books, equipment and visual aids being still acute. Criticisms are made that the two-year course at the new technical colleges is not long enough, that syllabuses are overcrowded, that on-the-job training needs radical overhauling, students being often used as a reserve of extra workers.

In 1956, 1,961,000 students, internal and external, at 3,757 secondary technical and vocational schools were under the jurisdiction of various ministries. These are distinct from the general schools; their status is higher than that of the Labour Reserve Colleges, but not so high as that of a university or institute. Successful completion of the *tekhnikum* course qualifies the student to apply for entrance to higher establishments. A large number of these *tekhnikums* train skilled workers, junior technicians and supervisory staff for agriculture, engineering, mining, building, transport, but the range is very wide and includes nursing, book-keeping and commerce, finance and credit, various branches of light industry, and one special course for theatre technicians, attached to the Moscow Arts Theatre. One special type of industrial *tekhnikum* trains skilled workers as instructors in the Labour Reserve Schools. At present more than a million technicians and specialists with secondary qualifications are working in industry and agriculture. The sixth Five-Year Plan estimates that more than two and a half million students will complete these secondary technical courses.

The *tekhnikums* are staffed partly by specialist teachers from the universities and institutes, and partly by craftsmen-instructors, full- or part-time, from industry. Successful *tekhnikum* students are expected to go straight into fairly responsible jobs, not usually as craftsmen but as team-leaders, technical and laboratory assistants and assistant supervisors. In agriculture they are expected to take charge of field-work teams or sectors of farm economy. There are already three candidates for each full-time place in a *tekhnikum*; the aim is to expand the intake to double or treble the present figure.

Higher technical education in the Soviet Union includes not only all faculties of all universities but also every kind of specialized institute; it is difficult to give accurate figures for those who graduate from universities or from institutes.

While Soviet universities train science graduates, there are no university faculties for engineering or technology as such. The difference in function of universities and higher technical institutes is well expressed in the report of the British engineers who visited the U.S.S.R. in 1956. "The thirty-three universities do not offer courses in technology, and they do not contribute directly to the education and training of engineers. . . . But the universities offer courses in physics, a great deal of which is applied to engineering, and this brings them into touch with the developing branches of engineering. Physicists and mathematicians from the universities provide some of the teaching force in the institutes, and some of them are employed by industry in application work."

Students at all higher educational establishments in 1956 numbered 1,867,000, an increase of more than 100 per cent since 1941. There are now more than 900 higher educational establishments in the U.S.S.R., including thirty-three universities, and the teaching staff at these establishments is to-day more than 100,000. With its new building for the science faculties, opened in 1953, the University of Moscow has more than 18,000 students, including a number from outside the Soviet Union. In 1946, most technical colleges were brought together under the U.S.S.R. Ministry of Higher Education, instead of being under the jurisdiction of various ministries.

The age limits for admission to higher education institutions are seventeen to thirty-five but there is no age-limit for external (correspondence) students.

After graduation, the State Planning Committee of the U.S.S.R. Council of ministers allocates the year's graduates to the different ministries in accordance with the national economic plan. Posts are allocated by a State Commission which takes into account the wishes and inclinations of the student. Volunteers for work in the central eastern and northern regions are encouraged by appeals to patriotism and the pioneering spirit and also by financial inducements of 10–100 per cent additions to normal wage-rates.

Research work often begins during the undergraduate course and many students are responsible for innovations and inventions. At the Bauman Technical College in Moscow, more than 700 students were engaged in research in 1950 and fifty received certificates for their inventions. The Scientific Society of the University of Moscow has 2,200 student members who conduct research. A number of honours students proceed to postgraduate research for three years, after which they take examinations and present a thesis for the degree of Candidate of Science. The titles of successful theses are published in the specialized journals every year. In 1952, 25,000 postgraduate students were being trained at higher educational establishments and research institutes.

The system of studying as external students, by correspondence or at evening classes, is widespread and forms an integral part of the higher education network. There are twenty-two higher educational correspondence institutions with a large number of branches, and 393 correspondence and 211 evening departments. More than half a million men and women are studying by this method. Correspondence students have short periods of practical work, lectures and examinations each year.

RADIOISOTOPES AND GLASS

A SYMPOSIUM on the subject "Radioisotopes and Glass" was held by the Society of Glass Technology at the Department of Glass Technology of the University of Sheffield on November 27. Dr. W. M. Hampton was chairman of the morning session, followed by the president of the Society, Mr. C. E. Ramsden, who took the chair in the afternoon.

In an introductory lecture, Mr. J. L. Putman (Atomic Energy Research Establishment, Harwell) directed attention to the dual nature of the discussions, in dealing with both the services which radioactive techniques can offer to the glass industry and the demands which the handling and measurement of radioactive materials make upon glass. He mentioned the use of glass for containers and remote-control manipulative equipment for use with radioactive solutions, the use of lead glass as a transparent screening material for operations with high gamma-ray intensities and the use of discoloration as an index of high gamma-ray doses.

Following a brief review of the nature and properties of radioisotopes, Mr. Putman indicated the main ways in which these materials could be used, as radioactive tracers in solid, liquid or gaseous form, as sources of radiation in non-contacting thickness and density gauges, and as dissipators of unwanted electrostatic charges on insulators. A particular note was made of the special role of glass in the construction of Geiger counters and other radiation detectors.

Mr. E. W. Jones (Isotope Developments, Ltd.) spoke on "Glass Level Measurement in Furnaces". After a brief review of orthodox measurements of glass level, he pointed out the advantages of a radioactive system which does not require access to the inside of the containing vessel.

He referred to an early French design using radium as the source, and described a more recent British installation for monitoring the level of molten glass in the feeder to a bottle-making machine. In this model, which operates through two brick and refractory walls each 9½ in. thick, encased in ⅜-in. steel, a cobalt-60 source of activity 200 mc. is used in conjunction with a water-cooled, all-metal Geiger counter as detector. Indications of changes in glass level up to ± ¼ in. are obtained, with a sensitivity of about ± 0·01 in. Gradual radioactive decay is compensated by increasing the electronic sensitivity, so that the cobalt-60 source (much cheaper than radium) can be used over a period of five years. About one hundred such instruments are now installed, but only a few employ the desirable feature of automatic control by servo adjustment of the screw feed.

Mr. Jones outlined other possibilities for using simple level gauges to operate high-level warning systems, on batch silos and hoppers, and also mentioned the possibilities of using thickness gauges for the inspection of bottles and sheet glass.

Dr. R. E. Bastick (Chance Brothers, Ltd.) described the "Development of Glasses for Use with Radioisotopes and other Sources of Radiation", with particular reference to their uses for screening. He outlined the calculation of lead equivalent and showed that experimental determinations of this are in agreement within 1 or 2 per cent. Lead equivalents up to 0·6 were reported for some lead glasses.

Dr. Bastick then discussed the coloration of crown and flint screening glasses by large doses of radiation and showed results of doses up to 10^7 r. on flint glass and the subsequent fading observed. The use of cerium oxide as an additive to inhibit coloration was described, with data showing the inhibitory effect of various quantities of cerium dioxide in flint glass at a total dose of 10^7 r.

Neutron absorbing glasses containing oxides of cadmium and boron were described, and the dependence of absorption coefficients on neutron energy was shown.

A brief account of the use of a lead glass scintillator in a Cerenkov counter was given, and the use of cobalt loaded borosilicate glass for gamma-ray dosimetry was described.

In discussion on this paper, the special property of quartz glass in withstanding gamma-radiation up to 10^8 r. without coloration was mentioned, and the purple coloration produced by radiation when 4–6 p.p.m. of aluminium is incorporated was proposed for dosimeters which show little or no fading. It was also noted that denser glasses required smaller concentrations of cerium dioxide to inhibit coloration (for example, plate glass requires 2 per cent, while lead glass needs only ½ per cent).

Mr. J. L. Putman (Atomic Energy Research Establishment, Harwell) then presented a short paper on the "Determination of Selenium in Glass by a Radioactivation Method", an investigation made in collaboration with the British Glass Industry Research Association. He remarked that in finding the retention by glass of selenium added as a decolorizer, colorimetric methods were not applicable because of their dependence on the chemical form of the sample, and chemical analysis was cumbersome. In the method described the simultaneous neutron irradiation, in a reactor, of glass samples with and without the selenium additive was followed by comparison in a differential gamma-ray spectrometer, which subtracted the response of one sample from another, leaving only the gamma-ray spectrum due to selenium-75. Determination was thus specific for the element and largely independent of other impurities. Concentrations of 19·5 p.p.m. were measured with an estimated accuracy of ± 5 per cent. The applicability of the technique to analysis of other constituents and to the use of non-radioactive tracers was suggested.

In the afternoon, Mr. B. E. Moody (United Glass Bottle Manufacturers, Ltd.) described an "Investigation of Glass Flow in Furnaces by Radioactive Tracers". To trace the flow through furnaces handling 90 tons a day, over a period of 12–14 days, phosphorus-32 was chosen as the tracer, thus avoiding radiation hazards from the high activity of radioactive glass in the furnace, since it emits only beta particles. The tracer was in the form of neutron-irradiated ground phosphate glass compatible with the melt, and contained 51 per cent phosphorus pentoxide. After a delay of one week to allow radioactivity of potash and alumina constituents to decay, the phosphate glass contained 2 mc./gm. of phosphorus-32. It was added to the feed of one or more of three batch chargers over a period of ½ hr. From 35 to 350 mc. of phosphorus-32 was used in an investigation, 175 mc. being found to be the optimum activity.

Samples were taken at intervals from the output of three bottle-making machines fed by the furnace and measured with an end-window Geiger counter. By using a metal iris to limit the area inspected by the counter and by using glass samples thicker than 3 mm., it was established that the shape of the samples did not critically affect the results, and pieces of bottles were conveniently used for measurements.

It was found that tracer added to one of the outside batch chargers appeared almost uniformly in the three bottle-making machines, indicating good mixing and absence of streaming in the furnace. After a delay of 7½–10 hr. for amber glass and 5–6 hr. for flint, radioactivity began to appear in the product, reaching a maximum in about 24 hr. This was followed by a nearly exponential decay, leaving only 1·4 per cent of the labelled glass after 12 days and undetectable activity after 14 days. Apart from the expected initial delay before marked constituents appeared in the product, agreement with the 'curve of perfect mixing' was fairly good. Some subsidiary peaks in the curve of activity versus time were unexplained, but some were believed to be due to the recycling of active cullet.

Mr. R. F. Barker (Pilkington Brothers, Ltd.) gave an account of an "Investigation of Glass Flow in Furnaces by Radioactivation Methods". The furnace described was producing 6·4 tons per hr. of soda lime silica glass and had a capacity of 1,350 tons. Measurements were required over a period of several weeks. The long half-life and high activity required in a radioactive tracer made the use of radioactivity in the furnace undesirable. Hence an inactive material which could be made radioactive by the subsequent neutron irradiation of samples was used. Tantalum was chosen because of its high neutron cross-section and the desirability of the gamma-emitting tantalum-182 formed on neutron irradiation, the half-life (110 days) of which was longer than that of any activity induced in the normal constituents of the glass. The tracer was in the form of 3¾ kgm. of tantalum peroxide.

Tests were made on three of five machines fed by the furnace, and 200 samples, each containing 5 gm. of powdered glass, were irradiated in a reactor at Harwell. After a delay of five weeks to allow short-lived activities to decay, measurements were made with a scintillation counter, using a single-channel pulse amplitude analyser to distinguish the tantalum-182 gamma rays. A minimum transit-time of 4 hr. was found, in agreement with other data. The tracer was at a maximum after 100 hr. and its decline was followed over a total time of 520 furnace-hours. Moderate agreement was found with W. M. Hampton's theoretical curve for perfect mixing, but Mr. Barker directed attention to significant departures from this curve near the time of injection.

In a second paper, on "The Assessment by Tracer Methods of Mixing during Sand Treatment", Mr. R. F. Barker described experiments made in collaboration with the Isotope Division, Harwell, using sand labelled by immersion in a solution of barium-140 and subsequent heating at 500° C. The adhesion of the radioactive material was already established under conditions of abrasion and washing with water. The daughter isotope lanthanum-140 (40 hr.) reaches equilibrium with the barium-140 (12 days) and measurements were made of gamma rays from the lanthanum.

Ten pounds of labelled sand, carrying 100 mc. of barium-140, were mixed with 5 cwt. of inactive sand in a cement mixer and added to a hopper feeding the washing plant. The progress of the radioactive material through the washing plant and grader was registered by recording meters placed outside the steel pipes carrying the sand slurry. A survey was made of the horizontal distribution of radioactively labelled sand in the storage bin (capacity 2,000 tons). At this stage the labelled sand was found still to be fairly localized. Further monitoring of the sand leaving the bin and in the railway transit wagons showed that mixing was introduced by the method of loading.

Finally, timed measurements were made of the radioactivity of glass drawn off from the tank furnace. From an analysis of these results the distribution of a particular sample of the original sand in the finished product was assessed.

The papers were followed by lively discussion. The proceedings of the symposium will be published in the *Journal of the Society of Glass Technology*.

J. L. Putman

MELTING AND DIFFUSION

The second symposium on "Melting, Diffusion and Related Topics" was held at the National Research Council Laboratories, Ottawa, on October 21–22. The meeting was sponsored by the Low Temperature and Solid State Physics Group of the Division of Pure Physics, National Research Council of Canada. As in the previous symposium, reported in *Nature* (177, 23; 1956), the object was to bring together workers with varied approaches to the subject and, by limiting the number of formal contributions to twelve, to encourage informal discussion.

In the previous symposium the melting process itself was a major topic of interest. In contrast, the programme on this occasion was concerned chiefly with processes having only a general bearing on melting, the direct approach being temporarily abandoned in favour of seeking clues from the solution of associated problems.

Among the papers concerned with measurements in the region of melting was one by D. L. Martin (National Research Council), who reviewed existing information concerning specific heat anomalies in the region of melting; he showed that both anharmonicity and lattice defects have been invoked in explanation but argued that little conclusive evidence exists as to their relative importance. N. H. Nachtrieb (Institute of Metals, Chicago) dealt with diffusion in liquid and solid pure metals and in alloys; the analysis of his measurements showed a clear relation between melting and diffusion parameters, but also underlined the restricted nature of purely thermodynamic arguments. Diffusion was also considered by J. A. Morrison and R. Rudham (National Research Council), who gave details of their identification of the mechanism of the anion diffusion process in sodium and potassium chloride crystals. Slow neutron diffraction measurements were described by a group of workers from Chalk River: D. G. Henshaw and N. K. Pope gave complementary experimental and theoretical accounts of the determination of the radial distribution function in solid and liquid helium and neon and in liquid argon, while B. N. Brockhouse showed how the incoherent scattering could give information on molecular motions and may provide a means of resolving some of the indeterminancies involved in the direct measurement of diffusion.

A second group of contributions dealt with transitions other than melting. R. W. Smith (University of Toronto) described investigations on the grey tin/white tin transformation carried out in Birmingham with G. V. Raynor, in which previous uncertainties of observation have been positively correlated with impurity content. D. Gugan and J. S. Dugdale (National Research Council) gave a preliminary report of work in which electrical resistivity measurements appear to provide information on the martensitic transformation in lithium. Z. S. Basinski (National Research Council) outlined a theory of work hardening of face-centred cubic metals in which the main obstacles were provided by the 'forest' of dislocations; the theory appeared to apply also to body-centred cubic metals, but in that case at low temperatures the mechanical properties were dominated by a large Peierls–Nabarro force. Work on the liquid state was represented by an account given by A. C. Hollis Hallett (University of Toronto) of recent experiments on the viscosity of liquid helium.

The single contribution dealing specifically with melting was by J. S. Dugdale, who discussed the Lindemann melting formula in relation to inert gas solids. R. J. Uffen (University of Western Ontario) once again made a convincing defence of large-scale approximation and extrapolation, this time discussing certain tectonic and volcanic phenomena in terms of the pressure dependence of melting of various types of magma.

In these days of high-speed conferences it is pleasurable to report on one at which the pace and length of discussion were such as to enable at least one non-expert to participate with profit. An informal report of the proceedings is in preparation.

J. W. LEECH

ELECTRONICALLY EXCITED SPECIES

A SYMPOSIUM on "The Structure and Reactivity of Electronically Excited Species" was held at Ottawa during September 5–6 under the auspices of the Physical Chemistry Division of the Chemical Institute of Canada.

In his introduction to the section on structure, G. Herzberg directed attention to the rapid increase, recently, in the number of polyatomic molecules, radicals and ions for which rotational and vibrational analyses of electronic systems had been carried out. This had demonstrated that, in many cases, the shapes in the excited states are different from those of the ground-states. For example, acetylene, hydrogen cyanide and carbon disulphide are linear in their ground-states but bent in their first electronically excited states. Throughout the meeting it was clear that the predictions made by A. D. Walsh in 1953 had been substantiated most impressively. References were repeatedly made to Walsh's energy diagrams.

G. W. Robinson and V. E. DiGiorgio showed in a submitted paper that formaldehyde is non-planar in a low-lying excited state, while K. Allison and A. D. Walsh concluded that the same may be true for one or two of the excited states involved in the Rydberg transitions. G. W. King presented evidence for the conclusion that there is only a small change in molecular geometry on exciting the glyoxal molecule in the transition studied by him.

During this part of the meeting much interest was shown in the interactions between electronic and vibrational motions of polyatomic molecules. M. H. L. Pryce, U. Opik, H. C. Longuet-Higgins and R. A. Sack dealt theoretically with the dynamical Jahn-Teller effect, considering the energy-levels of a non-linear molecule in a doubly degenerate electronic state which is split by a doubly degenerate vibrational mode. K. Dressler and D. A. Ramsay dealt with the Renner effect in linear molecules. The lowest state of linear NH_2 would be a Π state. Experimental results suggest that the ground-state is bent and the first excited state is linear, the vibrational levels of the hypothetical linear state correlating with the levels of those two states, half with those of the excited and half with those of the ground-state. The ground- and excited states are degenerate when the radical is linear but different in energy when it is bent. The radical HCO appears to behave similarly.

Two papers by J. N. Murrell and by D. S. McClure were submitted which discussed the transfer of electronic and vibrational energy between weakly coupled systems. This is a subject of very great interest at the moment.

In addition to molecules and radicals the excited states of ions were discussed during the meeting. D. C. Frost and C. A. McDowell described their mass spectrometer which has been employed to determine the energies of the excited states of the ions produced in the instrument. This complements information that can be obtained spectroscopically, though so far detailed analyses of polyatomic ionic spectra are only available for CO_2^+, CS_2^+ and $C_4H_2^+$. Also J. W. Sidman, in an interesting paper, described results obtained for the nitrite ion in the crystalline state. From these he obtained information concerning the vibrational and lattice frequencies of the ground- and excited states.

There is doubt about the multiplicities of the excited states of some molecules and, in this connexion, A. E. Douglas presented some results for the Zeeman effect in the near ultra-violet bands of carbon disulphide. This indicates that the excited state is a triplet. G. W. Robinson and V. E. DiGiorgio concluded that the weak bands of formaldehyde studies by them were due to a singlet–triplet system.

On the theoretical side R. S. Mulliken suggested that it may soon be possible to make more reliable calculations of the energies of excited molecular states. He presented results for carbon monoxide, nitrogen and acetylene and for several molecules of the AB_2 type. The possibility of chlorine dioxide in the excited state being unsymmetrical was discussed, since the antisymmetric vibration appears to be excited on going to the upper state. J. W. Linnett discussed the electron distribution in the ground- and low-lying excited state of acetylene by transforming the molecular to equivalent orbitals. On this basis it was possible to understand why the carbon–carbon bond-length in the excited state is about the same as that in the ground-state of benzene and why the molecule is bent.

E. W. R. Steacie gave the introductory paper to the section on reactivity and pointed out that, while the evidence for excited species occurring in chemical processes had in the past often been very meagre, firmer knowledge of their participation in reactions is now being obtained. H. Eyring also gave a broad survey of the field and stressed the value of potential energy surfaces when considering chemical reactions theoretically.

There were several interesting theoretical contributions to this section. R. A. Marcus considered the case of electronically excited molecules reacting unimolecularly, the course of reaction being examined as motion on a potential energy surface. B. Stevens pointed out that while totally symmetric vibrations are excited when an electronic transition occurs, the excitation of non-totally symmetric vibrations are usually necessary for dissociation. A transfer of energy must therefore occur, and this will depend on the anharmonicity. Stevens suggested that the dissociation rate will consequently depend on the magnitude of optical energy taken up. E. K. Gill and K. J. Laidler discussed theoretically the reaction:

$$\mathrm{Hg}^*(^3P_1) + \mathrm{O}_2(^3\Sigma_g^-) \rightarrow \mathrm{Hg}(^1S_0) + \mathrm{O}_2^*$$

They reached the conclusion that both the theoretical and experimental evidence leads to the view that oxygen is produced in the $^3\Sigma_u^+$ state. This involves the minimum transfer of energy from one form to another. Potential energy surfaces were used by these authors also.

H. E. Gunning described experiments which made use of a mercury-vapour lamp charged with mercury-202. With this, mercury-202 could be excited in ordinary mercury vapour in the presence of gases with which the excited mercury could react. Isotopic enrichment in a solid product indicated that this was formed in a primary process; no enrichment indicated that it was formed secondarily. No enrichment in mercuric oxide was obtained from nitrous oxide and oxygen but enrichment in mercurous chloride was found with hydrogen and methyl chlorides and with carbon tetrachloride.

J. D. McKinley and S. C. Polanyi had mixed atomic sodium with atomic and molecular hydrogen. They discussed the reactions that might lead to the chemiluminescence (sodium D lines) that is observed. J. C. Polanyi and also C. L. Arnot and C. A. McDowell discussed the results they had obtained for the rate of transfer of vibrational energy to translational when iodine is excited by the mercury green line to the twenty-sixth vibrational level of the excited state in the presence of inert gases. The competition between energy transfer and fluorescence is studied. Arnot and McDowell found that the ratio of rates was greater than expected from theory and suggested that the fluorescence lifetime may be less than has been supposed.

T. M. Sugden and E. M. Bulewicz and also F. Kaufman described work on the green emission that is obtained when nitric oxide is added to systems containing oxygen atoms. The former workers concluded that the intensity of the glow is determined by a more complicated process than the simple combination of atomic oxygen and nitric oxide.

G. J. Minkoff discussed the polymerization of acetylene and considered the possibility that a bent triplet diradical might be involved in the mechanism.

H. P. Broida and K. E. Shuler described the use of the reversal of iron lines in studying flame temperatures. This proves to be a sound method if equilibrium is established. Moreover, it is possible to discover when equilibrium is not established. P. Carrington had studied the emission by $^2\Sigma^+$OH radicals in oxy-acetylene flames. It appears that the electronically excited radicals are deactivated at nearly every collision, so any departure from the equilibrium distribution that is observed must represent the situation prevailing on the production of the excited radicals.

J. Heicklen and W. A. Noyes described photochemical experiments that had been carried out with ketones and bi-acetyl. In the latter case they concluded that triplet excited molecules were involved. They discussed the decomposition, fluorescence and phosphorescence of these substances. H. Okabe described work on the fluorescence and photolysis of hexafluoroacetone. The effect of pressure and the addition of foreign gases was studied.

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SUPPLY AND DEMAND

PROF. M. G. Say delivered his chairman's address before the Supply Section of the Institution of Electrical Engineers on October 23. The address, which was given under the title "Too Much and Too Little", was by no means confined to strictly technological considerations, and constituted, rather, a broad philosophical review of the persistent disparity between demand and supply, between needs and resources. Commenting on the use of the figure representing the power available per head of the population as an index of the standard of civilized life, Prof. Say remarked that in North America, Western Europe, and the Soviet Union, energy resources were being developed as fast as practicable, while in the underdeveloped countries—representing three-quarters of the habitable world and two-thirds of the world's population—the demand for auxiliary energy was beginning. With the development of nuclear energy the production of electric power, which until now had been dependent upon coal, oil, or water-power, had become largely independent of geography or geology. It must, however, be remembered that a country might remain poor and underdeveloped because poverty put out of reach the opportunity to build up the supply of power which would enable development to take place.

The total world consumption of power in the year 1950 was some 30,000 million kilowatt-hours. On a United Nations estimate of the annual rate of increase of power consumption at 3¼ per cent the year A.D. 2000 would see a three-fold increase on the present demand for power. This must be met very largely from nuclear energy, for by that time coal and oil outputs would be well past their peaks and hydro-electric power would be approaching its full development. It should be noted that the present methods of generating electric power, by means of a thermal cycle, were inherently wasteful, nearly four-fifths of the available heat being rejected. If this rate of loss should continue the world would in fifty years' time be wasting heat in the production of electricity at a level in excess of twice the present total world consumption of power.

Referring to engineering as a career and to the present shortage of engineering graduates, Prof. Say drew a comparison between the situation in the U.S.S.R. and in Britain. It was worth noting that despite the scale of the Russian need for engineers and scientists there was no extreme specialization in science in the secondary schools. In the U.S.S.R. the three final years of school, to age seventeen, included the study of physics, chemistry and mathematics for about 40 per cent of the time, and this held for all pupils, arts as well as science. Thus potential arts men had to pass examinations in science subjects while potential engineers and scientists had to study literary subjects to a level quite beyond that of the average British technical student.

The concluding section of Prof. Say's address was concerned with the ultimate values in human life and the possible threat which was offered by the pressure and strain of a mechanistic age to the qualities of imagination and creation which were key elements in the human make-up. "We cannot deny," he said, "that the threat exists, nor on the other hand that industrialization has brought great benefits to mankind. It will bring more, but only if the mastery remains where it belongs—in the care of the human spirit." J. GREIG

NATURAL HISTORY OF THE FOX SQUIRREL

A FIELD study of the fox squirrel (*Sciurus niger*) in the south-eastern coastal area of the United States has been made by J. C. Moore (*Bull. Amer. Mus. Nat. Hist.*, 13, Art. 1). The fox squirrel has probably diminished greatly in numbers and range because of changes wrought by man. *Sciurus niger shermani* was investigated in the sand hills of north Florida in a fir-maintained plant community which is common over a wide area of the south-eastern coastal plain, the *Pinus australis–Quercus laevis* associates. This plant community was changed suddenly and radically from a tall but very open forest of primeval long-leaf pines with turkey oak indifferently represented as a secondary, lower level dominant, to a virtually pure stand of turkey oak, relatively close-ranked and low.

Moore's inquiry was designed to determine how this large tree squirrel, after presumably evolving in the open stands of large pines, lives now in the lowly oak forest which has succeeded the logged-off pine.

The principal predatory enemies of *Sciurus niger shermani* are apparently the bald eagle, the red-tailed hawk, and man. There are few suitable refuges for so large a tree squirrel in this low, open forest of deciduous trees and this may have brought about the following developments in behaviour unusual for a tree squirrel: a fairly well-established tendency for it to take refuge, when hard pressed, in the burrows of gopher tortoises underground; the use by the fox squirrels of hollows that extend down through the tops of old stumps to nesting chambers underground; an escape behaviour, which may have developed since the removal of the old pines and which is presumed to be employed only against man, that involves hiding in the top of a second-growth long-leaf pine by ascending the plume-like apical twig so that the twig bends over horizontally under the squirrel, and the squirrel lies on top hidden from all below; there is, apparently, an excessive number of leaf-nests per individual squirrel, thus providing more refuge.

While these forms of behaviour have survival value, they do not enable the animal to prosper.

THE BRITISH COUNCIL

THE annual report of the British Council for 1956–57 refers briefly to the review of Overseas Information Services made by Dr. C. Hill. The decisions recorded in the White Paper accepted about nine-tenths of the Council's proposals for increased activities and the Council specially welcome the reference to co-operation with people and interests outside the Government. The Council's work depends largely on the help and advice of many educational, professional, scientific and industrial bodies as well as of thousands of individuals. About half the report deals with the Council and the sciences and an increasing proportion of the Council's work consists of making known British scientific achievement, assisting the dissemination of information to the appropriate specialists and in serving as a link between British experts and professional bodies and their opposite numbers abroad. Allied to this is assistance in training. Since 1950, the number of overseas students in the United Kingdom has risen from 10,000 to nearly 35,000, about a third of whom are at universities or university colleges, while 60 per cent are concerned with the sciences. By far the largest increase in students is among those attending technical colleges, and the numbers might be greater still if their countries could find the necessary funds or Britain could offer scholarships and places on the scale of some of her competitors.

The report stresses Britain's advantage, shared with the Commonwealth and the United States, in the establishment of the English language among scientists as an essential means of communication, and the Council's work in furthering the study of English is thus of importance in this connexion. The

University of Edinburgh inaugurated its new School of Applied Linguistics in October 1957. This is conceived especially for those who are responsible for training teachers of English and the establishment or revision of teacher-training methods. Three Council officers are participating in the course together with experts in teaching English from overseas invited by the Council. English language teaching now occupies so important a place in the Council's activities that the English Studies Advisory Committee has been divided into two separate panels, one advising on literature and the other on language.

In fostering the knowledge of British scientific achievements, the Council's special function is to use its staff in the field to find out what demands for information and training are being left unsatisfied and to put learned institutions and individual scientists overseas in touch with the appropriate organization or individuals here. Even within the Commonwealth the established links are not always adequate and the Council has been able to reinforce them by, for example, the exchange of delegates between the British Association and the corresponding organizations in Ceylon, India and Pakistan, by showing medical films in the more advanced Colonies, sending lecturers on such subjects as the use and local manufacture of laboratory apparatus, or enlisting the help of specialists who happen to be visiting the territories.

The Council's most important role in the sciences is in promoting visits by scientists to and from Britain for discussion, observation and study, and of all the visitors to Britain for which the Council makes arrangements about 13 per cent are financed by the Council. In the past five years the Council has assisted in some 7,000 visits of individuals in the sciences, or about 32 per cent of the total for all subjects. Of the Council's postgraduate scholarships, 594 or 56 per cent of the total in the past five years went to the sciences, and for the 221 awards in 1956–57 there were 2,500 applicants. The Council is also the national supervising agency for the United Nations Technical Assistance Administration Fellowship Scheme and other Fellowship Schemes of the Specialized Agencies under which 2,941 Fellows have visited the United Kingdom during the past ten years, of whom about two-thirds were concerned with science and technology, medicine, agriculture and training leading to development. Among the short-term visitors, the proportion whose interests lie in science has increased since 1950 from 25 to 30 per cent, but among the bursars it has increased from 25 to 40 per cent. There have been few changes in emphasis as regards subject, though interest in the nuclear sciences has grown and the organization of technical education has greatly increased, while the steadily growing demand for British professors, lecturers and teachers is reflected in the number of rectors of overseas universities, senior officials of Ministries of Education, and principals of teacher-training colleges who have sought the Council's help, first to study the organization of research in Britain and our methods of teaching scientific and technical staff, and then in recruiting British staff for their own institutions.

The Council operates two schemes for the interchange of university teachers, one dealing with Western European countries and the other with the Commonwealth, under which 161 scientists from United Kingdom universities have visited thirteen European countries and 62 have visited Commonwealth countries. There have been 154 reciprocal visits from foreign countries and 200 from the Commonwealth, the percentage of all these visits devoted to the sciences being 60. Under the interchange scheme for younger research workers started in 1954 there have been 33 visits from the United Kingdom to four European countries and 27 visits from these countries to the United Kingdom. Stress is also laid on the lecture and advisory tours of specialists which the Council organizes in co-operation with overseas countries, and in 1956–57 the Council initiated a pilot project to enable British experts to visit and work in Latin American universities and research institutions under which four such visits were arranged between July 1956 and March 1957. During the past five years the Council has accepted responsibility for recruitment to some forty vacancies for British scientists in teaching posts in universities and schools, but not all these have been filled.

More than 6,000 British papers from learned periodicals were supplied in 1956–57 and more than 400 specialists from some 70 countries visited the Council's medical and science libraries. Noteworthy among the group exchange visits with the U.S.S.R., arranged by the Soviet Relations Committee of the Council, were the exchanges of delegations between the Royal Society and the U.S.S.R. Academy of Sciences; between the Royal College of Surgeons of England and the Royal College of Surgeons, Edinburgh, and Russian surgeons; and exchanges of delegations interested in engineering education and training, whose programme in Britain was organized by the major engineering institutions. These visits, as Sir David Kelly emphasizes, were in marked contrast to others, non-reciprocal, since the Soviet delegations were interested simply in acquiring technical information.

DIAMONDS IN SIBERIA

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UNTIL quite recently no diamond deposits in the territory of the U.S.S.R. were known, while at the same time the rapid progress of industrialization was pressing for a supply of industrial diamonds, which had to be imported from abroad. This prompted the Soviet Government, through the appropriate channels of the Geological Survey, the Ministry of Geology and the Academy of Sciences, to embark on a series of planned explorations for diamonds. In 1941, diamond placers were discovered in the Urals, but these proved to be of no commercial value. In 1944 the wild tracts of taiga, situated between the rivers of Enisey and Lena, were selected as a possible diamantiferous region, and this selection proved to be a correct one, for in 1948 diamond placers were discovered in the basin of Nizhneya Tunguska, in 1949 in the basin of Vilui, and finally in 1954 the first kimberlite pipe, named 'Zarnitza', was discovered in the basin of Daldyn, in the north-west Yakutia. Subsequent explorations and prospecting greatly extended the diamantiferous area situated between the Enisey and Lena.

This work, which began during the War, was carried out in an atmosphere of secrecy, and no results were published in scientific periodicals. Only recently, when rumours about Siberian diamonds began to be more persistent, has a popular account of the results of this exploration been published (V. S. Trofimov, *Priroda*, No. 7, 10; 1957). This article, published in a Russian popular science journal, gives a clear and comprehensive account of the diamond fields of Siberia, and is provided with a map showing the distribution of the deposits and illustrated by numerous photographs including two colour photographs of kimberlites.

The diamantiferous province is situated in the Central Siberian Plateau. Its approximate boundaries form a rectangle, 400 km. by 1,500 km. in size, stretching in a north-easterly direction from the River Angara in the south, to the River Lena between Muna and Vilui in the north-east. The whole of this area is situated in the region of taiga (north coniferous forest zone), which has a permanently frozen ground, severe climate and a very sparse population. The exploring and prospecting were mainly along the water courses at first. Operations included sampling alluvial deposits, mapping out placers and tracing pay streaks to their sources—the kimberlitic pipes. In this way several dozen kimberlite pipes were discovered in the north-western Yakutia, the only region where commercial diamonds were found both in the pipes and in the placers. The pipes pierce limestones, dolomites and marls of Cambrian and Ordovician times, but fragments enclosed in them suggest that they are of Jurassic or Cretaceous origin. All the pipes are found in a belt 1,000 km. long, 250 km. wide at the northern end and 35 km. wide at the southern end. Kimberlite is a brecciated rock containing fragments of various rocks, and crystals of pyrope, olivine, chrome-diopside, ilmenite and other minerals, including the rare diamond, but Siberian kimberlite contains little phlogopite. The pipes are oval or irregular in cross-section, with a diameter varying from 50 m. to 550 m. The usual zoning from 'yellow ground' to 'blue ground' and finally to 'hard-bank' kimberlite is rather poorly developed, probably because of the severe action of the frost, which disintegrated the solid rock of the ground water level. In some pipes several intrusive phases of kimberlite are present; for example, in the pipe 'Zarnitza' there are five columns of kimberlite, each successive phase enclosing fragments of the previous phase. The yield of diamonds from kimberlite pipes is sometimes higher than 1 metric carat per cubic metre.

Towards the end of 1956 the following groups of Yakutian pipes were located: Malo-Batuobinskaya (middle course of Irelyakh, left tributary of Malo-Batuobi, tributary of Vilui), Daldynskaya (basin of Daldyn, left tributary of Markh), Alakitskaya (upper reaches of Alakita, right tributary of Olenek), Munskaya (upper reaches of Muna, left tributary of Lena), Olenekskaya (middle and lower reaches of Olenek).

The diamantiferous alluvial deposits adjoining the kimberlite pipes in the north-eastern part of the province contain pay placers, but those of the south-western part of the province, presumed to be originally of a Pre-Cambrian age, are of no commercial value. The yield of diamonds in placers varies from 0·01 carat to several carats per cubic metre. The richer placers are situated in the basin of the Vilui River.

Siberian diamonds are rather heterogeneous both in their size and in their quality. Every region is characterized by certain types of diamonds. In size they vary from a fraction of a carat to 32·5 carats, but stones above 0·5 carat are rare. The bulk of stones extracted are less than 0·1 carat in size. The average for all stones hitherto extracted is 0·07 carat. The majority are colourless. Coloured stones (yellowish-brown, smoky, and rare greenish and pinkish) are found in the south-western part of the province. Inclusions of graphite, olivine, pyrope and small diamond crystals are often found in Siberian diamonds. Their quality is not very high. Stones of gem quality form 9–38 per cent of the total, the remainder being industrial diamonds.

No figures, as yet, are given relating to annual production, methods of working, or industrial applications of Siberian diamonds.

Additional information relating to the kimberlite pipes is provided by L. N. Leontiev and A. A. Kadensky (*Doklady Akad. Nauk S.S.S.R.*, **115**, 368; 1957). The age of pipes is definitely fixed as Triassic, more or less contemporaneous with the wide-spread intrusions and extrusions of basalt and dolerite belonging to the series of the so-called 'Siberian Traps'. The great depth, of a few kilometres, of the foci of explosions of the pipes suggests that the kimberlite is not derived from the periodotite mantle of the Earth, but is genetically connected to the alkaline variety of basic magma. The grouping of pipes suggests that they are placed along certain important tectonic features of the Earth's crust, such as flexures and tectonic breaks.

ADENOSINE TRIPHOSPHATE METABOLISM IN THE RABBIT ERYTHROCYTE *IN VIVO*

By DR. BERTRAM A. LOWY, DR. BRACHA RAMOT and DR. IRVING M. LONDON

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ADENOSINE triphosphate is known to play a key part in the metabolism of many cells, including the erythrocytes of numerous species. It serves as a source of energy and as an essential component of many biosynthetic reactions and participates in co-enzyme synthesis. Although the active turnover of the labile phosphate groups of adenosine triphosphate has been investigated[1], little is actually known concerning the turnover of the remainder of this molecule. Knowledge of the biochemical origin and metabolic behaviour of adenosine triphosphate within the erythrocyte may provide some insight into the mechanisms which determine the life-span of this cell.

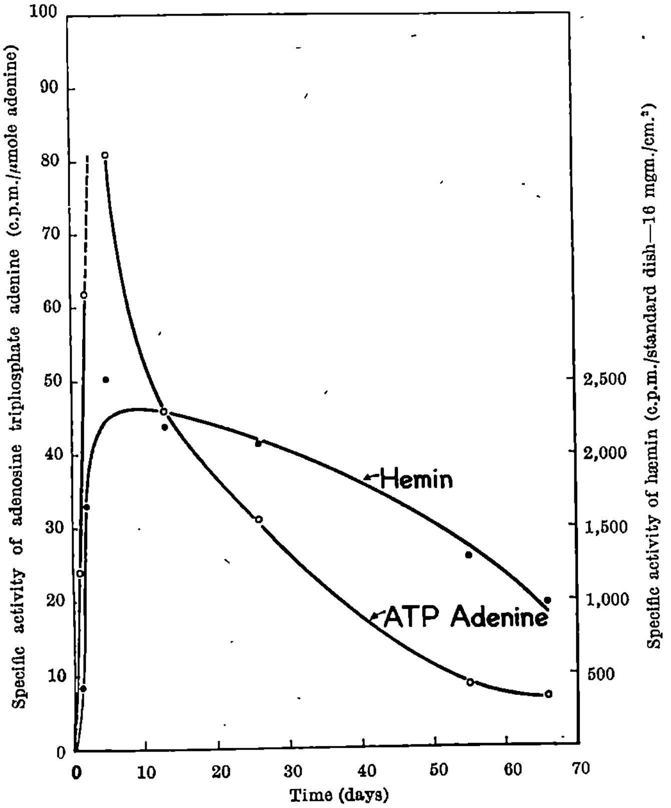

Fig. 1. Incorporation of glycine-2-^{14}C into the adenine moiety of rabbit erythrocyte adenosine triphosphate and into the hæmin of hæmoglobin

The synthesis of the adenine portion of rabbit erythrocyte adenosine triphosphate *in vivo* has been studied in order to determine the extent to which the purine moiety arises from glycine-2-^{14}C, a known precursor of purines. The metabolic behaviour of this adenine moiety has been investigated in terms of whether it resembles hæmoglobin in its metabolic stability[2,3], or is more closely related to cholesterol[4] or glutathione[5], which have been found to undergo turnover during the life of the human erythrocyte.

A number of white male New Zealand rabbits received single subcutaneous injections of 1·0 ml. of glycine-2-^{14}C in 0·9 per cent sodium chloride solution containing 0·2 millimole per ml. with a specific activity of 1·0 millicurie per millimole. After periods of time ranging from 24 hr. to 66 days, one or two rabbits were heparinized and bled by heart puncture shortly after intraperitoneal administration of 2·5 ml. of 25 per cent magnesium sulphate solution. Hind-leg muscles were removed for adenosine triphosphate preparation, and nucleic acids were isolated from the internal organs. These aspects of this work will be reported in detail elsewhere.

Erythrocytes were washed three times in cold 0·9 per cent sodium chloride solution after removal of the plasma and buffy coat. The final sample of erythrocytes had less than 0·01 per cent contamination with white cells.

Adenosine triphosphate was extracted with cold trichloracetic acid, and the barium salt was prepared[6]. The barium precipitate also contained adenosine diphosphate, adenosine monophosphate, sugar phosphates, phosphoglyceric acids and inorganic phosphate. Partial purification of the adenosine triphosphate was effected by ion exchange chromatography on 'Dowex-1-Cl' resin[7]. A mixture of adenosine triphosphate and 2,3-diphosphoglycerate, free of the other constituents of the barium precipitate, was eluted by 0·06 *N* hydrochloric acid. The adenosine triphosphate was hydrolysed with *N* hydrochloric acid by heating for 1 hr. in a boiling water bath without affecting the 2,3-diphosphoglycerate, which is markedly resistant to acid hydrolysis. The resultant mixture of adenine, ribose-5-phosphate and 2,3-diphosphoglycerate was adjusted to *p*H 9·0–9·5 with *N* ammonium hydroxide and passed through a 'Dowex-1-Cl' column. Adenine was eluted with 0·001 *N* hydrochloric acid, and purity was established by spectrophotometry, paper chromatography, and ribose and phosphorus analyses.

Aliquots of the eluates were plated on planchets at infinite thinness and assayed for radioactivity in a 'Nuclear-Chicago' gas flow counter with a micromil window. Rechromatography and elution from 'Dowex-1-Cl' resin and from Whatman No. 1 filter paper resulted in no change in specific activity.

Hæmin was prepared from a small aliquot of washed erythrocytes. Standard samples, recrystallized to constant radioactivity, were assayed.

The results, summarized in Fig. 1, indicate that glycine-2-^{14}C serves as a precursor of the adenine moiety of erythrocyte adenosine triphosphate. They also confirm[3] the stability of the hæmoglobin of the rabbit erythrocyte during the 65–70 day life-span despite the somewhat greater lability of the rabbit erythrocyte compared to that of the human red cell[2]. In contrast to the relative metabolic stability of the hæm, the metabolic behaviour of the adenine portion of the adenosine triphosphate is clearly different since the specific activity of the adenine declined exponentially after about the fifth day and reached a very low activity after about 55 days.

In order to explain the decline in the specific activity of the adenine, several possibilities, which may not be mutually exclusive, should be considered. One possible explanation is that the mature erythrocyte is capable of synthesizing the purine portion of adenosine triphosphate. This would result in a gradual decrease in its specific activity. Thus far, however, in several experiments in this laboratory *de novo* synthesis of adenosine triphosphate adenine from glycine-2-^{14}C has not been demonstrated in the mature erythrocytes of rabbit or man, *in vitro*. Although these preliminary experiments do not eliminate the possibility of a biosynthetic mechanism, they suggest that a complete pathway may be lacking. The possibility of the absence of a purine-synthesizing system in the mature mammalian erythrocyte is compatible with the absence of a number of other common metabolic processes, such as the synthesis of nucleic acid and protein, the Krebs tricarboxylic acid cycle, and the cytochrome system. It is also of interest to note[3] that in rabbit bone marrow, *in vitro*, there is a limited ability for the synthesis of nucleic acid purines from formate-^{14}C. Further studies bearing upon this problem are in progress.

Dilution of the isotope as a result of an exchange with preformed adenosine triphosphate is unlikely since there is little or no adenosine triphosphate in rabbit plasma and since the mature erythrocyte is considered to be impermeable to phosphorylated compounds. Phosphorylation of adenosine or inosine is unlikely because there appears to be no significant concentration of purine nucleosides in the peripheral blood. Furthermore, adenosine would be expected to undergo deamination by the active adenosine deaminase of the rabbit erythrocyte. Inosine is known to undergo extensive phosphorylytic cleavage in the rabbit erythrocyte.

The alternative explanation for the observations would result from a decreasing level of adenosine triphosphate in the erythrocyte during the *in vivo* ageing process so that the amount initially provided to the cell is gradually depleted. The decline in specific activity would be due to dilution by the adenosine triphosphate of younger cells in which the concentration would be at a higher level. There is some evidence bearing upon this possibility. It is known that the adenosine triphosphate concentration in reticulocytes is about 2·5 times that of mature erythrocytes[9]. The level of adenosine triphosphate in a sample of mature erythrocytes is actually an average concentration of adenosine triphosphate in a cell population of all ages. Our results may be explicable in terms of a progressive diminution in adenosine triphosphate content in each erythrocyte concomitant with ageing of the cell. If such a decline in the content of adenosine triphosphate of the aged erythrocyte occurs, it may result in the impairment of one or more reactions essential for the integrity of the erythrocyte and thus contribute to the demise of the cell. It is known that a decline of adenosine triphosphate in an erythrocyte accompanies *in vitro* ageing and, in fact, is responsible for the lost ability of *in vitro* aged cells to metabolize glucose because of the requirement of adenosine triphosphate for its phosphorylation.

The possibility that the content of adenosine triphosphate of the circulating erythrocyte is a determinant of its life-span is being studied.

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EXAMINATION OF CELLULOSE FIBRE BY THE LOW-TEMPERATURE SPECIMEN METHOD OF ELECTRON DIFFRACTION AND ELECTRON MICROSCOPY

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THE electron diffraction method has the advantage of yielding fairly intense diffraction patterns from a very small amount of material. Recent techniques of electron diffraction have improved this advantage further, making it possible to confine the effective specimen area to a very small size of the order of 1 × 1 μ^2. By means of a method originated by Hillier[1] we can focus the electron beam on an area of this size in specimens. By means of the three-stage electron microscope originated by Boersch[2] and le Poole[3], we can select the specimen area from the field of the highly magnified electron image. Preston and Ripley[4] applied this method to the study of the cell wall of *Valonia*. They verified the correspondence between the textural and atomic structures of the microfibril, and observed in detail the structure of the wall, which consisted of sheets of differently oriented microfibrils.

Unfortunately, however, the atomic structures of an organic substance like cellulose fibre are so liable to be damaged by irradiation in electron beams that the crystalline diffraction patterns can be observed for only a very short time. Preston and Ripley succeeded in taking photographs of the diffraction patterns from *Valonia* microfibril by reducing greatly the irradiating intensity. They stated in their report that it was also necessary to lower the accelerating voltage of electrons to as low as 25 kV. This condition seems to us rather unfavourable. The damage to atomic structure in the specimens is considered to be caused mainly by the rise in temperature of the specimens due to the electron bombardment; and the lowering of the accelerating voltage must increase the interaction of electrons with the specimens and so increase the rise in temperature. In fact, we observed that the crystalline diffraction patterns of *Valonia* microfibril were maintained for a longer time under irradiation by 100 kV. electrons than by 50 kV. electrons, though even with the higher accelerating voltage it was not easy to maintain the patterns longer than a few seconds under irradiations of usual intensity.

In order to avoid this difficulty we devised a method of cooling the specimens. Concerning cooling devices for specimens in an electron diffraction camera and in an electron microscope, one of us

(G. H.) and other collaborators[5] have previously reported in detail.

Cooling the specimens was, in fact, very effective in protecting them from damage. It was not difficult to observe the crystalline diffraction patterns from *Valonia* microfibril for as long a time as necessary even with fairly intense irradiation, namely, with irradiations giving apparent electron micrographs of direct magnification of 5,000.

Figs. 1 and 2 reproduce two pairs of electron micrographs and diffraction patterns of *Valonia* microfibril taken by Boersch–le Poole's method. Fig. 1 was taken without cooling and Fig. 2 by cooling the specimen to −40° C. The improvement in the diffraction pattern by cooling is evident. This specimen is composed of two sheets of microfibril having fibre axes along the directions indicated by the arrows.

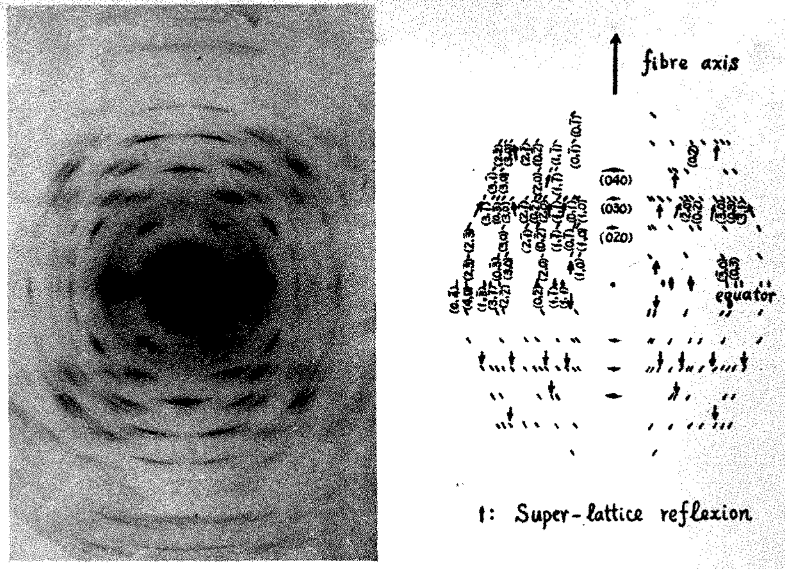
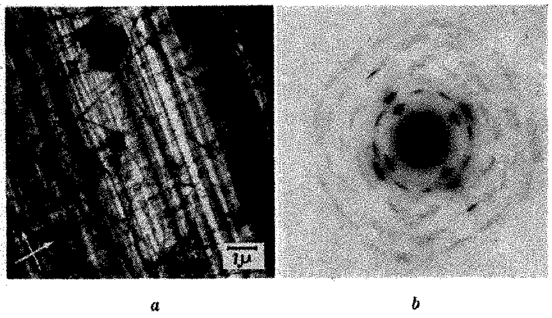


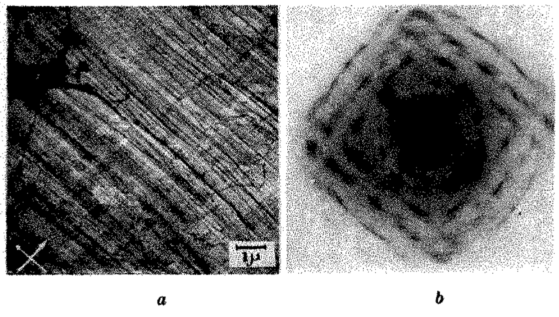
Fig. 3. Electron diffraction pattern of *Valonia* microfibril cooled to −100° C. taken by Hillier's method

Fig. 3 reproduces the electron diffraction pattern from *Valonia* microfibril cooled to −100° C. taken by Hillier's method. This specimen was composed of a single sheet of microfibrils. It may be noted that this pattern contains a very large number of reflexions having fairly good resolution up to as high as the tenth layer line. In Fig. 3 as many as 400 reflexion spots appear, while the usual methods give at most a few score reflexions. This improvement in the diffraction pattern is considered to have resulted partly from the reduction of the thermal agitation by cooling and partly from the selection of a good crystalline part in the specimen.



a b

Fig. 1. (*a*) Electron micrograph; and (*b*) electron diffraction pattern of *Valonia* microfibril taken without cooling by Boersch–le Poole's method



a b

Fig. 2. (*a*) Electron micrograph; and (*b*) electron diffraction pattern of *Valonia* microfibril cooled to −40° C., taken by Boersch–le Poole's method

Many of the reflexions in Fig. 3 can be indexed by a monoclinic unit cell having $a = 8{\cdot}39$ A., $b = 10{\cdot}58$ A., $c = 7{\cdot}94$ A., and $\beta = 82°$, which is nearly identical to that proposed for cellulose I by Meyer and Misch[6]. These reflexions are shown by the black circles in Fig. 4, which is the projection of the reciprocal lattice in the (010)-plane. The numerical figures attached to the circles indicate the indices of the layer lines on which the reflexions appeared. It has been reported that cellobiose chains within the microfibrils of *Valonia* have a selective orientation called 'biaxial' or 'uniplanar' orientation, that is, an orientation for which not only the *b*-axis is parallel to the fibre axis but also the (101) lattice plane is parallel to the plane of the wall. The appearance of the observed reflexions can be understood if we

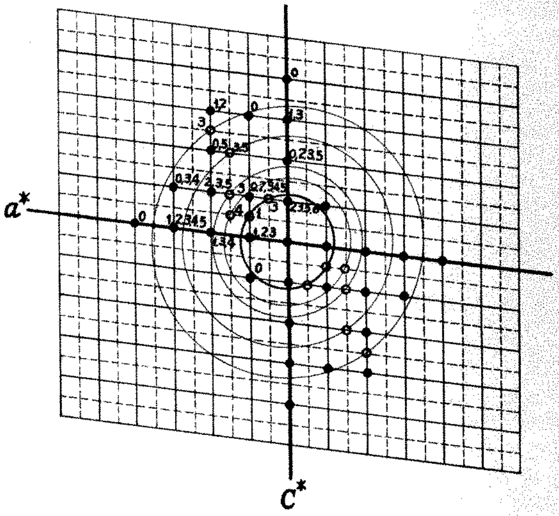


Fig. 4. (010)-Projection of reciprocal lattice. ●, Observed reflexions, which can be indexed by Meyer and Misch's unit cell; ○, super-lattice reflexions

assume that the specimen film of the microfibril was curled.

Two important points should be noted in this pattern. One point is that the reflexions (*hkl*) and ($\bar{h}\bar{k}\bar{l}$), for example, (032) and (03$\bar{2}$), have markedly different intensities. By observing the patterns for various inclinations of the specimen film around the fibre axis, it was concluded that the difference is not due to a trivial origin such as an asymmetric setting of the specimen, but rather to the difference in magnitude of the structure factors. This fact contradicts the structure of cellulose I proposed by Meyer and Misch, belonging to the space group $P_{2_1} = C^2{}_2$. The structure factor for the space group is given by

$$F_{hkl} = \begin{cases} 2\sum_j f_j \exp.(2\pi iky_j) \cos 2\pi\,(hx_j + lz_j) : k = \text{even} \\ 2i\sum_j f_j \exp.(2\pi iky_j) \sin 2\pi\,(hx_j + lz_j) : \ k = \text{odd} \end{cases}$$

by virtue of the two-fold screw axis, and would have the same magnitude for (*hkl*) and ($\bar{h}\bar{k}\bar{l}$) reflexions.

Another point to be noted in the pattern is the appearance of the reflexions indicated by the arrows (Fig. 3). They are on layer lines other than the equator. The reciprocal lattice points for these reflexions must lie upon the circles described in Fig. 4. Thus they can be indexed not by the Meyer–Misch unit cell, but by a unit cell having *a* and *c* periods twice as long as those of the Meyer–Misch unit cell.

Thus the structure appropriate for the pattern is decidedly different from the structure of cellulose I. Of course, it is different also from other structures proposed for cellulose, such as cellulose II, III and IV. It is certain that the cooling of the specimen did not influence the formation of the structure, since the reflexion characteristic of it was observed also for the specimen without cooling.

We have not yet established the details of the structure. But at least it is certain that the arrangement of cellobiose chains along the fibre axis has an order considerably different from that proposed by Meyer and Misch for cellulose I. We are not yet certain whether this structure is a new one or whether it is the correct structure for cellulose I. However, since the previous determinations of the structure of cellulose were based generally on X-ray diffraction patterns of poor resolution, their renewed examination by the new technique used above seems to be worth while.

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DISTRIBUTION OF TRITIUM-LABELLED THYMIDINE IN *ESCHERICHIA COLI* DURING CELL MULTIPLICATION

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CONSIDERABLE evidence[1] shows that deoxyribonucleic acid is at least one of the chemical constituents capable of carrying and transmitting genetic information in biological systems. The replication of deoxyribonucleic acid is thus an essential prerequisite to the multiplication of organisms, and fresh insight on this problem has been obtained at such widely separated points of the biological spectrum as bacteriophage by Levinthal and Thomas[2,3] and plant chromosomes by Taylor, Woods and Hughes[4]. The use of phosphorus-32 as a specific deoxyribonucleic acid label in the phage experiments was possible because the acid is probably the exclusive location of phage phosphorus[5,6]. In cellular systems, the presence of several phosphorus-rich components considerably complicates the analysis of tracer experiments. Biochemical evidence indicates the predominant fate of thymidine to be a precursor of deoxyribonucleic acid[7-9]. Plaut and Mazia[10] were the first to use this nucleoside, labelled with carbon-14, in experiments concerned with deoxyribonucleic acid replication. Recognizing the greater resolution to be expected with tritium, Taylor, Woods and Hughes[4] prepared tritium-labelled thymidine, with which they have been able to demonstrate a remarkable orderliness for the replication of the deoxyribonucleic acid of individual chromosomes in plant roots. In bacteria, the morphological organization of the acid is far from clear. Using phosphorus-32, some limits have been placed on this organization and the mode of replication of deoxyribonucleic acid in *Micrococcus cryophilus*[11] and in *Escherichia coli* B/r[12]. The availability of tritiated thymidine of suitable specific activity and of a thymine-requiring strain of *E. coli* (*Escherichia coli* 15 T-), the deficiency of which can also be satisfied by thymidine[13], made it seem useful to study the distribution of the incorporated label among the daughters of labelled cells following growth on unlabelled medium. Since the experiments almost immediately indicated a rather striking qualitative result, we felt it worth while to communicate our initial observations.

Escherichia coli 15 T- was kindly supplied by Dr. Hazel Barner. Thymidine, labelled with tritium on the pyrimidine ring, was radiochemically pure as judged by crystallization with carrier (analysis by Schwarz Laboratories, Inc., Mt. Vernon, New York, which are now supplying the material). The specific activity was approximately 2 µc./µgm. Liquid glucose-mineral medium containing 2–4 µgm./ml. of tritiated thymidine was inoculated with a log-phase culture, suitably diluted to minimize carry-over of unlabelled thymidine. Following at least 100-fold growth at 37° C. in the labelled medium, two types of

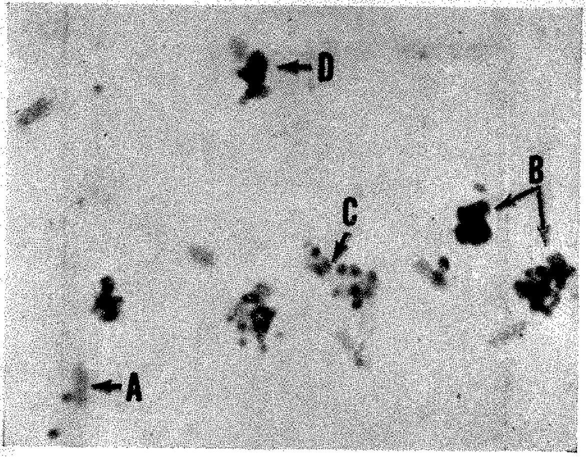

Fig. 1. Autoradiograph (× 1,600) of *E. coli* labelled with tritiated thymidine and grown in non-radioactive medium for about three generations. *A*, an example of cell showing no label; *B*, clusters of grains caused by heavily labelled cells, the grains overlying and obscuring the bacteria; *C*, an example of lightly labelled cells, where eleven individual grains can be observed over three or four cells; *D*, an example of an 'all-or-none' split, where one of a pair of cells has a cluster of grains over it, while the other has none

experiments were performed. In the first, the cells were washed in saline and grown in medium containing excess unlabelled thymidine. Direct cell counts from aliquots were taken at the time of inoculation and every 30 min. thereafter. Each time a doubling of the population of the culture occurred, as determined by the direct cell count, smears were made. These were fixed by heat, washed with water, and autoradiographs made by the stripping film technique[14]. After various exposure times, varying from 5 to 40 days, the slides were developed and stained with 0·04 per cent crystal violet. In the second type of experiment, labelled cells were isolated micromanipulatively on nutrient agar medium which contains excess unlabelled precursor. Progeny lines were obtained from these isolates, cell growth stopped by drying the agar medium, and stripping film autoradiographs made after fixing in 3 : 1 ethyl alcohol–glacial acetic acid and a series of alcohol–water solutions.

Both experiments revealed very clearly that the distribution of the incorporated tritium from the tritiated thymidine among the daughter cells grown on unlabelled medium is very heterogeneous (Fig. 1). At least as soon as the third generation and possibly sooner, one finds cells with no label in the presence of those containing considerable label. In the liquid-culture experiment, all-or-none splits, where one of an unseparated pair of cells exhibited heavy label (6–14 grains) while the other had no grains above it, were observed occasionally. Even allowing for some possible trackiness which appears to be present in the grain patterns, the magnitude and frequency of such splits made it extremely unlikely that they occur by chance. Such all-or-nothing splits are also seen in the micromanipulation experiments where the sibling relations in the progeny line are known. These micromanipulation experiments indicate that the heterogeneity observed in bulk culture experiments is not primarily a result of the death of the cell (from radiation or any other cause) and/or differences in growth-rates for individual bacteria.

Two additional comments can be made: (1) At the first division on cold medium, no case of all-or-nothing distribution has yet been seen even though attempts were made to select the smallest possible labelled cells as the sources of a progeny line. (2) Each clonal line does not show the same distribution of label. Specifically, each starting cell does not give rise to a unique number of hot cells dispersed among other cold ones; rather, the distribution of grains differs from clone to clone. In some, the distribution would be difficult to distinguish from random. In the rest, 'hot spots' and all-or-nothing splits occur at different frequencies and in patterns which still require deciphering.

The question of whether all the label is in bacterial deoxyribonucleic acid has not been completely settled. The best chemical estimates to date indicate that no less than 80 per cent is in deoxyribonucleic acid thymidine. Check experiments with two organisms not requiring thymine for growth, *Bacillus megaterium* and *Escherichia coli* B, showed that the uptake of tritiated thymidine was less than 10 per cent of that of *E. coli* 15 T-.

The observation that simple dilution of tritiated thymidine during growth does not occur would seem to indicate that relatively large amounts of parental deoxyribonucleic acid can remain functionally associated in transmission to daughter cells. It is also clear that the extent of this association of the parental deoxyribonucleic acid differs from clone to clone; that is, there is a reasonable probability of a sharing of at least some of the parental deoxyribonucleic acid between daughters at division. These results are not inconsistent with findings for deoxyribonucleic acid phosphorus-32 distribution in another bacterium[11]. Whether the functional two-strandedness of both phage and plant chromosomal deoxyribonucleic acid will be found to hold for bacteria is not clear from the results, although the lack of all-or-nothing splits at the first generation and their appearance in later generations are not in conflict with this possibility.

An exclusive model to explain these results depends, among other things, on independent information concerning the number of deoxyribonucleic acid-containing structures within a bacterium and on the quantitative aspects of the distributional patterns. We hope to report in more detail on these problems in the future.

We would like to express our thanks to Dr. J. H. Taylor for his interest and helpful discussion during the course of this work. The second author wants to express his sincere appreciation to Miss D. Patricia Frost for her excellent assistance in performing his part in these experiments.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Rate of Accretion of Cosmic Dust on the Earth

As guest professor of geophysics at the University of Hawaii, I have had opportunities for collecting cosmic dust by filtering large volumes of air through fine-pored filters at Mauna Loa Observatory on Hawaii (11,000 ft.) and from the summit of Mt. Haleakala on Maui (10,000 ft.), localities where the air is generally free from terrestrial dust to a remarkable degree. The filters were analysed for the radioactive fall-out products, strontium-89 and strontium-90, in the laboratories of the U.S. Atomic Energy Commission in New York, and for iron, nickel and cobalt in the II Chemisches Institut der Universität, Vienna. I am indebted to Mr. John H. Harley for the strontium analyses, which will be published elsewhere, and also to Prof. F. Hecht and his collaborator Dr. E. Tomic of Vienna for carrying out the analyses for the ferrides.

Of the twenty-two filters from Mt. Haleakala so far analysed for ferrides, all contained notable quantities of nickel, whereas in seven of the nine filters from Mauna Loa nickel was also found, far in excess of any possible contamination from terrestrial sources. The average weight of nickel per 1,000 m.^{3} of air passed through the filters was 14·3 μgm. as compared with 1,577 μgm. of iron, that is, a nickel to iron ratio of 0·9 per cent. Cobalt was also found in several of the filters, although in much smaller quantities than nickel, the ratio of cobalt to iron being 0·2 per cent.

The weight of cosmic dust on the filters may be estimated from the nickel content using the average amount (2·5 per cent) of nickel in meteorites of all kinds quoted by F. G. Watson[1], which gives a weight of meteoric dust of 572 μgm./1,000 m.^{3} of air.

Assuming the dust-content of cosmic origin in the atmosphere to be uniform up to the 100-km. level, for the whole atmosphere below that level a quantity of suspended dust of cosmic origin of 28·6 million tons is obtained.

In order to find from this figure a value for the annual increment of cosmic dust to the Earth, we have to assume a probable rate of descent from the 100-km. level to the 3-km. level, where the dust was collected. In the case of the finest volcanic dust from the Krakatoa eruption in 1883, according to W. J. Humphreys[2], it required about two years to settle down to the Earth's surface. With a similar rate of descent, the cosmic dust suspended in the atmosphere should be renewed in the course of two years, which makes the annual increment of such dust to the Earth equal to one half the figure given above, or 14·3 million metric tons. If more rapid renewal of the cosmic dust suspended in the atmosphere is assumed, the annual increment becomes correspondingly higher.

Comparing this figure with Van de Hulst's value[3] for the weight of the interplanetary dust giving rise to the zodiacal light and being swept up by the Earth, as 1,700 tons a day, one obtains a rate of accretion for interplanetary dust to the Earth of only a little more than 4 per cent of that for meteoric dust, or 0·62 million tons a year.

On the other hand, Watson assumes the total weight of meteoric matter reaching the Earth to be "between 1,000 or, perhaps, 10,000 tons per diem" (ref. 1, p. 94). Even with the higher of these two estimates, one finds that a total weight of 3,650,000 tons of meteoric matter should reach the Earth annually, or about one-fourth of that estimated from these experiments.

Considering the general interest for many different branches of geophysics of the rate of accretion of cosmic dust, these discrepancies call for repeated and extended experiments of this kind at other high-altitude observation posts.

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Oct. 31.

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Energy Spectrum of Cosmic Radiation

THE spectrum of cosmic radiation has the remarkable property that it is a power function

$$f = \text{const. } p^{-n} \qquad (1)$$

(where p is momentum), in which n has a constant value of about 2·5 for several powers of ten of p. In Fermi's theory, n is given by the ratio τ/T between the time of acceleration τ and the time of absorption (or diffusion) T. This means that the empirical formula is obtained only if one assumes that accidentally τ and T are of the same order of magnitude, and that the ratio is constant over a very wide range of momentum. Neither of these assumptions is plausible.

It is the purpose of this communication to point out that a power law can be obtained if we assume that particles, which are injected at low energies, are pumped up to higher energies by a pump, the speed of which is a power function of the momentum. No considerable loss of particles should occur during the acceleration, but when the particles have reached the maximum energy which can be stored in the accelerator, they leave the accelerator. (In this way the time of dissipation is determined by the time of acceleration.) Hence all cosmic-ray particles move up through the energy spectrum in a more or less systematic way, and the time they spend in a certain energy-range is inversely proportional to the speed of the pump.

This effect can be produced in several ways, and we shall consider a mechanism in which the betatron effect is combined with a scattering or diffusion of the particles[1]. If the magnetic field H in a certain volume U' increases, the momentum p of charged particles in the volume increases by Δp, which is proportional to p. If the particles are scattered, or diffused out of U' to an adjacent volume where H is constant, and later the field in U' returns to its initial value, the net result of the process is that a number of particles fU' have increased their momenta by

$$\Delta p = \alpha p \qquad (2)$$

where α is a constant. If the process is iterated and low-energy particles are injected at a constant rate, this leads to a power spectrum with $n = 1$.

If this process takes place in the neighbourhood of the Sun under influence of varying magnetic fields produced by solar activity (cf. ref. 1), the value of n may be changed for geometrical reasons. Particles that have gained enough energy diffuse away from the environment of the Sun and fill a volume U which we may put equal to :

$$U = \beta p^b \quad (3)$$

where β is a constant and $b = 2$ or 3 depending on the properties of the trapping field. They may be accelerated further, but at a slower rate because the average value of α decreases when the distance from the Sun increases. Hence α depends implicitly on U, and we may put :

$$\alpha = a . U^{-\nu} \quad (4)$$

A stationary state requires that the number of particles dn passing a certain momentum p is independent of p. Thus we have :

$$U f \Delta p = \text{const.}$$

or from (2), (3) and (4) :

$$f = \text{const. } p^{-n}$$

with $n = b(1 - \nu) + 1$. An agreement with the observational value $n = 2{\cdot}5$ requires $\nu = 0{\cdot}25$ for $b = 2$, or $\nu = 0{\cdot}5$ for $b = 3$.

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Confinement of Charged Particles by a Magnetic Field

DIFFUSION which is caused by collisions in an ionized gas and which takes place across a magnetic field is known to be reduced by the field. The gas may be confined to a limited region, provided that particles can escape neither by motion along the field nor by drift motion across it. In the longitudinal direction, the particles may be trapped by strong field inhomogeneities[1] or simply by having the field lines closed within the gas volume.

Axially symmetrical, stationary magnetic fields **B** and electric fields **E** will be discussed in the present communication. The radius of gyration of a particle is assumed to be small and the drift velocity $\mathbf{u} = \mathbf{u}_\parallel + \mathbf{u}_\perp$ to be determined by[2] :

$$\mathbf{u}_\perp = \left(q\mathbf{E} - \mu \nabla B - m\frac{\mathrm{d}\mathbf{u}}{\mathrm{d}t}\right) \times \mathbf{B}/(qB^2) \quad (1)$$

where (‖) and (⊥) denote directions parallel with and perpendicular to **B**, q the charge, m the mass, μ the magnetic moment of the equivalent dipole representing the gyrating particle and $\mathrm{d}/\mathrm{d}t = \partial/\partial t + (\mathbf{u}.\nabla)$. We write :

$$(\mathbf{u}\cdot\nabla)\mathbf{u} = (\mathbf{u}_\parallel\cdot\nabla)\mathbf{u}_\parallel + (\mathbf{u}_\parallel\cdot\nabla)\mathbf{u}_\perp + (\mathbf{u}_\perp\cdot\nabla)\mathbf{u}_\parallel + (\mathbf{u}_\perp\cdot\nabla)\mathbf{u}_\perp \quad (2)$$

A magnetic field produced by a toroidal coil forms circles around the axis of symmetry, that is, the z-axis in a co-ordinate system (r, φ, z). Particles cannot be trapped in the field which gives rise to a drift motion in the z-direction.

Instead, a poloidal field is considered as shown in Fig. 1, where both **B** and **E** are supposed to be situated in planes through the z-axis. **E** may arise partly from ambipolar diffusion. The first and the fourth terms in the right-hand member of equation 2 give centrifugal forces in planes through the z-axis, whereas the third term as well as the second term give a contribution $\mathbf{u'}_\perp$ to the total drift velocity $\mathbf{u}_\perp$. The velocity $\mathbf{u'}_\perp$ is situated in planes through the z-axis, whereas all other contributions, $\mathbf{u}_\perp - \mathbf{u'}_\perp$, are drift motions in circles around the same axis. The motion $\mathbf{u'}_\perp$ of ions differs from that of electrons, and this may cause a separation of charge and generate an electric field. However, the drift arising from this additional field will be situated in the φ-direction, provided that the density distribution of the particles is axially symmetrical. The relative importance of $\mathbf{u'}_\perp$ is roughly estimated from equations 1 and 2 :

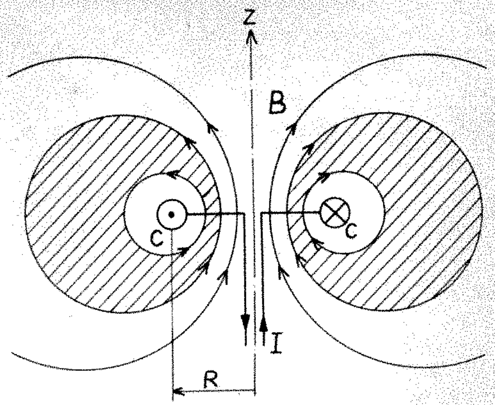

Fig. 1. The magnetic field **B** generated by a circular coil C

$$\mathbf{u'}_\perp/\mathbf{u}_\perp \approx m u_\parallel / qBR \quad (3)$$

If the gas approaches thermodynamic equilibrium, the velocity of gyration becomes comparable to $u_\parallel$, and $u'_\perp/u_\perp$ is nearly equal to the ratio between the radius of gyration and the characteristic distance R. As an example, we may choose an ionized deuterium gas at $T = 10^8$ °K. in a magnetic field $B = 30$ V.sec./m.^{2} (3×10^5 gauss) produced by a coil of radius $R = 5$ m. For ions, $u'_\perp/u_\perp$ becomes about 10^{-4} and for electrons about 10^{-6}. Even if the electric field should be as high as $V/R \approx 3 \times 10^3$ V./m., where V is the potential drop corresponding to the particle energy $3kT/2$, the drift $u'_\perp$ is not greater than 4×10^{-2} m./sec. for ions and 6×10^{-4} m./sec. for electrons. Ions will escape after about 50 sec. if only the drift $\mathbf{u'}_\perp$ is taken into account and particle interactions are neglected. Thus, a strong magnetic field is able to trap particles effectively inside a region such as that shaded in Fig. 1, at least at low gas densities.

Time variations of the magnetic field induce an electric field E_φ and a drift $\mathbf{u''}_\perp$ in planes through the z-axis, directed outwards from the coil windings when $\partial B/\partial t$ is positive. It has the magnitude :

$$|\mathbf{u''}_\perp| \approx (R/B)\cdot\left|\frac{\partial B}{\partial t}\right| \quad (4)$$

and may be regarded as a motion of matter 'frozen to' the magnetic-field lines. If B is changed by the amount ΔB during the time Δt, the displacement by the drift $\mathbf{u''}_\perp$ becomes about $R\Delta B/B$.

The magnetic field may be produced by a coil C as in Fig. 1, where the areas of the coil connexions are made as small as possible. If, in the immediate neighbourhood of the connexions, the magnetic field from the supply current predominates over the field from the coil, particles will be reflected and will not be absorbed by the connexions. The field from the supply current gives an additional drift in planes through the z-axis; but since the connexions carry current in opposite radial directions, a cancellation of the drift takes place for particles passing around the z-axis repeatedly. Further, the coil windings will have finite electric conductivity and a stationary electric field will be generated by a potential drop in the φ-direction. This field should be screened by a metal coating around the coil and its connexions.

Charged particles may be injected by sources touching the outer edge of the shaded area in Fig. 1. A slowly decreasing magnetic field may possibly produce an inward drift which prevents the particles from hitting the sources repeatedly.

Confinement at high gas densities is outside the scope of this short communication and requires more knowledge about the stability of the field, the pressure balance and the interactions between particles. The coil windings may act as a metallic wall and have some stabilizing effect on deformations of the magnetic field by motion of the gas. A particle density $n = 6 \times 10^{22}$ m.$^{-3}$, corresponding to a pressure $P \approx B^2/4\mu_0$, gives a reaction time of 15 sec. in the example above. The behaviour of a toroidal induced discharge[3] is of great interest in the present connexion.

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A Travelling-Wave Parametric Amplifier

THE principle of parametric excitation of an oscillatory system has been known for many years. An electric oscillatory circuit can be excited in this way if the condenser plates are instantaneously pulled apart by a fixed amount whenever the voltage reaches a maximum value, and instantaneously restored to their original positions when the voltage is zero. Under these conditions energy is communicated to the circuit when the plates are pulled apart; but none is extracted when they are restored, and so oscillations can be maintained. The capacitance/time graph envisaged in the foregoing is a square wave at twice the resonant frequency of the circuit; but it can be shown that a sinusoidal variation at twice the resonant frequency may be used. Any method of periodically varying the capacitance may be used, or alternatively the inductance may be varied. Moreover, such a circuit can be used as an amplifier, since, at the fundamental frequency, the excitation mechanism is analogous to negative resistance.

In considering the possibility of obtaining a useful amount of parametric amplification at high radio-frequencies, a travelling-wave type of parametric excitation has been studied. It has been found that a loss-less transmission line having distributed inductance per unit length given by:

$$L = L_0[1 + \eta \sin 2(\omega t - \beta x)]$$

and constant distributed capacitance C_0 per unit length will support a growing current wave of the form

$$i = i_0 \exp(\alpha x) \sin(\omega t - \beta x + \varphi)$$

where

$$\alpha \doteqdot \omega\sqrt{L_0 C_0}.\frac{\eta}{4} \cos 2\varphi$$

$$\beta \doteqdot \omega\sqrt{L_0 C_0}\left(1 - \frac{\eta}{4} \sin 2\varphi\right)$$

If $\cos 2\varphi = 1$ the maximum possible amplification is obtained and $\alpha = \omega\sqrt{L_0 C_0}.\frac{\eta}{4}$ nepers per unit length. Under these conditions it is also found that $\beta = \omega\sqrt{L_0 C_0}$.

For example, if $\eta = 0{\cdot}1$, a gain of 1·36 db./wavelength is theoretically obtainable. However, this amplification is only obtained when the frequency ratio is precisely 2, and the correct phase relationship must be preserved if the maximum amplification is desired. Thus, the oscillator used for providing the periodic variation of inductance must be synchronized to the incoming signal.

The noise figure of such an amplifier should be very favourable, and an experimental study is being made. Related schemes, in which precise frequency and phase relationships are not demanded, are also being studied.

I am greatly indebted to Mr. I. M. Ross of the Services Electronics Research Laboratory, Harlow, for a stimulating conversation about parametric amplification.

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Nov. 12.

Lattice Image of Twin Structure observed directly by Electron Microscope in a Crystal of Copper Phthalocyanine

RECENTLY, with the increase of the resolving power of the electron microscope, it has become possible to make a direct observation of a crystal lattice composed of large molecules. J. W. Menter[1] succeeded for the first time in observing the lattice structure and the edge dislocation contained in it in crystals of metal phthalocyanines. This method is also applicable to the study of the local variation of the fine structure in a crystal lattice, and the so-called selected area micro-diffraction method, when used jointly with this method, has proved its further usefulness.

As an example of such an application, we have observed directly the twin structure in the crystal lattice of the stable copper phthalocyanine, which has a lath-shaped crystal habit. It is well known that this substance has a crystal structure with space group $P\,2_1/a$ of the monoclinic system, as reported by Robertson[2], and a crystal habit in which generally the (001) plane is the largest habit surface; the crystal lath usually lies on this surface, and the b-axis coincides with the direction of the longest edge of the lath-shaped crystal. The lattice image of the $(20\bar{1})$ plane was observed by Menter with the crystal of such habit. Further investigation has shown that some crystals of the stable copper phthalocyanine frequently acquire another lath-shaped crystal habit in which the lattice plane (001) runs almost perpendicular to the flaky habit surface, which may correspond to such a plane as $(20\bar{1})$, contrary to the ordinary crystal habit. We have also taken electron micrographs of the lattice image corresponding to the (001) plane as reported in the previous paper[3]. The periodic spacing of the lattice image of the $(20\bar{1})$ plane is about 9·8 A., even when the effect of the slight inclination of the lattice plane to the surface of the usual habit is taken into consideration, while that of the (001) plane is estimated to be about 12·6 A. and is obviously larger than the spacing of the $(20\bar{1})$ plane in the ordinary crystal habit.

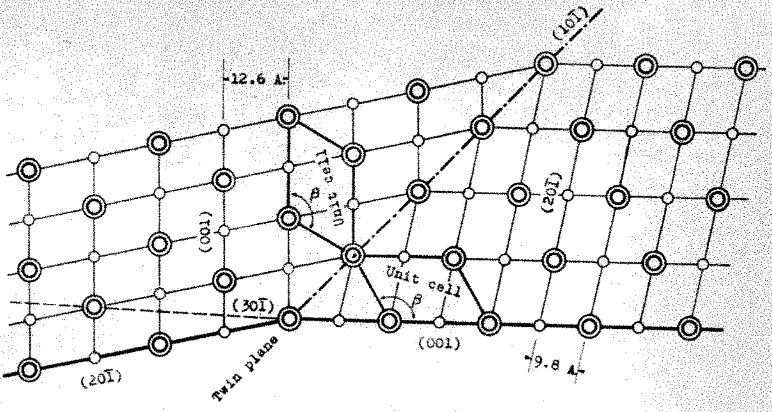

Fig. 2. Molecular configuration of the twin structure of copper phthalocyanine, projected on the *b*-plane. Small circles are at the level of $\pm \frac{1}{2} b_0$

As shown in Fig. 1, which was taken with a Hitachi electron microscope type *HU*–10, it is often observed that the lattice images of these two crystal habits are parallel and side by side, separated only with a narrow gap. The specimen used here was a stable copper phthalocyanine prepared by boiling the powder of the metastable compound with carbon tetrachloride for about 10 hr.; and it had been completely converted into the stable form. The electron micro-diffraction pattern of the selected area has two series of equidistant diffraction spots that are attributable to $(20\bar{1})$ and (001) reflexions with their higher-order reflexions superimposed on the equator, which is taken in the direction perpendicular to the *b*-axis.

We believe that such a fine structure containing the two different kinds of lattice images is due to the twin structure and is not caused by a fortuitous contact of two kinds of completely separate crystals, because the gap between the two lattices is always very narrow and has almost the same magnitude as the lattice spacing itself. Further, no contour fringe can be observed at the boundary of the two parts, even when the photograph was taken slightly out of focus so that another part of the perimeter would be bounded by the contour fringes.

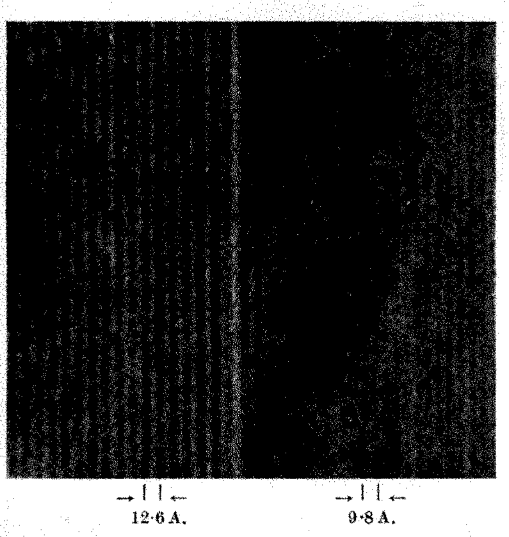

Fig. 1. Lattice image of lath-shaped copper phthalocyanine containing a twin structure

The relation between these two kinds of crystal habits and the twin structure must be considered from the point of view of the molecular arrangement. As the direction of the *b*-axis is common to the separate two parts, and the boundary is also parallel to the same axis, it is reasonable to consider that the twin plane is one of the (*h*0*l*) planes which is also parallel to the same axis. Taking the two kinds of crystal habit into consideration, the most appropriate twin plane, by which the largest habit surface of each part can be brought into a position nearly parallel to the supporting film for electron microscopy, is the $(10\bar{1})$ plane as shown in Fig. 2, in which the two kinds of the largest crystal habit surface, shown by the thick line, cross at an angle of about 14°. With this structure, the crystal can orient itself so that the incident electron beam can simultaneously satisfy the Bragg condition for both the $(20\bar{1})$ and the (001) planes, which contain an angle of about 14°; furthermore, slight relaxation of the bent crystal on the film and the elongation of the intensity region for reflexion accompanying the reciprocal lattice points (caused by the thinness of the lath crystal itself), give the reflexions from the two parts at the same time, thus enabling the lattice image of the twin structure to be observed by the electron microscope. As shown by the broken line in Fig. 2, if the $(30\bar{1})$ plane, in place of the $(20\bar{1})$ plane, is taken as the largest crystal habit surface for the part where the (001) plane runs perpendicularly to the habit surface, the flaky surface of the crystal lath becomes approximately flat as a whole. But the possibility of such structure is considered to be rather small, because the molecular density in the lattice plane of the outer crystal habit surface becomes extraordinarily small compared with the former structure.

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Density of Water sorbed on Montmorillonite

In a recent communication, Anderson and Low[1] have described some investigations indicating that the water present in Wyoming bentonite (montmorillonite) pastes has a density lower than that of liquid water. It should be noted, however, that this does not preclude the water sorbed in the primary process having a close-packed structure around the ions[2], and consequently having a much higher density. For example, for monovalent or divalent ions the amount of such water would only be some 4 or 12 molecules, respectively, per ion, and if the additional sorbed water were considered to have, say, the hexagonal-net structure[3], the density of which would be about 0·9, the value for the density of the sorbed water would drop rapidly at water contents above about 7–10 per cent, and for pastes with 60 per cent water[1] could easily be less than unity. Such a decrease in density of sorbed water is well shown by the results of De Wit and Arens[4], who obtained values as high as 1·41 at 11·6 per cent moisture, dropping to 0·997 above 30 per cent. Somewhat similar results were obtained in this Institute some time ago using a density-bottle technique with a specially devised de-airing procedure and 'Dekalin' as the non-sorbed liquid. Values ranging from about 1·38 at 9 per cent water to about 1·06 at 20 per cent water were obtained—in substantial agreement with the results of De Wit and Arens[4].

The validity of any results for the density of sorbed water are, however, extremely difficult to assess, since every value must necessarily involve the volume of the sorbed water, and this has to be estimated on the assumption that the amount of swelling of the mineral represents the volume of this water. Irrespective of water content, this can only be true if the surfaces of the individual mineral layers are impermeable. It is well known, however, that the layer surfaces of montmorillonite are not continuous but consist of a hexagonal network of oxygen ions with holes of approximate radius 1·3 A. On complete removal of water, ions can, at least partially, fit into these holes. Furthermore, recent unpublished work with montmorillonite saturated with various cations suggests that the oxygen ions of UO_2^{2+} may, to some extent, fit into the holes when the mineral is in the collapsed condition (cf. the results of Nuss and Wey[5]). It is reasonable, therefore, to suppose that at least some water molecules may find their way into such holes, and thus have an apparent density approaching infinity. This factor would influence results whether clay pastes or clay powders are used, and all results must be influenced thereby. It is not possible at present to determine the magnitude of error likely to arise from this cause, or even to decide whether it is appreciable. The fact that montmorillonite equilibrated at 0 per cent relative humidity has, according to De Wit and Arens[4], a higher density than clay oven-dried to 0·0 per cent moisture, cannot be used as an estimate of the size of the effect, since (although no details are given) it is likely that the oven-drying was carried out at 105° C. when a few per cent of sorbed water was still present. In the results obtained at this Institute drying at 190° C. was employed.

Another factor only operative at low water contents is the assumption that the layers are sufficiently flexible to fit closely around the interlayer water 'islands'. Any departure from this condition would tend to act in the opposite way from the above effect and give low values. The magnitude of the error likely to arise from this factor is also unknown, but the two opposing tendencies cannot balance since this error becomes less the higher the proportion of water.

From the above considerations, it would appear that no very useful conclusions regarding interlayer water configuration can yet be drawn from density measurements.

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Amino-acids in Anthracite

A topic of current interest in palæo-biochemistry is the demonstration of chemical constituents in fossils from the earliest plant and animal life. It has been shown that bones of great archæological age may contain appreciable amounts of organic nitrogen[1,2]. Even such highly organized compounds as amino-acids have been identified in fossil shells and bones[3].

As a contribution to these investigations, it seemed worth while to analyse the protein remains in anthracite—one of the oldest fossils known.

The central part of a thoroughly rinsed piece of anthracite from a British mine was ground into a powder in a mortar. After drying, 100-mgm. aliquots of the powder were hydrolysed in ampoules with 6 *N* hydrochloric acid for 24 hr. at 100° C. The hydrochloric acid was afterwards removed by means of freeze-drying. The residue was dissolved in distilled water, filtered to remove coal particles and evaporated *in vacuo* to dryness. The residue was redissolved in 0·2 ml. of distilled water. 100 µl. of the solution were applied to paper sheets (Whatman No. 4) for two-dimensional chromatography in phenol and colloidin–water systems according to Dent[4]. The amino-acid spots revealed with ninhydrin were allowed to develop for 24 hr. in the dark and preserved by treatment with a solution of cupric nitrate in ethanol. The semi-quantitative estimations of the amino-acid content of the spots were made according to Dent[4]. The α-amino-nitrogen content was determined by a method suggested by Woiwod[5].

After two-dimensional paper chromatography, aspartic acid, glutamic acid and glycine could be demonstrated in the coal samples. The semi-quantitative estimation showed a relative proportion of 12 per cent aspartic acid, 40 per cent glutamic acid and 48 per cent glycine. The α-amino-nitrogen content was 0·12 per cent, which roughly corresponds to 1 per cent of amino-acids in the original anthracite sample.

Amino-acids have thus been demonstrated in fossils about 250 million years old. Because of the procedure used for the preparation, it is impossible to tell whether these amino-acids are free or the result of the hydrolysis of peptides, though it is highly probable that the source of the amino-acids was the original proteins. We cannot, however, give any satisfactory explanation as to why only these three amino-acids, namely, aspartic acid, glutamic acid and glycine, were left unchanged by time, but it is interesting in this connexion to note that Ezra and Cook[6] recently reported the finding of these three amino-acids in fossil bones some thousand years old. Abelson[3] demonstrated the same three amino-acids, together with alanine, leucine and valine, in a fossil of Devonian age.

It is furthermore tempting to correlate our results with those of Chen and Rickenbacher[7], who found traces of aspartic acid and glutamic acid in amphibian eggs. Not until in the gastrula and blastula stages did the rest of the amino-acids appear.

These investigations thus suggest that aspartic acid, glutamic acid and glycine are among the first amino-acids to be formed and the last to be decomposed in living organisms.

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Small-Scale Preparation of Glyoxylic Acid labelled with Carbon-14

During the course of a study of glyoxylic acid metabolism in wheat it became desirable to obtain glyoxylate labelled with carbon-14, a compound which does not appear to be available commercially. Oxalic acid, which is available commercially as oxalic acid-^{14}C, has been used in the synthesis of glyoxylic acid[1–4]. Weinhouse and Friedmann[5] synthesized glyoxylate-^{14}C from oxalate-^{14}C by reduction with mercuric chloride and Grignard magnesium. In order to isolate the crystalline bisulphite addition product of glyoxylate it was necessary to dilute the oxalate-^{14}C (2·25 mgm.) with 900 mgm. of inactive oxalate. Tafel and co-workers[3,4] introduced an electrolytic method for the reduction of oxalate to glyoxylate. These workers used relatively large amounts of oxalate (10 gm.) and obtained very high yields (87 per cent). The reaction was carried out in 10 per cent sulphuric acid at 10° C. with a current of 4 amp. and was complete in 30 min. Mohrschulz[2] investigated the reaction more thoroughly and showed that it could be carried out in 2 per cent sulphuric acid at a temperature of 15–20° C. The highest yields were obtained using mercury as the cathode (rather than lead, copper or nickel).

We have found it possible to extend the electrolytic method to the reduction of milligram quantities of oxalate and have obtained high yields of glyoxylate. The electrolysis apparatus (Fig. 1) consists of a vessel 1·4 cm. in diameter and 2·4 cm. high containing 1 ml. of mercury, a 4½-volt dry-cell battery, and two 26-gauge platinum electrodes.

0·1 ml. of 2 per cent sulphuric acid containing 0·14–3 mgm. of oxalic acid is pipetted into the beaker to form a peripheral layer into which dips the anode. The cathode leads through a short length of glass tubing (diam. 5 mm.) into the mercury.

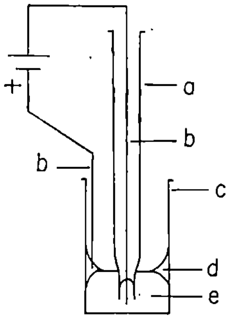

Fig. 1. Electrolysis apparatus used in the reduction of oxalic acid: *a*, glass tube; *b*, 26-gauge platinum electrode; *c*, glass beaker, diameter 1·4 cm.; *d*, reaction mixture; *e*, mercury cathode. Power source is a 4½-V. dry cell

The effects of the quantity of oxalate and of the reaction time on the yield of glyoxylic acid were studied. Some results are shown in Table 1. Glyoxylic acid was determined quantitatively as its 2,4-dinitrophenylhydrazone. The reaction products were treated with a slight excess of 2,4-dinitrophenylhydrazine in 2 *N* hydrochloric acid and the mixture extracted into ethyl acetate. The ethyl acetate extract was washed with ethyl acetate, made to volume and its density determined spectrophotometrically at 368 mμ using a Beckman model *DU* spectrophotometer.

Glyoxylic acid 2,4-dinitrophenylhydrazone was identified by paper chromatography[6]. This compound gives two spots on chromatograms which are recognizable by their R_F values and by their characteristic colour reaction with ethanolic sodium hydroxide.

With 0·7 mgm. of oxalic acid a reaction time of 10 min. was found to be very satisfactory. After a number of trials with inactive oxalate which gave consistently high yields (about 95 per cent), radioactive oxalate was used. 0·7 mgm. oxalic acid-^{14}C (26·5 μc./mgm.) in 0·1 ml. of 2 per cent sulphuric acid was electrolysed for 10 min. and the reaction solution was chromatographed in one direction on Whatman No. 1 paper by the ascending method, using chloroform/95 per cent ethanol, 1/1 + 2 per cent (v/v) formic acid[7] as solvent. In this solvent system the R_F values of oxalic and of glyoxylic acids are 0·06 and 0·80 respectively. Counting the radioactivity directly on the paper showed approximately 95 per cent of the activity in glyoxylate, 3 per cent in oxalate and 2 per cent in an unidentified band of R_F 0·9. The identity of the zone corresponding to glyoxylate was verified by elution of the band with water, and reaction of the eluate with 2,4-dinitrophenylhydrazine followed by paper chromatography. In addition, the 2,4-dinitrophenylhydrazone was hydrogenated, and the resulting radioactive glycine identified with two-directional paper chromatography[8].

The advantages of this method for preparing glyoxylic acid-^{14}C are that it is simple, rapid and inexpensive. Because it is suitable for use with small

Table 1. Yield of Glyoxylic Acid by Electrolytic Reduction of Oxalic Acid in 2 per cent Sulphuric Acid at 4½ Volts (Mercury Cathode, Platinum Anode)

Time (min.)	Amount of oxalic acid (mgm.)	Yield of glyoxylic acid* (per cent)
15	5·7	22
15	2·9	61
15	1·4	73
15	0·14	59
10	0·7	95
15	0·7	73
23	0·7	71

* Determined spectrophotometrically as 2,4-dinitrophenylhydrazone in 1 per cent sodium carbonate at 368 mμ.

quantities, radioactive oxalate may be reduced directly, without dilution with inactive oxalate, to give glyoxylate of the same molar activity. We have used the diluted electrolysis mixture directly in studies of the dissimilation of glyoxylic acid in plant tissues.

We wish to thank the National Research Council of Canada for the award of a studentship to one of us (R. M. K.) and for a grant in aid of research.

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Distribution of Carbon-14 in Labelled Amino-acids separated on Paper Chromatograms

An important problem in the biochemical application of the labelled pool technique is the determination of the uniformity of labelling of compounds separated on paper chromatograms in amounts below the limits of chemical detection[1].

The use of ninhydrin (triketohydrindene hydrate) as a spray[2] or, preferably, as an acetone dip[3] for the detection of α-amino-acids separated on paper chromatograms, is well established. The reaction involves a quantitative oxidative deamination of the α-amino-acid according to the equation[4-6]:

$$R.\mathrm{CH(NH_2).COOH} + \cdot\mathrm{O} = R.\mathrm{CHO} + \mathrm{NH_3} + \mathrm{CO_2}$$

The loss of radioactivity from an α-amino-acid separated on a paper chromatogram, as a result of treating it with ninhydrin, might then be expected to indicate the proportion of carbon-14 in the carboxyl group of the acid. This was found not to be the case in practice because of the volatility of the labelled aldehyde also produced, and because decarboxylation only appeared to be quantitative under the right conditions of time, temperature and relative humidity. The effect of relative humidity on the ninhydrin colour reaction has been noted by other authors[7].

The simple method described below was developed for application to α-amino-acids labelled with carbon-14 separated on paper chromatograms and has given reproducible results with known labelled acids as shown in Table 1.

The low recoveries of carbon-14 dioxide from the 1-^{14}C-glutamate are not understood but do not appear to be explained by the presence of carbon-14 in groups other than the 1-carboxyl (see below). The proportions of carbon-14 in the 1-carboxyl group of the labelled amino-acids was confirmed by measuring the specific activity of the $^{14}CO_2$ liberated from carrier-diluted samples on the semi-micro scale by an adaptation of the Van Slyke method[4,5]. These results are shown in Table 2. Doubts earlier expressed[8] on the uniformity of labelling of amino-acids from *Chlorella* grown on $^{14}CO_2$ as sole carbon source are now believed to be unfounded (Catch, J. R., personal communication).

Table 1. NINHYDRIN DECARBOXYLATION OF AMINO-ACIDS LABELLED WITH CARBON-14 ON PAPER

Acid	Theoretical proportion of total carbon-14 in carboxyl group (per cent)	Proportion of total carbon-14 recovered (per cent)
DL-Glutamic acid-1-carbon-14	100·0	82·0
,, ,, ,,	100·0	81·0
*Uniformly labelled L-glutamic acid	20·0	20·5
,, ,, ,, ,,	20·0	19·0
,, ,, ,, ,,	20·0	22·7
,, ,, ,, ,,	20·0	21·0
,, ,, L-*iso*leucine	16·6	15·5
,, ,, ,,	16·6	15·5
,, ,, L-phenylalanine	11·1	10·5
,, ,, ,,	11·1	10·1
,, ,, L-valine	20·0	20·8
,, ,, ,,	20·0	19·7
,, ,, L-tyrosine	11·1	11·7
,, ,, ,,	11·1	11·1

* Uniformly labelled acids prepared from *Chlorella* grown in $^{14}CO_2$ as sole carbon source.

The apparatus consists of a 15 cm. × 1·5 cm. 'Pyrex' tube provided with a *B* 14 standard head and vacuum tap as illustrated (Fig. 1). Aqueous sodium hydroxide (40 µl. of 1 *N* solution) is micro-pipetted on to a 2-cm. circle of Whatman No. 1 paper, dried in a warm air stream, and gently pushed into position *A* of the tube. A plug of glass wool washed with hydrochloric acid is inserted at *B* followed by a 1-cm. layer of granular activated charcoal at *C*. Four or five drops of distilled water are placed on the charcoal. A 2-cm. circular sample of the labelled amino-acid zone (located by scanning[1]) is removed from the Whatman No. 1 paper chromatogram by means of a suitable cork-borer. It is weighed and assayed for activity of carbon-14 under a thin end-window Geiger–Müller tube by mounting under rigid and reproducible geometrical conditions and taking the mean of pairs of counts made over both faces of the sample. The sample should not contain more than 50 µgm. of the amino-acid. The sample is briefly dipped in a 0·5 per cent (w/v) solution of ninhydrin in acetone (analytical reagent), quickly dried, and pushed into position *D* of the tube. The *B* 14 head is immediately placed in position, the tube pumped out to approximately 30 cm. of mercury pressure, and the tube warmed in an oven at 90–95° C. for 2 hr. The tube is next allowed to cool for a further hour at room temperature. The alkaline paper circle is then

Table 2. NINHYDRIN DECARBOXYLATION OF AMINO-ACIDS LABELLED WITH CARBON-14 IN SOLUTION

Acid	Theoretical proportion of total carbon-14 in carboxyl group (per cent)	Proportion of total carbon-14 recovered (per cent)
DL-Glutamic acid-1-carbon-14	100·0	101
,, ,, ,,	100·0	98
,, ,, ,,	100·0	95
*Uniformly labelled L-glutamic acid	20·0	20·2
,, ,, ,, ,,	20·0	21·8
,, ,, ,, ,,	20·0	20·2
,, ,, ,, ,,	20·0	21·6
,, ,, ,, ,,	20·0	20·0
,, ,, L-tyrosine	11·1	11·8
,, ,, ,,	11·1	11·3
,, ,, L-phenylalanine	11·1	10·95
,, ,, L-valine	20·0	18·9
,, ,, ,,	20·0	20·1
,, ,, L-*iso*leucine	16·67	16·4

* Uniformly labelled acids prepared from *Chlorella* grown in $^{14}CO_2$ as sole carbon source.

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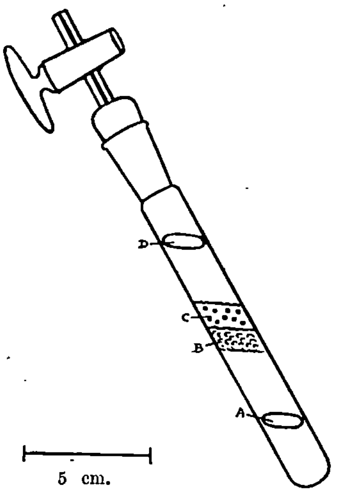

Fig. 1

removed, weighed, and assayed for activity of carbon-14 as above. Self-absorption corrections are made if the weights per unit area of the circles differ significantly[9]. The water in the tube provides the necessary moisture for the reaction, and the activated charcoal selectively absorbs any labelled volatile aldehyde formed. The proportion of the original activity of carbon-14 recovered on the alkaline circle represents the proportion of the carbon-14 present in the 1-carboxyl group. The method provides a simple test for the uniformity of labelling of α-amino-acids.

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Absorption Spectra of Molecular Complexes

It has been shown by several workers[1-4] that there is a rough correlation between the lowest ionization potential of an electron donor and the frequency of the maximum of the charge-transfer band (ν_{CT}) of lowest energy characteristic of the complex of the donor with a given acceptor. That the relation is not a very strict one is illustrated by Fig. 1, where such a plot is given for chloranil complexes in solution in carbon tetrachloride. The ionization potentials are those measured by Watanabe[5] using a photo-ionization method.

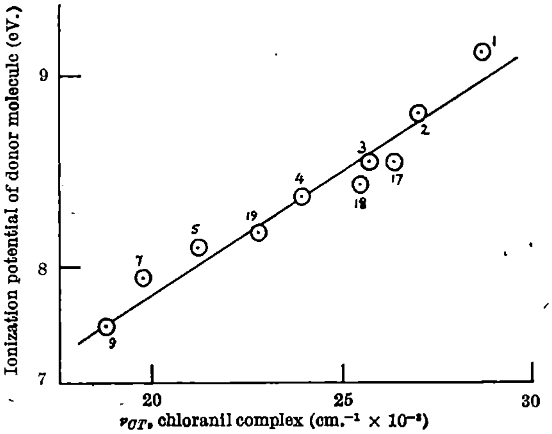

Fig. 1. The relation between the ionization potential of the donor molecule and ν_{CT} of the corresponding chloranil complexes in carbon tetrachloride

However, the plot of ν_{CT} for a series of complexes of electron donors with a particular acceptor against ν_{CT} for the same series of donors with a second acceptor shows a much closer correlation. Examples of such plots are given in Fig. 2. The values of ν_{CT} for the iodine and iodine monochloride complexes are those obtained by Keefer and Andrews[3] and de Maine[6]. It was not possible to assign a reliable value to ν_{CT} for the chloranil–durene complex, because of the skew nature of the absorption band. The solvent in all cases was carbon tetrachloride. To change the solvent to *cyclo*hexane increases ν_{CT} for the chloranil

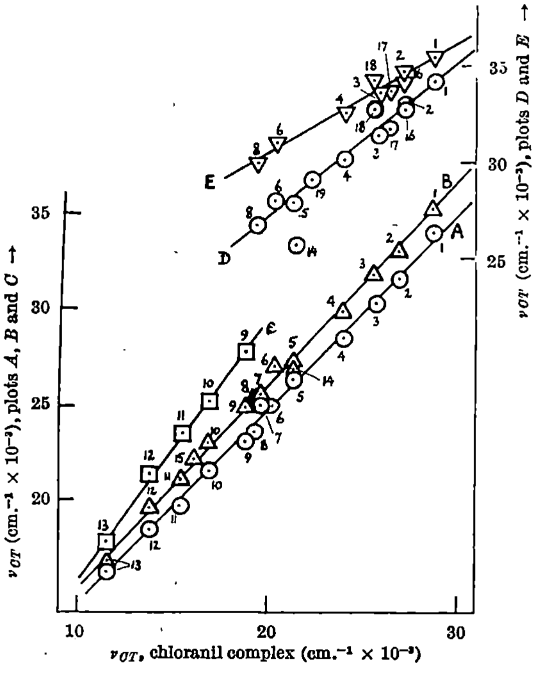

Fig. 2. The relation between ν_{CT} of chloranil complexes and ν_{CT} of complexes involving (*A*) *p*-benzoquinone; (*B*) *s*-trinitrobenzene; (*C*) *s*-trinitrotoluene; (*D*) iodine; (*E*) iodine monochloride. The numbers in the figures refer to the donor molecules: (1) benzene; (2) toluene; (3) *m*-xylene; (4) mesitylene; (5) naphthalene; (6) pentamethylbenzene; (7) 1-methylnaphthalene; (8) hexamethylbenzene; (9) aniline; (10) N-methylaniline; (11) N:N-dimethylaniline; (12) tetrabase; (13) N:N:N′:N′-tetramethyl-*p*-phenylenediamine; (14) phenanthrene; (15) anthracene; (16) dibenzyl; (17) *o*-xylene; (18) *p*-xylene; (19) anisole

complexes by about 300 cm.$^{-1}$, but a change of solvent to *cyclo*hexane or to chloroform[4] has little general effect in the case of the *s*-trinitrobenzene complexes.

The correlations in the case of the iodine monochloride and iodine complexes are not so close. In particular it would appear that the value of ν_{CT} for the naphthalene–iodine monochloride measured by Keefer and Andrews[2] is very high. Some of these variations may be due to differences arising from the perpendicular orientation of the acceptor in the complexes involving halogen molecules and the parallel orientation when the acceptor molecule is an aromatic or a quinone.

It may be noted that the variation of ν_{CT} with changing donor molecule is less in the complexes with iodine monochloride than in the complexes with iodine. This might be expected, as iodine monochloride is the weaker Lewis acid of the two. The reverse appears to hold, however, in the case of the *s*-trinitrotoluene and *s*-trinitrobenzene complexes, where *s*-trinitrotoluene is the weaker Lewis acid.

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Adsorption Chromatography on Silica-treated Paper

PAPER partition chromatography is not successful with many organic compounds for two reasons: (1) the compounds have low solubility in water, and hence move on the solvent front in normal partition systems; (2) low reactivity of the compounds makes detection of the position of spots difficult.

To overcome the first of the difficulties, methods have been described which employ an organic solvent as the stationary phase on the chromatogram[1–3]. Alternatively, adsorption chromatography may be used instead of partition chromatography[4]. Also, Kirchner and Keller[5] have described the use of silica-treated paper for chromatography of dinitrophenylhydrazones.

The method here described has the convenience of paper chromatography, and may be used for a wide range of compounds difficult to chromatograph by partition methods. The chromatograms are run, with the solvents normally used in adsorption chromatography, on filter paper which contains approximately 20 per cent (w/w) of silica. Unreactive compounds are detected by the blue colour of the starch–iodine reaction, while other more reactive compounds may be detected by their own specific reactions.

The silica-treated paper is prepared as follows. Sheets of Whatman No. 1 filter paper (24 in. × 8 in. has been found a convenient size to handle) are passed slowly through a 25 per cent (w/v) solution of commercial sodium silicate in water and hung up to drain for approximately 30 min. It is essential that the paper is not allowed to dry at this stage. The papers are then passed slowly through a 3 *N* hydrochloric acid bath, and once again allowed to drain for 30 min. After draining, the papers are washed in running tap water for 2 hr. and finally hung up to dry overnight. Heating the dry paper in the oven at 100° C. for 15–30 min. before use activates the silica considerably, and produces better resolution on the chromatograms.

The mixture to be chromatographed is spotted on the paper in the usual way. It is preferable to use a volatile solvent for applying the mixture, as the applied spot must be free from moisture before the paper is placed in the chromatography tank. Chromatograms are developed by the ascending-flow method, in tightly sealed jars lined with filter paper saturated with the solvent. (Battery jars with ground-glass edges have been found suitable.) Light petroleum (b.p., 40–60° C.), benzene and chloroform have been found to be the most useful solvents for development of the chromatograms. The solvent front is allowed to ascend about 10–15 cm. before the chromatograms are removed.

Unreactive compounds are detected by dipping the dry chromatograms in a solution of iodine (1·5 per cent) in carbon tetrachloride, and allowing excess iodine to evaporate off the paper. A stream of air is useful in hastening this process. Compounds then show up as brown spots on a white background[6]. The spots may be intensified by dipping the iodine-treated chromatogram in 1 per cent starch solution, when blue spots of greater intensity are obtained. Any background of blue due to residual iodine may be removed by a brief exposure to sulphur dioxide gas.

The method has been successfully applied to the separation of many types of organic compounds, including terpenes, leaf pigments, phenolic ethers and esters, and steroids.

I am indebted to Dr. W. G. C. Forsyth, director of the Colonial Microbiological Research Institute, for helpful advice, and to the Colonial Products Council for permission to publish this communication.

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Thermocell with Ion-exchange Polymer Electrolyte

RECENT communications[1,2] have described some thermocells in which two electrolyte solutions in contact with reversible electrodes are separated by an ion-exchange resin barrier. The ion-exchange resin in our apparatus is the sole electrolyte in physical contact with two identical copper electrodes and behaves as a solid electrolyte. The theoretical development of thermocells[3] is then applicable in an especially simple form.

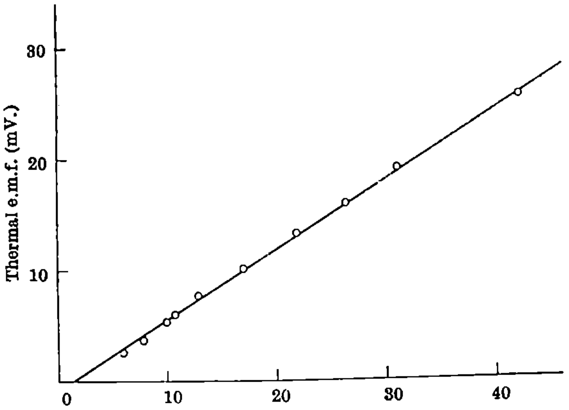

Fig. 1. Thermal electromotive force *vs.* temperature difference for the thermocell $(t)\mathrm{Cu/Cu^{2+}}$ ion-exchange resin/$\mathrm{Cu}(t + \Delta t)$, where $t = 2{\cdot}5 \pm 2{\cdot}5°$ C. The cell dimensions are: *A*, 12 cm.^{2}; *d*, 0·07 cm. The cold electrode is the anode; the electrolyte is saturated with water

The cell was constructed by pressing the ion-exchange resin in the form of a flat sheet between machined surfaces of copper. The electrolyte itself was an ion-exchange membrane, 'Nepton' *CR*–51 (unbacked type, Ionics, Inc., Cambridge, Mass.), consisting of a condensation polymer of phenol sulphonic acid and formaldehyde. This membrane had been converted into the leached copper-ion state by equilibration in five successive 2 *N* copper sulphate solutions of 100 times the membrane volume followed by long rinsing in distilled water. It is presumed that the membrane thus prepared contains copper ions in such amount that their charges exactly compensate the fixed negative sulphonate groups on the polymeric matrix. The transference number of copper ions in this electrolyte is unity.

The massive copper plate electrodes were maintained in intimate thermal contact with a stream of water at various controlled temperatures on the hot side and a rapidly stirred water-ice bath on the cold side. Measurement of Δt was accomplished by means of a differential copper-constantan thermocouple. The thermocell potentials were measured using an accurate potentiometer to the nearest 0·1 mV.

The results of three sets of measurements employing different samples of the ion-exchange polymer have yielded values 0·59, 0·64 and 0·65 mV./°C. (average 0·63) for the thermal electromotive force of the cell. A typical set of results is shown in Fig. 1. The relation between potential and temperature difference is linear, but extrapolation reveals a small dissymmetry potential which may be caused by inhomogeneity in the ion-exchange resin.

The Soret effect for copper ions appears to be entirely prevented by the nature of the electrolyte, but diffusion of water under the influence of the thermal gradient can occur.

The present results are consistent with other information. It has been reported[5] that a copper thermocell containing an aqueous copper sulphate electrolyte (0·94 *M*) had a thermoelectric power of 0·96 mV./°C. with the high-temperature electrode as the cathode. The temperature coefficient of the ($\mathrm{Cu} \rightarrow \mathrm{Cu^{2}+} + 2e-$) half-cell has recently been reported[6] to have the value −0·81 mV./°C. for copper solutions of unit activity and independent of the nature of the anion. Our results probably are indicative of an activity of copper ions less than unity. Holtan's treatment of thermocells could be applied to the present case if further information on the water transported by copper-ion migration[6] and the activity of copper ions in the ion exchanger were available. Evidence that the copper–copper ion-exchange membrane half-cells are probably reversible has already been obtained and will be reported elsewhere. Such ion-exchange thermocells may have some practical application as a temperature-sensing device.

I am indebted to Dr. H. A. Liebhafsky of this Laboratory for suggesting this type of ion-exchange thermocell.

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Synthesis of Succinate from Acetate by an Enzyme System of Pig Heart Muscle

The oxidation and condensation of two molecules of acetate to form succinate was first proposed by Thunberg[1]. Many later attempts have been made to demonstrate this reaction, with for the most part equivocal results. Recently, evidence has been presented[2] that the reaction does not occur in *E. coli*. On the other hand, evidence has been presented[3,4] that extracts of *Tetrahymena* catalyse the Thunberg reaction at a slow rate, and Seaman[5] has presented evidence that mammalian tissue catalyses the reduction of succinate to acetyl coenzyme A.

This report presents evidence that an enzyme system present in pig heart muscle catalyses the oxidation and condensation of acetate to form succinate.

The enzyme was prepared by extracting an acetone-dried powder of pig heart muscle with potassium phosphate buffer (0·1 *M*, *p*H 7·4) and fractionating with ammonium sulphate. The protein precipitated between 30 and 65 per cent saturation was dissolved in the minimum volume of potassium phosphate buffer (0·1 *M*, *p*H 8·0) and stored in the deep freeze at −18°. Activity was retained for at least four months.

When the enzyme was incubated under anaerobic conditions with acetate-2-^{14}C, adenosine triphosphate, magnesium, coenzyme A and glutathione, a number of radioactive spots were obtained (Fig. 1). Some of the compounds have been identified as S-acetyl-coenzyme A and S-acetyl glutathione, but the compound with an R_F of 0·55 in butanol/formic acid/water has not yet been identified. The radioactive compound with the highest R_F was identified as succinate by the following criteria: (1) Chromatography and co-chromatography in the following solvents: butanol/formic acid/water; tertiary amyl alcohol/formic acid/water; propanol/ammonia/water; ethanol/ammonia/water and phenol. (2) Two dimensional co-chromatography in tertiary amyl alcohol/formic acid/water and ethanol/ammonia/water. (3) Oxidation by succinoxidase prepared from pigeon breast muscle. The products of the oxidation were identified as fumarate and malate (Fig. 2).

The radioactivity incorporated into succinate is small, but is increased several-fold by the addition of oxidized glutathione or acetaldehyde diphosphopyridine nucleotide and alcohol-dehydrogenase to serve as hydrogen acceptors (Table 1).

Table 1. EFFECT OF HYDROGEN ACCEPTING SYSTEMS ON THE FORMATION OF SUCCINATE FROM ACETATE-2-^{14}C. REACTION MIXTURE AS IN FIG. 1. INCUBATION AT 30° FOR 2·5 HR.

Conditions	Counts per min. in succinate
No additions	1,560
Oxidized glutathione 10 μmoles	5,800
Oxidized glutathione 10 μmoles Acetaldehyde 20 μmoles, coenzyme I 0·1 μmole, alcohol dehydrogenase 0·1 mgm.	7,220

The physiological significance of the enzyme system is uncertain. The very slow rate of succinate formation from acetate (0·07 μmole succinate/hour/10 mgm. protein) agrees with the results of Seaman, who suggests that the enzyme may function by splitting succinate. However, many biological dehydrogenations are driven against an energy barrier by coupling to the electron transporting system. Consequently, coupling the Thunberg condensation to the electron transporting system should increase the formation of succinate. Preliminary experiments with pigeon liver mitochondria show that when succinate oxidation is blocked by malonate there is a 10 per cent incorporation of acetate in succinate. It is thus possible that, in the conversion of fats to carbohydrates[6], the Thunberg condensation serves as an alternative reaction to that catalysed by malate synthetase[7]. In this context it is perhaps relevant that malate synthetase has not been demonstrated in animals[8].

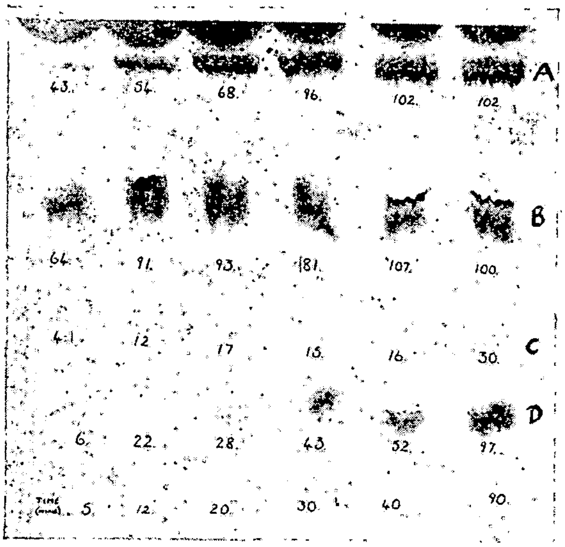

Fig. 1. Radiochromatogram demonstrating the formation of succinate from acetate-2-^{14}C. Reaction mixture potassium acetate (10 μmoles), acetate-2-^{14}C (10^5 counts per min.), magnesium chloride (5 μmoles), adenosine triphosphate (10 μmoles), glutathione (50 μmoles), coenzyme A (0·1 μmole), *tris* buffer *p*H 8·0 (0·1 *M*), enzyme (0·2 ml.), total volume 2 ml. Anaerobic conditions, bath temperature 35°. Samples (0·2 ml.) removed at times indicated and after removal of protein applied to filter paper chromatograph and run in butanol/formic acid/water. Figures under radioactive areas give counts per min. *A*, Acetyl coenzyme A; *B*, acetylglutathione; *C*, unknown; *D*, succinate

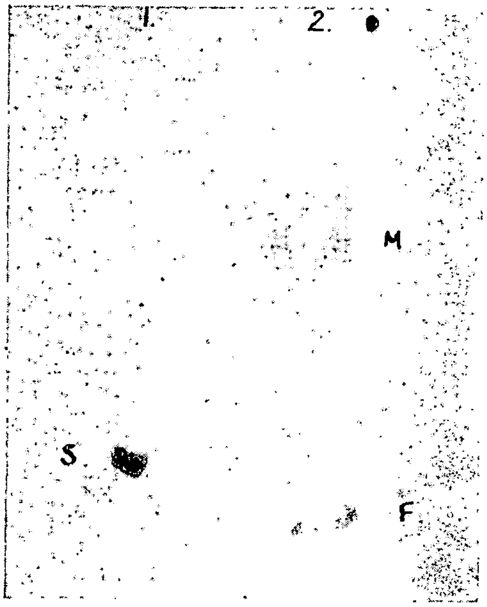

Fig. 2. Radiochromatogram demonstrating that the radioactive compound, identified as succinate, gives fumarate and malate labelled with carbon-14 after oxidation with succinoxidase. Line 1, Succinate before oxidation; line 2, products after oxidation with succinoxidase. Solvent system tertiary amyl alcohol/formic acid/water. *M*, Malate; *S*, succinate; *F*, fumarate

I am indebted to Prof. T. A. Bennet-Clark, Sir Hans Krebs and Dr. H. L. Kornberg for valuable discussion and advice.

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N-Terminal Amino-acids of Bovine Eye Lens Proteins

THE proteins of the crystalline lens are of particular significance to the embryologist because of the (serological) organ specificity of this part of the eye. In connexion with other biochemical and serological studies in our laboratory an investigation is being made on the N-terminal amino-acids of the main lens proteins: α-, β- and γ-crystallin. The preparations of α-crystallin have been isolated mainly by zone electrophoresis on starch[1]. They showed one single peak in both paper electrophoresis and moving-boundary electrophoresis at *p*H 4·2; 6·2; 7·1; 7·8; and 8·9 respectively. In the ultracentrifuge only a very small percentage of impurities was still noticeable. Some preliminary experiments were also made on β- and γ-crystallin, which preparations were obtained by salting out with ammonium sulphate and still showed small amounts of impurities when investigated by electrophoresis and ultracentrifugation.

For the end-group determinations Sanger's dinitrofluorobenzene method, as described by Fraenkel-

Conrat, Harris and Levy[2] was mainly used. The dialysed and freeze-dried proteins were dissolved in portions of 200 mgm. in 9 ml. water, and 300 mgm. dinitrofluorobenzene in 6 ml. ethanol added. The mixture was kept at pH 8·1 with 0·05 N sodium hydroxide added by means of an autotitrator. From the alkali uptake during the reaction it was found that, at room temperature, a period of 7 hr. was necessary for completing the reaction with α-crystallin. The dinitrophenyl–protein remained in solution ; spectrophotometric analysis prior to hydrolysis showed dinitrophenyl–proline and –hydroxyproline to be absent. By using performic acid oxidation cystine could also be excluded as N-terminal amino-acid.

After precipitation with hydrochloric acid, the dinitrophenyl–α-crystallin was washed out as usual with water, ethanol, ether and ethyl acetate to ensure a complete removal of dinitrophenyl–peptides that might be present together with salts and excess reagent. Hydrolysis was carried out by heating at 110° C. with 5·7 N hydrochloric acid in sealed evacuated tubes for 8 hr. For the determination of dinitrophenyl–ε-lysine a hydrolysis time of 72 hr. was necessary.

For paper chromatography Whatman No. 52 paper was used.

In the water-soluble fraction of the hydrolysate only dinitrophenyl–ε-lysine was present, in a quantity of 21 moles per 100,000 gm. dinitrophenyl–α-crystallin. In the ether-soluble fraction the following dinitrophenyl–amino-acids were found in α-crystallin (Table 1).

Table 1. N-TERMINAL AMINO-ACIDS IN α-CRYSTALLIN

Dinitrophenyl-amino-acid	R_F*	R_F†	Mol. dinitrophenyl-amino-acid per 100,000 gm. dinitrophenyl-protein‡
Glutamic acid	0·01	0·49	1·00
Serine	0·12	0·43	0·12
Glycine	0·18	0·27	0·07
Alanine	0·27	0·37	0·05
Threonine	0·18	0·42	0·02

* R_F toluene system of Biserte *et al.*, as modified by Levy (ref. 3).
† R_F phosphate buffer (Levy, ref. 3).
‡ Corrected for losses during the procedure.

The very small quantities of dinitrophenyl derivatives of serine, glycine, alanine and threonine may represent either impurities still present in the preparations or terminal groups resulting from partial breakdown of the peptide chain.

An interesting result of the preliminary experiments on the other fractions, β- and γ-crystallin, was that the same N-terminal amino-acids (mainly glutamic acid) were found to be present, although in different proportions. This might be an expression of organ specificity of these proteins. The experiments are being continued.

We are grateful to Prof. H. Gerding for his interest and critical discussions ; thanks are also due to Dr. W. F. Bon for carrying out the ultracentrifuge experiments and to Mr. H. P. Wijnand for assistance with electrophoresis.

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A Histoautoradiographic Study of the Effect of Section of the Facial Nerve on the Uptake of Methionine-^{35}S by the Cells of the Facial Nerve Nucleus

RETROGRADE degeneration of nerve cells was first described by Nissl in 1892[1]. Its main features are swelling of the cells, breaking up of the cytoplasmic chromophile granules and displacement of the nucleus to the cell margin. These changes occur after a lesion in the axon, after excitation of long duration or after certain virus diseases, as, for example, poliomyelitis. It is still not known whether these changes are entirely degenerative in nature or are due to increased metabolic activity associated with increased synthesis of protein molecules. The biochemical processes underlying these changes have so far not been adequately explained. The results obtained from ultra-violet microspectrography of the nucleic acid content of these cells have not been entirely satisfactory[2].

The present communication deals with the results obtained by studying the incorporation of methionine-^{35}S into the affected nerve cells. In a previous investigation[3], it was found that methionine-^{35}S becomes incorporated to a larger extent in the grey matter than in the white matter, and this is in agreement with the findings of other workers[4]. Twenty-four hours after the administration of methionine-^{35}S, 98 per cent of the amino-acid in the brain has become bound to the protein of the central nervous system. The degree of incorporation of methionine-^{35}S therefore indicates the protein synthetic activity of the respective structure.

Five rabbits weighing 3–3·5 kgm. were used for the present investigation. The facial nerve on one side was cut in each animal at a distance of about 3 mm. from the stylo-mastoid foramen. After thirteen days, 500 μc. of methionine-^{35}S was injected intraperitoneally into each animal. All the animals were killed 24 hr. later and the pons and medulla oblongata were removed and fixed in 96 per cent alcohol and then embedded in paraffin wax. The isotope content of all the liquids used in processing the tissues was measured and no activity was found. Histological sections of the facial nerve nucleus area were then prepared so that in one section there were the nuclei of both the injured and the normal facial nerves. The histoautoradiographic 'coating method' was used, the emulsion being prepared as described previously[5]. The duration of exposure was 61 days. The sections were kept in an exsiccator at 4° C. The developed sections were then stained with hæmatoxylin and eosin using the Bélanger method[6].

The degree of blackening of the emulsion coating the section indicated the concentration of the radioactive amino-acid in the section. Photographs of retrograde degenerated cells of the injured seventh nerve nucleus as well as photographs of cells of the normal nucleus were then taken. Photographs were also taken of the emulsion coating at corresponding levels just above these cells. By subtracting the degree of blackening over the surrounding tissues from the amount of blackening over a cell of the seventh nerve nucleus, a value of the incorporation of methionine-^{35}S into the cell of the nucleus was obtained. In addition, the area of each cell was calculated by means of a planimeter. The results were then evaluated statistically.

It was found that more methionine-^{35}S was incorporated into the nerve cells than into the surrounding white matter, thus confirming previous observations. In all the sections the nerve cells of the denervated seventh nerve nucleus had incorporated significantly more methionine-^{35}S than the cells in the normal control nerve nucleus. The planimeter measurements showed that the area of the nerve cells of the denervated nerve nucleus was in most cases greater than the area of the nerve cells of the control nucleus. The nerve cells of the denervated nucleus incorporated per unit area more methionine-^{35}S than the corresponding area of the cells of the control nucleus.

The results therefore show that nerve cells undergoing retrograde degeneration have an increased uptake of methionine, indicating that an increased synthesis of protein molecules is taking place.

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Perosis and Folic Acid Antagonism in Chickens

The folic acid antagonist pyrimethamine has been shown to act as a synergist with sulphadimidine against *Eimeria tenella* in chickens[1]. During our investigation of this combination, a decreased growth-rate was noted in chickens fed for five days on an all-mash diet containing 100 p.p.m. of pyrimethamine.

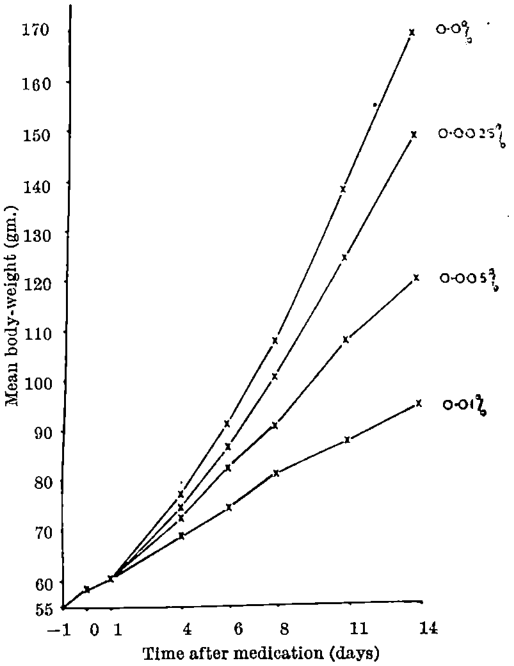
The toxicity of pyrimethamine was therefore examined with four groups of forty chickens which were fed mash containing pyrimethamine 0, 25, 50 or 100 p.p.m. from 7 days of age. The growth-curves are shown in Fig. 1. During the first fourteen days feeding, one chicken fed 25 p.p.m. and two fed 100 p.p.m. died of pyrimethamine poisoning. After fourteen days feeding two chickens were selected at random from each group for hæmatological study. The remainder of each group was randomized by weight into two even sub-groups, one chicken in the group fed 25 p.p.m. being discarded. One sub-group continued on the medicated feed and the other sub-group was fed basal ration. The chickens fed basal ration quickly resumed normal growth. In this period six chickens fed 100 p.p.m. died of pyrimethamine poisoning.

Table 1. Mean Weight Gains, Number of Deaths and Incidence of Perosis in Chickens fed Pyrimethamine 0, 25, 50 or 100 p.p.m. for 14 or 32 Days

Pyrimethamine in diet (p.p.m.) 0–14 days	Pyrimethamine in diet (p.p.m.) 15–32 days	Mean gain in weight (gm.) after 14 days	Mean gain in weight (gm.) after 32 days	Cases of Perosis	Cases of Death
0	0 0	113	393 370	0/19* 0/19	0
25	0 25	93	361 331	2/18 11/18	1
50	0 50	64	307 212	2/19 19/19	0
100	0 100	40	260 101	6/18 13/15†	8

* Number of cases of perosis/number in group.

† Three of these died late in the experiment and were examined for perosis.



Perosis was seen in the medicated groups after twenty-five days feeding. At thirty-two days all chickens were examined for perosis, and Table 1 shows the incidence in the various groups. Some chickens fed 25 p.p.m. pyrimethamine for only fourteen days showed perosis. The diet contained ¼ oz. anhydrous manganese sulphate per 100 lb. mash and was calculated to contain 80 p.p.m. of manganese.

Daniel, Farmer and Norris[2] showed that perosis occurred in chickens fed a diet low in folic acid and was prevented by adding synthetic folic acid to the diet. The addition of succinyl sulphathiazole accentuated the severity of the perosis on a diet low in folic acid. This seems to support the theory that chickens synthesize folic acid from *p*-aminobenzoic acid, which is made by the degradation of folic acid in the diet[3].

In our work, it seems certain that the perosis was due to a deficiency of folic acid caused by pyrimethamine, a potent folic acid antagonist.

A detailed account of these experiments will be published elsewhere.

I am grateful to Burroughs Wellcome and Co. (Australia), Ltd., who generously provided a quantity of pyrimethamine.

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Oct. 18.

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A Comparative Biochemical Study of Nucleohistones from Different Vertebrates

RESULTS recently reported by Crampton *et al.*[1] lead those authors to the conclusion that the nucleohistones extracted from the different tissues of the same animal are very similar in composition. Our own investigations on different organs of the calf confirm these results (Table 1, Fig. 1).

Table 1. AMINO-ACID RESIDUE (GM.) PER 100 GM. PROTEIN

	Calf thymus histone	Calf liver histone	Calf kidney histone
Arginine	12·6	11·8	12·3
Lysine	15·5	15·2	16·1
Histidine	2·4	2·5	2·3

Table 2. AMINO-ACID RESIDUE (GM.) PER 100 GM. PROTEIN

	1	2	3	4	5	6	7	8
	Carp erythrocyte histone	Trout erythrocyte histone	Pike erythrocyte histone	Calf thymus histone	Fowl erythrocyte histone	Duck erythrocyte histone	Tench erythrocyte histone	Frog erythrocyte histone
Arginine	13·5	13·5	11·4	12·6	13·3	13·0	—	12·8
Lysine	15·5	15·2	13·5	15·5	16·6	15·7	—	14·0
Histidine	2·3	2·5	1·9	2·4	2·5	2·4	—	2·9

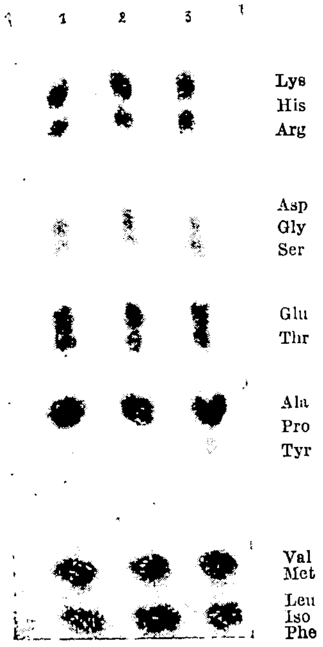

Fig. 1. Chromatograms of nucleohistones extracted in *M* sodium chloride from calf thymus, liver and kidney. Hydrolysates containing identical quantities of deoxyribonucleic acid were used in all three cases. Whatman paper No. 1. Solvent: 4 parts, butanol; 1 part, ethanol; 1 part, acetic acid; 2 parts, water

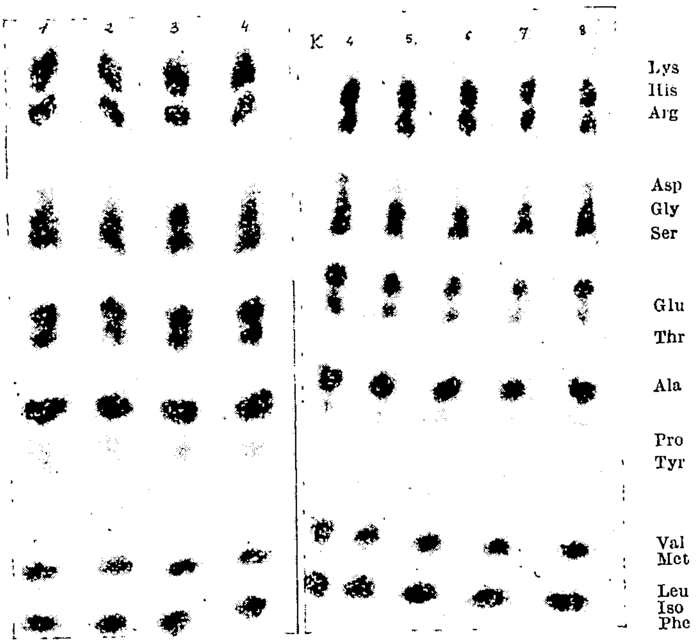

Fig. 2. Chromatograms of nucleohistones from different vertebrates (each volume of hydrolysate corresponds to the same quantity of deoxyribonucleic acid. Nucleohistone from: (1) carp erythrocytes; (2) trout erythrocytes; (3) pike erythrocytes; (4) calf thymus; (5) fowl erythrocytes; (6) duck erythrocytes; (7) tench erythrocytes; (8) frog erythrocytes. Whatman paper No. 1. Solvent: 4 parts, butanol; 1 part, ethanol; 1 part, acetic acid; 2 parts, water

But a comparison of nucleohistones extracted from different animal species is also of interest. For that reason, we have studied nucleoproteins isolated by the technique of Signer and Schwander[2] from different materials, namely, calf thymus and erythrocytes of carp, trout, pike, tench, frog, fowl and duck. Chromatograms were made of all these nucleohistones. Before chromatography, the hydrolysates were adjusted to identical content of deoxyribonucleic acid, in order to permit an easy comparison of the chromatograms run in parallel on the same paper (Fig. 2). The amounts of arginine, lysine and histidine in all these nucleohistones were also determined (Table 2).

This comparison reveals a striking similarity between all the nucleohistones studied, so it appears that if differences do exist between the histones of the various animals, they are beyond the sensitivity of our analytical technique. The classical results of Chargaff[3], at least concerning vertebrates, on the analysis of deoxyribonucleic acid from different organs of an animal and the same organ in various animal species (mammals, birds, fishes and reptiles) fail to reveal very marked differences between these deoxyribonucleic acids, though the slight differences detected could be significant. In the nucleohistone a similarity of general composition seems to occur in the samples studied, and reflects the similarity of the general composition of the nucleic acids.

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Rate of Body-Water Distribution studied with Triple Labelled Water

The rate of equilibration of extra- and intracellular water is determined by the passage of the water through the cell membrane. The transfer of water through cell membranes can proceed by various mechanisms. The simplest mechanism is diffusion of water molecules as a whole. Another mechanism is a biological carrier system, such as exists, for example, in the tubular mechanism of the kidney; and another route of transfer is ionic migration of protons and hydroxyl ions independently through the cell membrane.

In order to elucidate the mechanism, water triply labelled with oxygen-18, deuterium and tritium was used. The aqueous system injected into rabbits contained therefore primarily H^{16}OH, H^{16}OD, H^{18}OH and H^{18}OD in equilibrium. The experiments, which were carried out on rabbits, were aimed at comparing the rates of transfer of the three isotopes from the blood to the intracellular volume and at the determination of the total volume of their distribution.

In our experiments, water containing 16–20 per cent of oxygen-18, 35–45 per cent of deuterium and 5–50 μc. of tritium per ml. was injected into the rabbits intravenously. Blood samples were withdrawn at intervals, centrifuged and the water distilled on a vacuum line at room temperature. The isotopic composition of oxygen was determined by decomposition of the water by alkaline hypobromite solution over cobaltic oxide in a sealed ampoule[1], the oxygen gas being analysed on a *CEC*21–401 isotope-ratio mass spectrometer. Two other portions of the water were totally reduced to hydrogen by zinc powder in sealed ampoules at 400° C., and one of these was analysed by a hydrogen/deuterium isotope-ratio mass spectrometer; the other hydrogen sample was introduced into a Geiger counter for activity determination. Some typical results are shown in Table 1.

Table 1. Volume of Distribution of Labelled Water in Rabbits

Rabbit No.	Time after injection (min.)	Isotopic composition of blood samples: Oxygen-18 (per cent)	Deuterium (per cent)	Tritium (μc.)	Volume of distribution from isotope dilution*: Oxygen-18 (ml.)	Deuterium (ml.)	Tritium (ml.)
*U*2	2·5	0·267	0·168	2·5 × 10^{-2}	1,260	1,235	1,278
*U*2	10	0·260	0·151	2·25 × 10^{-2}	1,415	1,392	1,420
*U*2	29	0·254	0·140	2·07 × 10^{-2}	1,560	1,517	1,542
*U*2	140	0·250	0·129	1·98 × 10^{-2}	1,670	1,665	1,615
A–3	4	0·274	0·235	1·40 × 10^{-1}	1,320	1,295	1,250
A–3	40	0·262	0·210	1·15 × 10^{-1}	1,570	1,545	1,525

* *U*2 was injected with 5 ml. of water containing: oxygen-18, 18·6 per cent; deuterium, 37·6 per cent; and tritium, 6·4 μc./ml. The isotopic composition of the blood was found to be before injection: oxygen-18, 0·195 per cent; deuterium, 0·016 per cent; tritium, zero activity. *A*–3 was injected with 5 ml. of water containing: oxygen-18, 18·4 per cent; deuterium, 40·3 per cent; and tritium, 33·3 μc./ml. This rabbit had been used in previous experiments so that its body water (blood) was slightly isotopically enriched at the time of injection, namely oxygen-18, 0·20 per cent; deuterium, 0·08 per cent; tritium, 5·4 × 10^{-3} μc./ml.

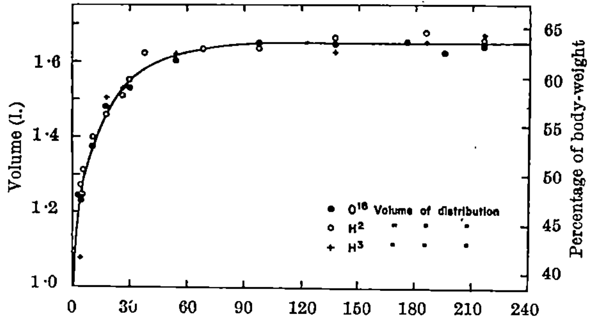

Fig. 1. The rate of distribution of water labelled with oxygen-18, deuterium and tritium as a function of time

Our results show that, within the experimental accuracy, no difference could be found in the rates of distribution of the three isotopes and their respective volumes of distribution (Fig. 1). (The standard deviations for the determination of oxygen-18, deuterium and tritium were 1, 2 and 2 per cent respectively.) The percentage of body water in our measurements is in full agreement with values obtained with deuterium as a tracer[2]. The small differences in fluid volumes of distribution could be explained either by the different rates of exchange between these isotopes and body constituents on one hand and the different routes of excretion on the other. Different results were obtained, however, in deeply anæsthetized animals.

The biological half-lives for oxygen-18, deuterium and tritium in rabbits were found to be 80, 220 and 130 hr. respectively (with a standard deviation of 10 per cent). The shorter biological half-life of oxygen-18 may be due to the additional route of excretion by expiration. The difference between tritium and deuterium may indicate a proton-transfer mechanism in the excretion process in which an isotope effect is involved.

As no appreciable difference could be detected between the rates of distribution of the three isotopes, it may be concluded that under normal conditions the most probable mechanism for water transfer through the cell membrane involves water molecules as such, and does not involve the breaking of the hydrogen–oxygen bond or prior ionization.

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Radioprotective Properties of Cystamine, Cysteamine and Cysteine when tested with Chick Fibroblasts *in vitro*

It is well known that a number of SH-containing compounds afford a certain amount of radioprotection to many organisms[1,2]. However, little information is available about the effects on cells *in vitro*. The present report deals with a series of experiments on the effects of cystamine, cysteamine and cysteine when added to cultures of chick fibroblasts shortly before irradiation.

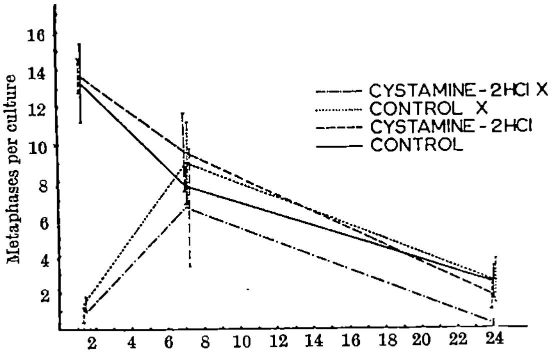

Fig. 1. Number of metaphases in hanging-drop cultures after treatment with 0·44 m*M* cystamine–2 hydrochloride and 200r. X-rays. The number of cultures for each point is 12 in the non-irradiated controls and 6 in the other groups

Heart fibroblasts from 9-day-old chick embryos were cultivated in standard media either in hanging drops or in Carrel flasks. The test substances were added in Tyrode solution, and the cultures were irradiated 15 min. later with 175 kV. X-rays, 0·5 mm. copper filtration, tissue dose-rate 50–100 r./min., under conditions of maximum back-scatter, in a water or air thermostat.

Mitotic inhibition was investigated in hanging-drop cultures. After 48 hr. in the second passage after explantation a non-toxic solution of 0·11 m*M* or 0·44 m*M* cystamine–2 hydrochloride or 0·21 m*M* cysteine–hydrochloride was added before irradiation with 200r. Prophases, metaphases, anaphases and telophases were counted in stained cultures, fixed 80 min. 4 hr., 7 hr. or 24 hr. after irradiation. The results obtained show that the radiation-induced mitotic inhibition was not influenced by the addition of either cystamine or cysteine in the above concentrations. Fig. 1 shows a typical response pattern.

Growth inhibition was investigated in cultures which were grown in Carrel flasks. When the explants had been cultured for four days, the liquid phase was substituted with test solution or Tyrode, and the cultures were irradiated. After irradiation the cultures were washed, and new liquid phase was added. Three days after treatment, the cultures were transferred to hanging drops and grown for 10–15 passages. At the end of every passage, each culture was scored as living or dead, the area of the growth migration zone was measured, and throughout the experiment the same person evaluated the vigour of each culture. Several concentrations of cystamine–2 hydrochloride, cysteamine–hydrochloride and cysteine–hydrochloride were tested after 1,500, 2,000 and 3,000r. After irradiation with such doses, the cultures deteriorate rapidly during the first 4–6 passages, after which most die in the next 5–10 passages.

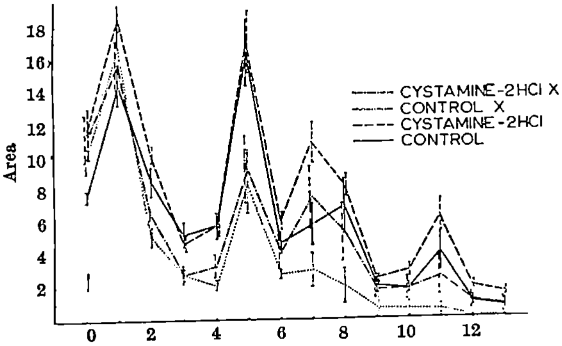

Fig. 2. Change with time of average area for 12 cultures irradiated with 1,500r. after addition of 0·89 m*M* cystamine–2 hydrochloride and controls, with standard deviation of the mean. × = irradiated groups

The results obtained show that the addition of 0·89 m*M* cystamine–2 hydrochloride before irradiation with 1,500 or 2,000r. helps the cultures through the critical phase which seems to occur after 4–6 passages. After this point the 'protected' cultures do better than the controls, having more survivors, a larger growth zone, and giving a more healthy impression. Fig. 2 shows average growth-zone areas from a typical experiment. It will be noted that the two groups of irradiated cultures have about the same area in the first 6 passages, but that during the subsequent passages the cultures receiving cystamine approach the non-irradiated controls. There is also a certain difference to be seen between the two groups of non-irradiated cultures. For cysteamine–hydrochloride or cysteine–hydrochloride no similar protective effect could be found.

The observed effect of cystamine may be explained as a result of one or more mechanisms operating during and immediately after irradiation[3,4]. However, the effect may also be attributed to a general growth-promoting property of cystamine in the concentration used. A combination of these two explanations is also possible.

A complete report will be published in the twenty-fifth anniversary publication of the Norwegian Radium Hospital.

The technical assistance of Miss Brit Falck Madsen and Miss Gudrun Braarvig is gratefully acknowledged. The investigation has been supported by the Norwegian Cancer Society.

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Immediate Effect of *l*-3 : 5 : 3′-Tri-iodothyroacetic Acid on Metabolic Rate and Body Temperature in Hypophysectomized Rats and the Action of Cortisone

The acetic acid analogues of thyroxine and tri-iodothyronine have been found to raise the metabolic rate of the thyroidectomized[1–4] and the hypophysectomized[3,4] rat without latency. In hypophysectomized rats intravenous injection of a few micrograms of tri-iodothyroacetic acid is invariably followed by a marked rise in oxygen consumption and body temperature, while only about half the thyroidectomized and none of the intact rats show a similar response[4].

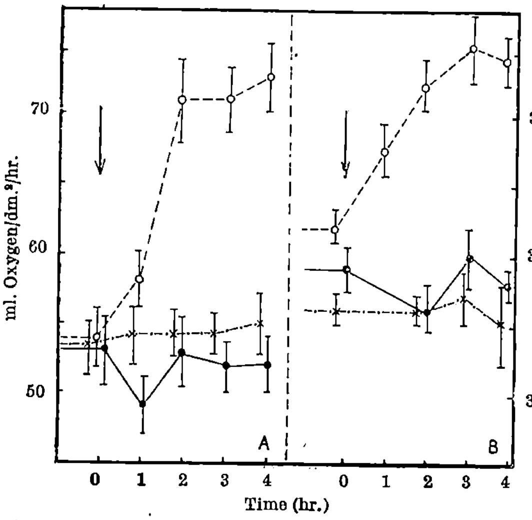

Fig. 1. Effect of 5 μgm. tri-iodothyroacetic acid injected intravenously on oxygen consumption (*A*) and body temperature (*B*) in the hypophysectomized rat ($n = 23$), O — — — O; in the cortisone-treated hypophysectomized rat ($n = 10$), ×—.—.—×. Effect of 0·2 ml. solvent on oxygen consumption (*A*) and body temperature (*B*) of the hypophysectomized rat ($n = 10$), ●——●

Experiments performed a few weeks after removal of the pituitary in adult male rats, and summarized in Fig. 1, demonstrate the marked rise in oxygen consumption and body temperature following intravenous injection of 5 μgm. of tri-iodothyroacetic acid (Glaxo), and show that both effects are completely abolished by 1 mgm. of cortisone (Organon) administered three hours earlier. (In some experiments a single cortisone injection was given, in others the rats received 1 mgm. daily for 2–3 days, the last being administered three hours before injecting tri-iodothyroacetic acid.) Injection of the solvent had no effect, nor did cortisone abolish the effect of a highly purified pyrogen[5], so that contamination with pyrogen can be excluded.

A large number of old and new observations tend to show an interaction of the thyroid and the adrenal gland[6], but, with the exception of adrenal hypertrophy in hyperthyroidism and atrophy in hypothyroidism and their experimental counterparts, the results are not very conclusive, and mainly concern the action of corticosteroids on the secretion of thyroid-stimulating hormone. The present experiments seem to be the first to demonstrate that a corticosteroid interferes with the action of a iodothyronine derivative.

That lack of adrenal cortical function is an essential condition for the manifestation of an immediate effect of tri-iodothyroacetic acid on oxygen consumption and body temperature is supported by the following observations. (1) No immediate response can be obtained in the hypophysectomized rat adequately treated with adrenocorticotrophic hormone. (2) An immediate response was elicited in all adrenalectomized rats, which later, after the withdrawal of sodium chloride, died of adrenal insufficiency. (3) The immediate response can be observed sixteen hours after the removal of the pituitary. (4) The immediate response in the hypophysectomized rat is not abolished by elevating the reduced metabolic rate to a normal or even high level by the administration of thyroxine.

Adrenal hypofunction may possibly be an adequate explanation for the less regular incidence of the immediate response in the thyroidectomized rat.

Immediate effects similar to those with tri-iodothyroacetic acid were obtained also with 3 : 5 : 3′-tri-iodothyronine (Glaxo) and some brands of thyroxine. Interpretation of these results is difficult, for as paper chromatographic analysis shows, iodothyronine preparations often contain more than a single compound[3,7].

We wish to express our thanks to Glaxo, Ltd., for the sample of tri-iodothyroacetic acid (Triac), to Organon N.V. for the cortisone and to Dr. O. Lüderitz (Säckingen) for the purified coli pyrogen.

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Distribution of Carbon-14 in Components of Goat's Milk, with Sodium Formate-^{14}C as Precursor

In a report dealing with the biosynthesis of milk components by the cow, Kleiber[1] described the use of sodium formate labelled with carbon-14 as one of the precursors. This communication reports the transfer of carbon-14 to the components of goat's milk when formate was the precursor.

A grade goat was injected intravenously with 30 mc. of sodium formate-^{14}C (Tracerlab) dissolved in 10 ml. of saline (0·85 per cent). Prior to dosing the animal, residual milk was removed from the

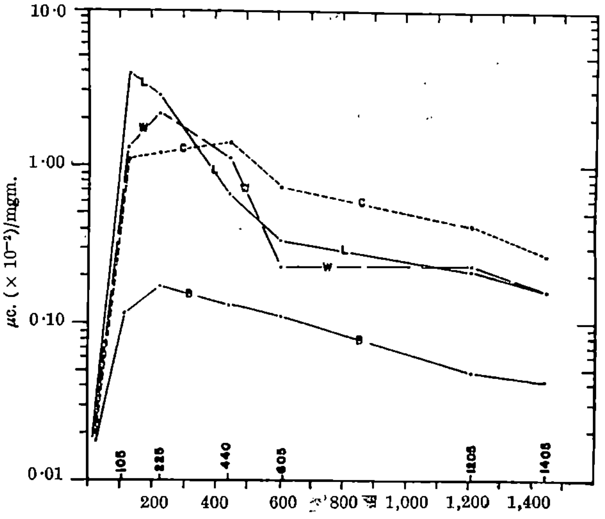

Fig. 1. Specific activity of milk components : ·—*B*—● , butterfat activity ; -----*C*---- , casein activity ; ·—*L*—● , lactose activity ; ·—*W*—· , whey–protein activity

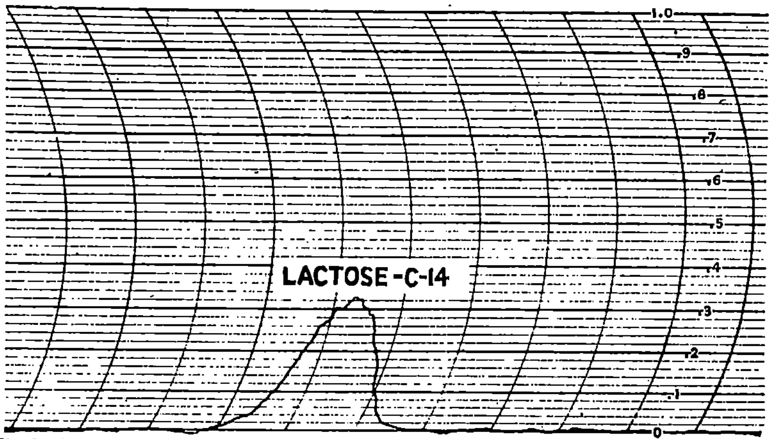

Fig. 2. A scanning record of a chromatogram containing 600 µgm. ($58 \cdot 6 \times 10^{-4}$µc.) of a sample of lactose-^{14}C

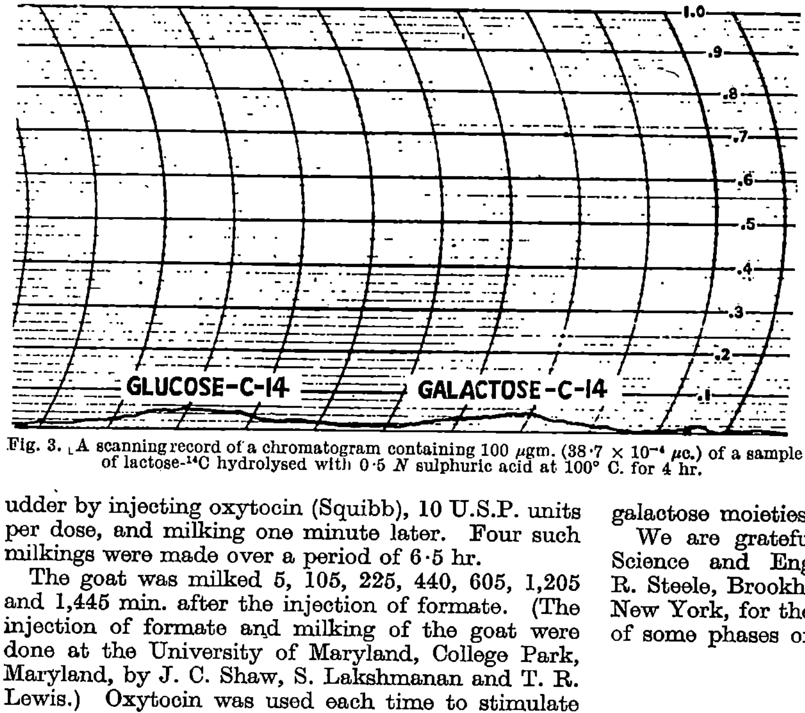

Fig. 3. A scanning record of a chromatogram containing 100 µgm. ($38 \cdot 7 \times 10^{-4}$ µc.) of a sample of lactose-^{14}C hydrolysed with 0·5 *N* sulphuric acid at 100° C. for 4 hr.

udder by injecting oxytocin (Squibb), 10 U.S.P. units per dose, and milking one minute later. Four such milkings were made over a period of 6·5 hr.

The goat was milked 5, 105, 225, 440, 605, 1,205 and 1,445 min. after the injection of formate. (The injection of formate and milking of the goat were done at the University of Maryland, College Park, Maryland, by J. C. Shaw, S. Lakshmanan and T. R. Lewis.) Oxytocin was used each time to stimulate the flow of milk. Each batch of milk was immediately frozen in 'dry ice', and held in the frozen state until it was fractionated.

After thawing the milk at 40° C., butterfat was separated by centrifugation and casein was precipitated at the isoelectric point. Precipitable whey-protein was separated by adjusting the *p*H of the whey to 4·0 with dilute hydrochloric acid. To facilitate the flocculation of the serum proteins, sodium bisulphite was added on a 0·1 per cent w/v ratio, based on the original volume of milk from which the whey was obtained[2]. The whey was heated at 95° C. for ten minutes and cooled to 20–30° C. before removal of the precipitate.

Since pure lactose-^{14}C was needed for metabolism studies, impurities were removed from the lactose in the following manner: 'Norit *A*' (Pfanstiehl) was added to the crude lactose at a level of 3 per cent of the original whole-milk volume. The mixture was heated to 95° C., centrifuged for 5 min. at 2,000 r.p.m. and decanted on to Whatman No. 5 filter paper. The filtrate was concentrated by evaporation on a steam-bath and was then freeze-dried. The lactose was dissolved in small quantities of boiling water, and the temperature was lowered gradually to −5° C. Methanol (two volumes) was added to reduce the solubility of the lactose, permitting crystallization at −5° C. in 48 hr. The crystals of lactose were then washed with methanol and dried with ether.

All samples for assay were combusted by the method of Gabourel[3], and carbon-14 was counted as $Ba^{14}CO_3$. As shown in Fig. 1, the specific activity of the lactose reached a maximum value 105 min. after the injection of the precursor, whey-protein and butterfat at 225 min., and casein at 440 min.

A sample from each batch of lactose was paper-chromatographed and scanned[4] for the detection of radioactive impurities. Samples showing radioactive contamination were recrystallized until the interfering activity was eliminated (Fig. 2). A sample of the purified lactose was hydrolysed with 0·5 *N* sulphuric acid in a sealed tube for 4 hr. at 100° C. The hydrolysate was adjusted to *p*H 4·5 with a saturated solution of barium hydroxide, filtered, condensed, chromatographed and scanned. The scan showed that the activity was equally distributed between the glucose and galactose moieties (Fig. 3).

We are grateful to Drs. A. Edelmann, Nuclear Science and Engineering Corp., Pittsburgh, and R. Steele, Brookhaven National Laboratory, Upton, New York, for their suggestions during the planning of some phases of this experiment.

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Occurrence of Rhodanese in a Species of *Thiobacillus*

THE enzyme rhodanese which catalyses the reaction:

$$S_2O_3'' + CN' \rightarrow CNS' + SO_3$$

has been shown to be present in *Thiobacillus thiocyanoxidans*. Cells of the organism, grown in thiosulphate medium with forced aeration and 2–5 per cent of carbon dioxide added[1], were harvested in a de Laval centrifugal separator, washed and suspended in $M/15$ phosphate buffer, pH 7·0.

Rhodanese activity was tested by the following procedure. Duplicate, 12-in. test-tubes containing: 0·5 ml., 0·125 M sodium thiosulphate; 0·5 ml., 0·125 M potassium cyanide; 0·5 ml., 0·2 M potassium dihydrogen phosphate; 1·0 ml. cell suspension (washed) were incubated at 30° C. for 15 min., the final pH of the mixture being 8·3. After incubation, the reaction was stopped by the addition of 0·5 ml. of 36 per cent formaldehyde. A blank tube was included in which the formaldehyde was added at the outset of the incubation period. The contents of the test-tubes were diluted with 25 ml. distilled water and centrifuged on a bench centrifuge to remove bacterial cells. 2·5 ml. ferric nitrate reagent were added to the clear supernatant, and the colours obtained were read at 470 mμ in a Unicam *S.P.* 600 spectrophotometer.

The following results were obtained:

Tube	Optical density at 470 mμ
Blank	0·01
I	0·750
II	0·735

These results seemed to indicate the presence of rhodanese. Boiled cells of *Th. thiocyanoxidans* were also incubated with thiosulphate, cyanide and potassium dihydrogen phosphate at pH 8·3, but there was no production of thiocyanate.

Another possibility was that thiocyanate might be formed from the chemical combination of cyanide and tetrathionate, the latter compound being a probable intermediate in thiosulphate oxidation by *Thiobacilli*.

To preclude this possibility the test for rhodanese was carried out under anaerobic conditions, in Thunberg tubes, which had been evacuated and filled with nitrogen. The results of this experiment indicated that the formation of thiocyanate from thiosulphate and cyanide does not involve the oxidation of thiosulphate to tetrathionate, but is a straightforward trans-sulphuration as required by the rhodanese reaction.

The production of thiocyanate with time is shown in Table 1.

Table 1. Thiocyanate Production when Washed Cells of *Th. thiocyanoxidans* are Incubated with Cyanide and Thiosulphate

Time (min.)	Thiocyanate (μgm./ml.)
10	55
30	65
40	70
60	76
80	81
120	85

The effect of varying the concentration of cyanide was tested. Reaction tubes were set up containing a standard amount, namely, 0·5 ml. of 0·05 M thiosulphate; the cyanide concentration was varied, as was the potassium dihydrogen phosphate concentration, so that the optimum pH of 8·3 was maintained.

Tubes were incubated at 30° C. for 70 min. and the reaction stopped by the addition of 0·5 ml. of 36 per cent formaldehyde. The tubes were centrifuged and their contents assayed with ferric nitrate for thiocyanate. The results are given in Table 2.

Table 2. Effect of Varying the Cyanide Concentration on the Production of Thiocyanate by *Th. thiocyanoxidans* from Thiosulphate and Cyanide

Molarity of potassium cyanide	Thiocyanate formed (μgm./ml./70 min.)
0·25	55
0·125	35
0·0025	20
0·005	5

If the concentration of thiosulphate is taken as the limiting factor for the production of thiocyanate, these results show that the rhodanese system is not inhibited by an excess of cyanide. This is a significant point of difference between the pure crystalline rhodanese obtained by other workers[2] and the rhodanese present in *Th. thiocyanoxidans*.

These latter results must, however, be treated with caution as they involve a comparison between a pure crystalline enzyme and whole cells.

This work was carried out with the encouragement and under the supervision of Prof. F. C. Happold and was aided by a grant from the Gas Research Council.

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Localization of Oxidative Enzyme Systems in the Uterus and Vagina of the Rat

The evolution of histochemical methods for the localization of oxidative enzyme systems in tissues[1] has made it possible to study the effects of endogenous hormones on the intensity and distribution of such enzymes in reproductive organs. Enzyme systems concerned with succinate and lactate oxidation in the uterus and vagina of the rat have been previously shown to be markedly under the influence of changes in the normal endogenous hormonal balance in the female albino rat[2]. We have now followed the histochemical changes in the uterus and vagina of the rat through the œstrous cycle.

Albino rats, 100 days old, were studied by the vaginal smear technique through three consecutive œstrous cycles. During the fourth cycle, regularly cycling females were selected for study at the following stages: preproœstrus, proœstrus, œstrus, metœstrus, 36-hr. diœstrus and 60-hr. diœstrus. The animals were killed by concussion and pieces of vagina and uterus were frozen immediately on 'dry ice', sectioned at 30μ and stained for succinate oxidation according to a procedure previously outlined (ref. 1, *b*). Staining as a result of lactate oxidation was carried out in a similar fashion with 4·0 ml. of 1·0 M sodium lactate substituted for succinate, 26 ml. of phosphate buffer with cyanide, and an addition of 4·0 ml. of lactate oxidation (1·0 mgm./ml.) in buffer. All tissues were studied by photographing the stained preparations under standardized conditions and comparing prints for intensity of staining.

Examination of vaginas at various stages of the œstrous cycle for lactate oxidation diaphorase showed that the most intense activity was displayed at periods characteristic of high œstrogen titre in the animal (preproœstrus, proœstrus and œstrus); while during metœstrus and both stages of diœstrus vaginas displayed considerably lower degrees of enzymatic oxidation. In the former more active stages, the localizations of lactate oxidation were concentrated in areas of the vaginal epithelium known to be metabolically active at this time. The germinative and luminal layers of epithelium during preproœstrus and proœstrus showed an intense reaction (Fig. 1,1). The cells of the lumen have been previously identified with high mucin production[3].

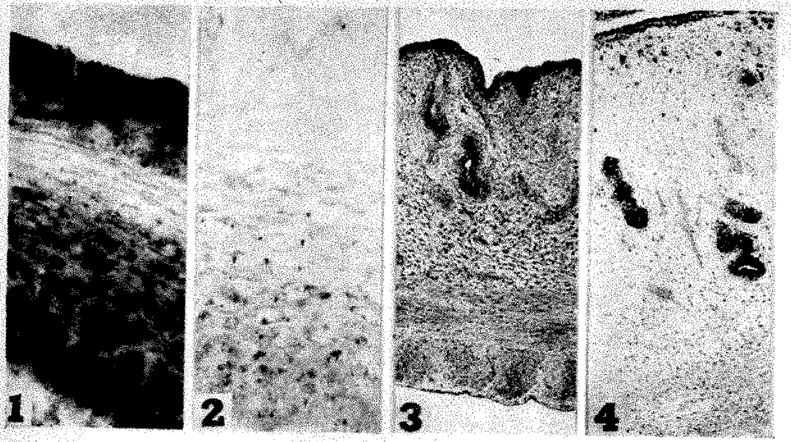

Fig. 1. 1, Lactate oxidation diaphorase in vaginal epithelium at prooestrus. Note high activity in luminal (upper) and germinative (lower) layers. Cornified cells (middle) show no activity. 2, Vaginal succinate oxidation activity at preprocestrus. Mucin-producing cells (upper) are inactive, whereas the germinative layer shows little staining. Cells undergoing cornification (middle) are losing much of the enzyme. 3, Procestrus uterus containing high lactate oxidation activity in the luminal and glandular epithelium. Considerable staining also occurs in the stromal and muscular elements. 4, Late procestrus or early œstrus uterus showing high succinate oxidation activity in epithelium and a low to negative reaction in the stroma. Muscle is lightly stained (lower right)

Consistent with current beliefs concerning the lowered metabolism or inactive state of cornified cells, our results demonstrated little or no enzymatic activity within such structures.

Oxidative enzymatic activity as a result of the succinate oxidation demonstrable with these methods was quite low in intensity. Although the highest activity was shown during œstrus and procœstrus, vaginas stained at these times had low activity in the germinative layers and no perceptible activity in cornified and mucified cells (Fig. 1,2). It should be noted that the apparent absence of succinate oxidation activity in cells producing mucin represents a feature quite distinct from that of lactate oxidation activity in similar cells. Mucin production as a result of exogenous œstradiol stimulation of the vagina has been shown to be associated with lactate oxidation diaphorase[4].

Uterine succinate oxidation and lactate oxidation was maximal during procœstrus when large quantities of fluid are found within the lumen of the uterus. Lactate oxidation activity was localized within the luminal and glandular epithelium, stromal cells and myometrium (Fig. 1,3). The greatest activity was associated with epithelial structures and this is probably a reflexion of increased oxidative metabolism of these structures requisite for synthetic and secretory activity[5]. Stromal connective tissue cells showed moderate to high staining within the cytoplasm, while the nuclear constituents were apparently unreactive. Muscle stained moderately throughout. The high activity of epithelial structures decreased considerably during metœstrus and continued to drop even further at diœstrus. Generally, both stromal elements and muscle showed a considerable reduction in enzymatic activity at these stages.

Succinate oxidation appeared to be very low or absent from the uterine stromal cells throughout all stages of the œstrous cycle. A drop in succinate oxidation activity was evident at late procœstrus or early œstrus, and was most pronounced in the myometrium, with a lesser loss evident in the epithelium (Fig. 1,4). With the onset of diœstrus and throughout this stage, both muscle and epithelium contained a low level of succinate oxidation.

It is believed that the above changes in succinate and lactate oxidation offer further evidence that these enzyme systems are under the influence of the changing hormonal environment within the animal. In addition, these results suggest that different structures or tissues within the same organ respond individualistically to presumably the same hormonal balance, thereby indicating that adequate histochemical localization of a given enzyme should be included with quantitative data such as that derived from homogenate studies. Enzyme distribution in the vaginal epithelium indicates clearly the type of error that can be introduced in homogenate studies if the mass of the tissue is not also considered in terms of highly active areas of oxidation coexistent with totally inactive (keratinized) regions within the same organ (Fig. 1, 1 and 2).

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Variation with Age of Shrinkage Temperature of Human Collagen

During the course of an investigation of hydrothermal shrinkage temperatures of human tissue, we examined many samples of different ages. Small fibres were teased out from the tissue immersed in 0·9 per cent sodium chloride solution and transferred with salt solution to a capillary tube. This was placed in a micro-melting point apparatus (Gallenkamp) and the shrinkage temperature determined by viewing under low magnification. The voltage across the heating element was controlled by a rheostat to give a rise of not more than 2 deg. per min. The temperatures at which the fibres started and finished shrinking were designated Ts_1 and Ts_2 respectively. Samples were taken from dura mater or fascia lata at autopsy or at operation from cases not suffering from 'connective tissue' disease and were examined without delay. In saline, fibres from either tissue from any one individual shrunk over the same range, and there was no difference between different fibres from one tissue. Results are given in Table 1.

Statistical analysis shows that for Ts_1 the variation ratio (F) between the groups is 35·3, which is highly

Table 1. Variation of Shrink Temperature with Age

Age group	Ts_1 (° C.)		Ts_2 (° C.)		No. of cases
	Mean	Range	Mean	Range	
Fœtuses 12–40 weeks	54·4	53–55	60	59–62	7
0–14 years	57·7	55–59	63·9	61–67	12
15–25	59·8	57–62	65·7	64–68	7
26–44	59·1	57–61	66·2	65–67	8
45–88	61·2	59–63	67	66–68	18

significant. The standard error for Ts_1 (single determination) is 1·33 and the least significant difference between the groups is 1·43 ($P = 0·05$) for means of seven determinations in each group and correspondingly less where the number in a group is greater than seven. It is seen that, except between the age-groups 15–25 and 26–44 years, the difference of the means between groups is greater than 1·43, and we therefore conclude that in any two age-groups, with the exception of those mentioned above, the Ts_1 is significantly higher in the older group. The Ts_2 figures clearly follow the same pattern and the same conclusions apply here.

A similar investigation was carried out with collagen fibres of human uteri and the results are given in Table 2. Here the tissues are divided into only two groups, 45 years being chosen as the approximate age of menopause. Except for one case aged 4 months, the younger group ranged from 25 to 45 years of age and four of these were pregnant; the range of the older group was 49–78 years. Within each group there appeared to be little variation of Ts_1, and statistical analyses showed that the Ts_1 means differed in a highly significant way between the two groups ($F = 14·41$; standard error of $Ts_1 = 1·74$; least significant difference of the means between the groups $= 1·37$ for $P = 0·05$). Ts_2 did not vary significantly between the two groups. By comparison with results in Table 1, collagen from the uterus up to about the age of menopause is seen to be closely similar, as regards hydrothermal stability, to fœtal collagen. Uterine collagen in the older group, on the other hand, resembled the 0–14 year collagen.

Table 2. Shrink Temperature of Human Uteri

Age (years)	Ts_1 (° C.)		Ts_2 (° C.)		No. of cases
	Mean	Range	Mean	Range	
Under 45	55·2	53–57	63·4	61–67	12
Over 45	57·8	55–61	63·1	61–67	16

Few studies of shrinkage temperature and age have been carried out on human tissue; but recently Hall and Reed[1] found that, in water, there was no difference with age in a group of twelve people whose ages ranged from 7 to 89 years. With one exception the range of shrinkage was 62–69·5°, which is somewhat higher than our range of 55–68° covering similar ages. This confirms our observation that shrinkage temperatures are higher in water than in saline, and it might be that, in water, any shrink temperature variation with age would not be evident.

The results reported here add further to the evidence, already accumulated from investigations of other properties[2–6], which demonstrate that collagen becomes more stable with age in the organism. Fœtal collagen is of special interest. Its consistently low shrinkage temperature, whatever the stage of development, suggests that there is a certain minimum degree of stability of collagen once it is laid down as a fibre, and that there is little change in this stability during fœtal life. It would appear from our results that, with growth and development, the collagen becomes further stabilized from birth until adolescence. There is no further stabilization until after middle age, when the subsequent shrinkage temperature rise may be a manifestation of the ageing process.

Harkness and Harkness[7] have shown that the uterus is exceptional in its property of rapid formation and rapid absorption of collagen during and after pregnancy, and in this property of more rapid metabolism it resembles collagen in young growing tissue[6]. The low shrinkage temperatures of uterine collagen would also suggest that it is a less mature form than collagen from elsewhere in the adult, though it is somewhat more stable after the menopause.

This work forms part of an investigation of the shrinkage temperatures of normal and abnormal human collagen, which it is intended to publish in full shortly.

We thank Miss B. M. Haines for introducing us to the micromethod of measuring shrinkage temperatures.

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Role of Phage Antibodies in the Development of Non-toxigenic Cultures of *Corynebacterium diphtheriae*

That the toxigenicity of diphtheria cultures is associated with the lysogenic state is well established. It now seems that the loss of ability to produce toxin may be mediated by the action of antiphage serum upon lysogenic cultures.

In guinea pigs given intracutaneous injections of virulent cultures of *C. diphtheriae*, and protected against death by the intraperitoneal administration of antitoxin some hours later, a low-grade infection may persist for several weeks. During the latter part of this period non-toxigenic, non-lysogenic cultures may be isolated from the lesions. At this time, also, the presence of phage-neutralizing antibodies in the animals' blood can be demonstrated.

Moreover, if antiphage serum is produced in rabbits by injection of filtered lysates of toxigenic diphtheria cultures, and a toxigenic culture is grown in broth fortified with this, after some ninety daily passages in the presence of these antibodies the culture is found to have become non-lysogenic and avirulent.

The avirulent cultures obtained either by the *in vivo* or the *in vitro* methods regain their virulence upon lysogenization with phage.

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It is well known that in other lysogenic species there is concomitantly (*a*) spontaneous induction of some cells resulting in subsequent lysis and liberation of phage, and (*b*) more or less frequent failure in transmission of prophage during cell division, so that non-lysogenic cells arise. Normally the latter are either lysed or lysogenized by the infectious phage present in the environment, so that a state of equilibrium is reached. It is known, also, that the addition of citrate or oxalate to the culture medium can prevent re-infection, and that by this method, after many transfers, cultures free of phage can be obtained. The findings outlined above suggest that antibodies to phage, by binding free virus, may bring about the same result.

It should be recalled that Jungeblut[1] found thirty years ago that six passages of virulent cultures in broth containing antitoxin brought about a loss of ability to produce toxin ; but his evidence suggested that this was a transient phenomenon. Some of our converted cultures have remained non-toxigenic during ten passages over a six-month period.

The work reported here offers support for the hypothesis that antiphage bodies are important in conversion, and may account for the occurrence of the avirulent cultures isolated from throats and from the lesions of the chronic cutaneous diphtheria cases found in some parts of the world.

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Protein Degradation of Fœtal and Cancer Tissues in the Presence of Ethionine

INTRACELLULAR proteolytic enzymes are present in many tissues and they hydrolyse proteins during autolysis. Some experimental data support the idea of a physiological action of these enzymes : the augmentation of catheptic activity during the regression of cancer[1], and of larval tails of *Xenopus*[2]. But it has been shown that intracellular protein degradation is dependent on energy[3], and that *o*-fluorophenylalanine, a well-known anti-amino-acid, inhibits protein catabolism[4,5]. Steinberg *et al.*[5] also showed that this compound does not influence catheptic proteolysis. These observations lead to the supposition of a mechanism of protein degradation different from that of the simple catheptic hydrolysis. Similar conclusions are reported by Yakovlev[6], who studied the action of phosphate, dinitrophenol and other substances on proteolysis of tissues. He reported also that fœtal tissues behave against dinitrophenol differently from the normal rat tissues.

I have investigated the action of another anti-amino-acid, ethionine, upon the intracellular protein degradation of normal and fœtal liver and of benzopyrene sarcoma. In all cases 400-mgm. aliquots of 0·5-mm. tissue slices are incubated for 3 hr. at 37° in 4 ml. phosphate buffer $M/15$ at *p*H 7·2 containing ethionine 2×10^{-3} M. At zero time, and at the end of the incubation, the slices are homogenized in their medium and proteins are precipitated with an equal amount of 14 per cent trichloracetic acid. On the supernatant the ninhydrin-positive substances are determined colorimetrically[7]. Table 1 gives the values of the amino-acids released in control experiments and those carried in the presence of ethionine.

Table 1. INHIBITION OF PROTEIN BREAKDOWN IN NORMAL AND FŒTAL RAT LIVER AND OF BENZOPYRENE SARCOMA

	mgm. released amino-acids/100 gm. fresh weight		
	Controls		Ethionine
	Zero time	3 hr.	3 hr.
Normal liver	108 ± 11	210 ± 18	117 ± 13
Fœtal liver	122 ± 13	180 ± 17	130 ± 13
Sarcoma	150 ± 14	270 ± 22	244 ± 21

The control experiments show decreased degradation of fœtal proteins, and increased degradation in sarcoma. In the presence of ethionine, degradation in sarcoma is slightly inhibited by the anti-amino-acid (only 20 per cent), where in both normal and fœtal livers ethionine inhibits about 90 per cent of the normal protein degradation. This difference is probably due to a different concentration of the proteolytic enzymes susceptible to anti-amino-acid in the tissues examined. It is also important to note that ethionine inhibition of protein degradation in fœtal liver is quantitatively the same as that observed in normal liver. This result is in contrast with the observations reported by Yakovlev[6] on the negative effect of dinitrophenol on fœtal liver autolysis. But it must be remembered that Yakovlev studied the autolysis of homogenates, whereas in the present case intracellular degradation is observed in tissue slices : this difference in the experimental conditions may explain the observed variations in Yakovlev's and my results.

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Presence of Œstrone, Œstradiol and Œstriol in Extracts of Ovaries of Laying Hens

GUSTAVSON[1] found a high œstrogenic activity in excreta of laying hens. Others[2] have found activity in ovaries and greater activity in maturing follicles. Hurst[3] has found œstriol and œstrone in excrement of hens, and œstriol, œstrone and œstradiol in that of roosters. The present communication describes the identification of œstrone, œstradiol and œstriol in ovarian tissue of the fowl and the results of a search for their presence in blood.

Ovaries were removed from laying white Leghorn hens. Follicles larger than about 5 mm. diamete. were slit open, and yolk material was discarded. Ovaries with follicle walls attached were weighedr immersed in methanol, and disintegrated with a Waring blendor.

Œstrogens were extracted as described by Mitchell and Davies[4] for human placenta. Residues from final extractions were taken up in a small volume of warm 90 per cent ethanol and stored for 18 hr. at −10° C. The supernatant was concentrated and chromatographed. Preliminary fractionation into œstriol and œstrone–œstradiol fractions was omitted.

Chromatography was performed on Whatman No. 1 filter paper and an absolute methanol – petroleum ether system at 34° ± 1° C. was used[5]. Good separation of reference œstriol, œstradiol and œstrone was obtained with a 6–10 hr. run, provided that strips were dried in an oven immediately before application of the steroids, and were then immediately placed in the chromatography chamber for equilibration.

Narrow strips cut from the developed chromatograms were immersed in freshly prepared diazotized sulphanilic acid and then in 1·1 per cent sodium carbonate. The yellow spots formed indicated the positions of the œstrogens. The steroids were eluted into ethanol, and the ultra-violet absorption spectra were examined on a recording spectrophotometer. Identifications of œstrone and of œstradiol were confirmed by 'finger-printing' with reference steroids labelled with carbon-14 (Chas. Frosst and Co., Montreal). The steroid labelled with carbon-14 was added to a sample of the presumptive œstrogen isolated from ovarian tissue in the estimated ratio 5 : 1 (carrier to labelled steroid). The amount of labelled material used was 5γ, which gave a barely perceptible stain with diazotized sulphanilic acid reagent. The mixture of labelled and presumptive steroid was chromatographed and the strip was stained and then exposed for three days on X-ray film. Complete coincidence of stained spots with spots on the radioautograph in respect of shape and position was taken as positive identification of presumptive œstrogen with labelled steroid. Three spots, positive to diazotized sulphanilic acid and to Kober reagent, were located on chromatograms of extracts of 'free' œstrogen fractions obtained from ovarian tissue. Mobilities were similar to those of œstriol, œstradiol and œstrone on reference chromatograms, and their ultra-violet absorption spectra agreed with those of the appropriate reference œstrogens. Results of the radioactive 'finger-printing' of the presumptive œstrone and œstradiol are shown in Fig. 1. Chromatograms of the 'conjugated' and 'protein-bound' fractions of ovarian extracts contained small amounts of material positive to diazotized sulphanilic acid, but individual œstrogens were not found in these fractions.

A ketosteroid described previously[6] was found in all extracts of ovaries and of blood from laying hens. The results of bioassays conducted on eluates of the ketosteroid indicated no œstrogenic activity. Neither œstradiol nor œstriol was located in any of the fractions of an extract from 650 ml. of blood from laying hens. A compound either identical with, or very similar to, œstrone was located in the 'conjugated' fraction of the extract. A ketosteroid described previously[6] was found both in 'free' and 'conjugated' blood fractions. This material was recovered by dialysis[6] from 50-ml. samples of blood from laying hens, but it was not found on chromatograms of similar extracts of 50 ml. blood from male or immature female fowl.

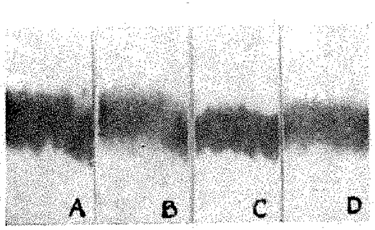

Fig. 1. Radioautographic 'finger-printing' of presumptive œstrogens from avian ovarian tissue.

(*A*) Spot on radioautogram of chromatogram of presumptive œstrone mixed with 5γ of œstrone labelled with carbon-14.

(*B*) Spot on same chromatogram stained with diazotized sulphanilic acid

(*C*) Spot on radioautogram of chromatogram of presumptive œstradiol mixed with 3γ of 17-β-œstradiol labelled with carbon-14.

(*D*) Spot on same chromatogram stained with diazotized sulphanilic acid

The results provide evidence, based on chromatographic mobility, ultra-violet spectrophotometry and chemical reaction, that the main œstrogens elaborated by the avian ovary are œstrone, œstradiol and œstriol. The identity of the presumptive œstrone and œstradiol with the reference compounds labelled with carbon-14 was established by the radioautographic 'finger-printing'. The identity of the chromatographic mobility of the presumptive œstriol with that of the reference sample, coupled with its ultra-violet absorption spectrum and positive Kober reaction, constitute strong evidence that the material isolated from avian ovaries was œstriol.

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Effect of Thiosemicarbazones on the Multiplication of Tobacco Mosaic Virus

While much effort has been expended on the chemotherapy of plant virus diseases[1], it seems to provide no conclusive evidence. Iwasaki *et al.*[2] obtained marked inhibition of influenza and Newcastle virus by thiosemicarbazones and related compounds. We have performed tests to determine the effect of certain of the thiosemicarbazone derivatives on the multiplication of tobacco mosaic virus in detached tobacco leaf tissues.

The strain of virus used was the ordinary strain found in Japan. Unsubstituted thiosemicarbazones from benzaldehyde, acetophenone, cinnamaldehyde, and benzalacetone and some of the para-substituents (nitro-, dimethylamino-, amino- and acetylamino-) of them were tested. The derivatives employed were obtained through the kindness of Dr. Tamio Nishimura of the Kitasato Institute, Tokyo. All

Table 1. INHIBITION OF MULTIPLICATION OF TOBACCO MOSAIC VIRUS BY THIOSEMICARBAZONES

Thiosemicarbazone derivatives	Para-substituents	Concentration of chemicals (μgm./ml.)	Percentage of increase (+) decrease (−) in virus multiplication	
Benzaldehyde	unsubstituted	50	+ 5*	−22†
,,	dimethylamino	25	—	+ 5
,,	acetylamino	25	—	−10
Cinnamaldehyde	unsubstituted	25	+14	−14
,,	dimethylamino	25	—	+ 6
,,	acetylamino	25	—	−12
Acetophenone	unsubstituted	50	—	−35
,,	acetylamino	25	—	− 4
Benzalacetone	unsubstituted	50	−20	−24
,,	nitro	50	− 5	—
,,	amino	50	− 5	− 9
,,	dimethylamino	50	−15	+ 6
,,	acetylamino	10	−19	+ 1

* Analysed by ammonium sulphate method; † by trichloracetic acid method. Figures represent the average values of 2–3 independently treated samples.

the compounds were dissolved in a small amount of acetone and were filled up to a desired volume with distilled water. Each compound was used at a concentration of 10–50 μgm./ml. The detached tobacco (*Nicotiana tabacum*, Turkish) leaves were inoculated by rubbing with a gauze pad soaked in tobacco juice infected with mosaic virus and were maintained in an incubator for 24 hr. at 25° suspended on water. Then the leaf-halves or leaf disks (12 mm. diam.) cut from the inoculated leaf were floated in continuous light (daylight fluorescent lamps) on aqueous solutions of the test compounds; the opposite leaf-halves or other disks floating on water served as controls.

After 6 days incubation, the leaf tissues were homogenized and analysed for the virus. Two analytical methods were tried. One consisted of precipitating virus protein by ammonium sulphate and then determining the relative concentration of the resultant precipitates by a colorimetric procedure using the Folin reagent[3]. The other method, in which usually 20 leaf disks (0·5–0·6 gm.) were used, was the combination, according to Bancroft and Curtis[4], of the chloroform–water emulsion technique and the trichloracetic acid method for precipitating and hydrolysing tobacco mosaic virus. In the latter case, the virus was assayed by spectrophotometric methods of measurement at 260 mμ.

Thiosemicarbazones, with or without para-substituents, were tested at first (Table 1). The compound most effective in producing inhibition was benzalacetone thiosemicarbazone both in the analysis by the ammonium sulphate method and by the trichloracetic acid method. Furthermore, in this case, the unsubstituted compound was most effective, indicating that introduction of a nitro-, amino-, dimethylamino-, or acetylamino-group at the para-position of the benzene nucleus diminishes the inhibitory activity. Among the para-substituents of benzalacetone thiosemicarbazone, however, it seemed likely that dimethylamino and acetylamino substituents exhibit a considerable inhibition by the analysis of the ammonium sulphate method, but not by that of the trichloracetic acid method. Accordingly, both dimethylamino- and acetylamino-para-substituents of benzaldehyde and cinnamaldehyde thiosemicarbazones were tested and were compared with the unsubstituted ones. From these results it is evident that these compounds do not show any detectable increase in inhibitory activity when analysed by the trichloracetic acid method. Although acetophenone thiosemicarbazone inhibited markedly, according to the trichloracetic acid method, the multiplication of the virus, it produced comparatively severe toxicity to host leaf, and these observations cannot be accepted without question. Iwasaki *et al.*[2] have reported that unsubstituted benzalacetone thiosemicarbazone is most effective against influenza viruses, *PR*8, *FM*1 and Lee strains, and Newcastle disease virus. In this respect, these results are well in accord with those obtained with the plant virus.

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Sensitivity of the Spermatogenic Process in the Rat to Radiomimetic Drugs and X-Rays

SPERMATOGONIA are considered to be the most radiosensitive cells of the male germinal epithelium. They may be selectively damaged or destroyed without apparently impairing the continued development into spermatozoa of later generations of spermatogenic cells present at the time of irradiation. In the mouse, Oakberg[1] has found that exposure to 200 r. rapidly destroyed all type *B* spermatogonia, and Bateman[2] observed a transient sterility in male mice six weeks after exposure to this dose which was associated with marked oligospermia. These two findings are correlated and provide an estimate of the overall time required for the development of spermatozoa in the seminiferous tubules (testicular phase) and their transport through the epididymis (epididymal phase). Other results from radioactive tracer experiments in the mouse[3] have also indicated a period of about 40 days for the same process. Since Oakberg[4] has proposed that five weeks (34·5 days) are required for the testicular phase of spermatogenesis in the mouse, it follows that an additional week is occupied by the epididymal phase.

In rats after 200 r. (whole-body irradiation) the only significant change we have observed during nine weeks of consecutive weekly matings was a reduction in average litter size during the fourth and fifth weeks (Fig. 1). There was no noticeable oligospermia. After 500 r. given either as a single dose or five daily exposures of 100 r., rats did not become sterile until the seventh week, although the average litter size dwindled progressively in previous weeks (Fig. 2). The onset of sterility was accompanied by pronounced oligospermia, and the sterile state persisted for at least three months. In the mouse, it is well known that prolonged sterility after 500 r. commences in the fourth week; according to Auerbach[5], this is due to the destruction of spermatocytes as well as spermatogonia. These comparative results suggest the following conclusions: (*a*) the radiosensitivity of corresponding cells in the mouse and rat are markedly different, and/or, (*b*) the overall

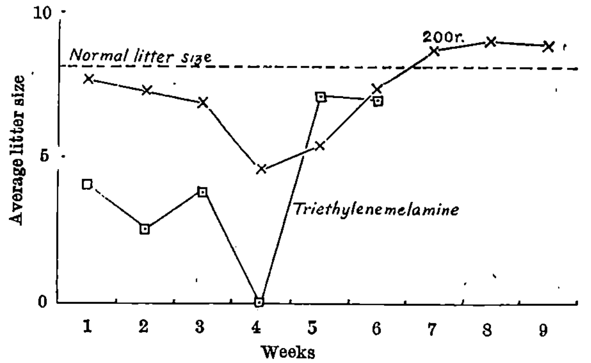

Fig. 1. Effect on male rat fertility of a single dose of triethylenemelamine (0·2 mgm./kgm., intraperitoneal) compared with one dose of X-irradiation (200 r., whole-body)

time for spermatozoa to develop in the testis and appear at insemination is considerably longer in the rat than the mouse.

If the radiosensitivity of cell types is comparable in the two species, then sterility in the fourth week in the mouse corresponds to the seventh week in the rat. On the other hand, recent publications suggest that the duration of the testicular phase in mouse and rat are similar; this will relate differences in the total time to that required for the passage of sperm through the epididymis. From a study of the progression of injected radio-opaque material through the rat epididymis, MacMillan and Harrison[6] have suggested that the duration of this phase is 12–16 days.

We also made detailed examinations of the effects of radiomimetic drugs (and related compounds) on the fertility of male rats. It is our experience that these substances can produce well-defined periods of sterility which are indicative of selective actions on various stages of spermatogenesis[7]. For example, for triethylenemelamine the most susceptible phase corresponds to a period of sterility in the fourth week after a dose (Fig. 1). This finding was previously correlated with drug action on spermatogonia[7], but no allowance was made for the epididymal phase. Infertility in the fourth week after giving triethylenemelamine now appears to be the result of interference with a later stage of spermatogenesis. The ability of a short course of this drug to produce a sterile period lasting for several weeks from treatment, followed by rapid recovery six weeks later, contrasts with the onset of prolonged sterility in the seventh week after 500 r. (Fig. 2). It is tempting to infer a significant correlation between the time relationships of these effects.

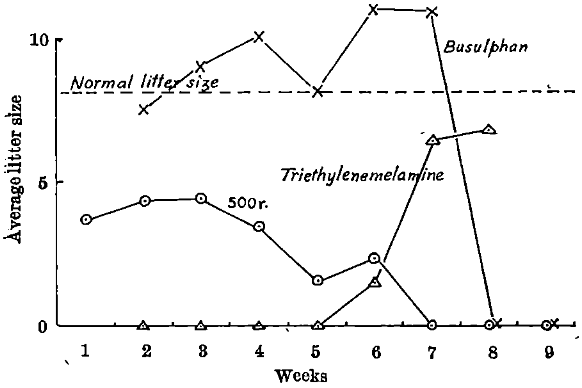

Fig. 2. Comparison of the effects on male rat fertility of triethylenemelamine (five daily doses, 0·2 mgm./kgm., intraperitoneal), X-irradiation (500 r., whole-body) and busulphan (one dose, 10 mgm./kgm., intraperitoneal)

We have also found that busulphan (myleran) has a well-defined action on rat fertility. This radiomimetic drug, unlike triethylenemelamine and radiation (500 r.), had no effect on size of litter until the eighth week after a single dose (Fig. 2), when sterility developed with remarkable rapidity. This change was also associated with the onset of oligospermia (as with 500 r.) and is consistent with the destruction of early germinal cells. Since the rats were fully fertile 45 days after the dose but sterile a week or so later, it may be that the overall time for sperm development and their appearance at copulation is even longer than has been supposed.

Comparable experiments in the mouse are in progress, and also histological studies in both species.

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Isolation of the Lethal Factor of Diphtheria Toxin by Electrophoresis in Starch Gel

Highly purified toxins of *Corynebacterium diphtheriae* have been shown to be very complex mixtures by antigen–antibody diffusion in gelatin[1]. In spite of their apparent homogeneity as determined by filter paper electrophoresis, one of us demonstrated the complex nature of such toxins by electrophoresis and immunoelectrophoresis in starch gel[2]. All the crude, as well as the crystalline, toxins (a generous gift of Dr. C. G. Pope) screened by these methods (Poulik, in preparation), have invariably shown the presence of two major components in addition to many minor ones. Since diphtheria toxin is lethal in very high dilutions for guinea pigs, it was assumed that it is most probably one of the two major components which is the cause of death.

Diphtheria toxin *TD*-3-51 (kindly given by Dr. Inge Scheibel, Statens Serum Institute of Denmark), was produced on a tryptic digest of beef muscle medium[3,4] and contained 162Lf./mgm. (0·084 mgm. total N/mgm.; 0·069 P–N/mgm.). This material was subjected to starch gel electrophoresis[5] in a discontinuous system of buffers (*tris*-citrate in the starch gel and sodium hydroxide/boric acid in the electrode vessels[6]). This combination of buffers resolved the two major components very well and thus assured their purity.

Fig. 1 shows diagrammatically the result obtained. After electrophoresis the gel was cut into blocks 1 cm. wide and the proteinous materials contained in these blocks were removed by squeezing the sponge-like starch blocks after freezing and thawing. The

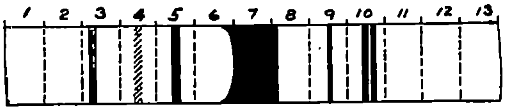

Fig. 1. Starch gel electrophoresis in discontinuous system of buffers, at 6 V./cm. for 5 hr. Material: Toxin-*TD*-3-51, 162Lf./mgm., 0·084 mgm. total N, 0·069 P–N/mgm.

toxicity of these solutions was tested on guinea pigs (250–300 gm.) by injecting 0·1 ml. intradermally. The material obtained from section 7 killed the animal in 1 : 1,000 dilution in four days or sooner and produced a typical skin reaction at dilution 1 : 100,000. The solution from section 5 killed the animal only when injected undiluted and produced a typical skin reaction at a dilution of 1 : 1,000. Autopsies performed on animals killed by the materials in sections 7 and 5 revealed pathological findings typical for diphtheria (hæmorrhage into adrenals; pleural effusion; congestion of the wall of the gut). Toxin recovered from section 5 produced a much larger area of necrosis at the site of injection. This activity and the slower rate of migration are the only criteria, at the present time, which make us feel that this is a different substance as compared with material in section 7. It has not yet been possible to obtain a conclusive demonstration that this component is a separate immunological entity.

It was concluded that the most potent lethal factor of the toxin of *Corynebacterium diphtheriae* was isolated in section 7. This component is not a single protein since starch gel immunoelectrophoresis[3] had demonstrated at least two and possibly four lines of flocculation in this area, two of them intersecting and thus further indicating the complexity of this fraction. Material from section 5 was also found to be heterogeneous. It was also shown experimentally that more than one lethal factor is present in the toxins grown in culture media, and that each of these is again a mixture of proteins, presumably with different enzymatic activities, such as hæmolysin, deoxyribonuclease[7], transferrin-splitting factor (Poulik, unpublished work), a possible mucopolysacharidase[2], hyaluronidase and a necrotizing factor[8], to mention just a few. Since any of these enzymes, and possibly others, may be present in either of the electrophoretic components described, speculation on the mode of action of diphtheria toxin is not justified until all the biologically active factors present are determined.

The opinion of O'Meara[9] and that of Niggemeyer[8], that the diverse clinical courses of the disease could be explained on the basis that several such factors are in operation either singly or in combination, is shared by us. Recent experiments described by Yoneda and Pappenheimer[10] on the production of extracellular products released by certain non-toxigenic strains of *C. diphtheriae* and a toxigenic strain derived from them by infection with a bacteriophage, showed the way of approach to such a problem. Since clinical cases exist (hypertoxic diphtheria) where administration of commercial antitoxins fails to control the course of the disease[8,9], the question remains what antigen or antigens should be used for preparation of antisera which would be able to cope adequately with all the toxic materials regardless of their type or quantity.

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Mode of Action of Organophosphorus Insecticides

It is widely held that organic phosphates exert their insecticidal action by the inhibition of cholinesterase activity in the nervous system. Definite proof of this theory, however, has never been furnished and some years ago doubt as to its correctness was expressed by Hopf[1] and also by Lord and Potter[2].

According to many investigators, there is an excess amount of cholinesterase in the nervous system of mammals, and toxic effects will only be seen after more than 80 per cent inhibition of enzymic activity. The occurrence in such an excess is quite a normal feature of enzymes. Assuming that the cholinesterase present in insects is essential for some vital function of the organism, possibly for conduction in the nervous system, one might expect poisoning symptoms to occur only when the cholinesterase activity is strongly inhibited. It should not be overlooked that, in order to prove that a substance derives its toxicity from the inhibition of some enzyme, it is necessary to show, (1) that it has a strong inhibitory action on the enzyme *in vitro*, and (2) that this enzyme in the living insect is actually inhibited at the time that symptoms of intoxication appear.

Our investigations were carried out largely with O,O-dimethyl-O-2,2-dichlorovinyl phosphate, which is very toxic to houseflies (*Musca domestica*; *LD*50< 0·1 µgm./gm.). The inhibitory action of this substance on housefly cholinesterase *in vitro* is about a hundred times that on horse-serum or mouse-brain cholinesterase and twice that of paraoxon on housefly cholinesterase. At a rough estimate, only 0·5–1·5 mol. of O,O-dimethyl-O-2,2-dichlorovinyl phosphate per mol. (active group) of enzyme is required to give 50 per cent inhibition. It is clear, therefore, that inhibition of cholinesterase could be the reason for its toxicity. However, it is also a very potent inhibitor of other esterases, especially in the housefly. One of these ali-esterases, present mainly in the thorax and clearly distinct from the cholinesterase which is chiefly found in the head, was able to split methyl butyrate at considerable speed *in vitro* and proved to be inhibited by approximately the same concentrations of O,O-dimethyl-O-2,2-dichlorovinyl phosphate as the cholinesterase; so its toxicity could also be due to inhibition of this ali-esterase. It was of interest, therefore, to investigate the inhibition, *in* *vivo*, of both enzymes at the time intoxication appeared.

Inhibition of cholinesterase *in vivo* was measured in the following way. Houseflies were exposed to O,O-dimethyl-O-2,2-dichlorovinyl phosphate vapour. Poisoning symptoms such as hyper-excitation and convulsions occurred after some time and eventually the flies were knocked down. A simple device enabled us to remove each individual fly from the experimental glass as soon as this stage of intoxication was reached. The flies were then, until further treatment, kept in a test-tube chilled by a mixture of ether and solid carbon dioxide. When all the flies had been collected they were quickly transferred to a flask containing bicarbonate-saline and acetylcholine (acetylcholine $1 \cdot 5 \times 10^{-2}$ *M*) and homogenized. The suspension obtained was immediately used for measurement of cholinesterase activity in the Warburg apparatus—at 37° C. and *p*H 7·4 (bicarbonate–carbon dioxide buffer), without any further addition of acetylcholine—and compared with a control suspension of untreated flies. It contained about 3×10^{-9} *M* O,O-dimethyl-O-2,2-dichlorovinyl phosphate, which in other experiments was found to cause more than 90 per cent inhibition after 1·5 hr. of incubation without protection by acetylcholine. The addition of acetylcholine to the saline in which the flies were homogenized was necessary to prevent any O,O-dimethyl-O-2,2-dichlorovinyl phosphate present in the tissues but not yet irreversibly bound to the enzyme surface, from attacking the enzyme; especially since we have shown (Fig. 1) that O,O-dimethyl-O-2,2-dichlorovinyl phosphate readily reacts with the cholinesterase, forming an inactive complex and thus producing inhibition. After addition of acetylcholine, however, no further increase of inhibition occurs, the enzyme being then completely protected by the substrate molecules. This was confirmed by several experiments in which rather high concentrations of O,O-dimethyl-O-2,2-dichlorovinyl phosphate were prevented from exerting inhibitory effects by the presence of acetylcholine in a concentration normally used in our experiments. As a consequence of the method used, the enzymatic reaction started about 25 min. before measurement in the Warburg-apparatus could be undertaken. We therefore investigated the possibility of reactivation of the enzyme, especially as Aldridge and Davison[3] have shown that the inhibition of cholinesterase from rabbit erythrocytes by dimethylphosphates is slowly reversible. We found that there was no reactivation at all in the case of housefly cholinesterase, although it did in fact occur in the case of mouse-brain cholinesterase.

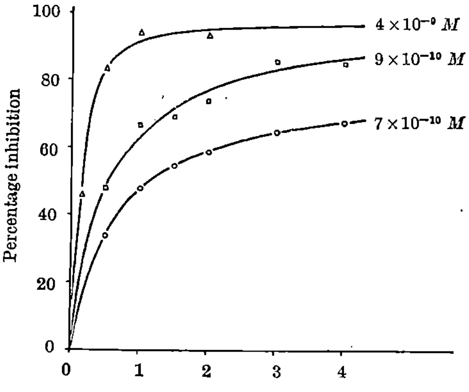

Fig. 1. Inhibition of housefly cholinesterase by O,O-dimethyl-O-2,2-dichlorovinyl phosphate. Incubation time is time available for the reaction between enzyme and inhibitor before the substrate is added

Measurements of *in vivo* inhibition as described above will, in our view, give a very good approximation to the actual inhibition value at the time of knockdown. Essentially the same method has been adopted for the measurement of inhibition of ali-esterase *in vivo*, using methyl butyrate as a substrate. Methyl butyrate, as was shown in several experiments, gives appropriate protection of the ali-esterase against O,O-dimethyl-O-2,2-dichlorovinyl phosphate under conditions such as those of our experiments on *in vivo* inhibition. In a few cases inhibition of cholinesterase has also been measured in heads or thoraces + abdomens, separated just before homogenizing took place. The results of our experiments are shown in Table 1.

Table 1. PERCENTAGE ENZYME INHIBITION AT THE TIME OF KNOCK-DOWN

ChE of whole flies	25, 27, 28, 24, 29, 29 per cent	mean 27 per cent
ChE of the heads	10, 39, 22 per cent	mean 24 per cent
ChE of thor.+abd.	43, 49 per cent	mean 46 per cent
AliE of whole flies	86, 84, 79 per cent	mean 83 per cent

These results are very striking. Although the overall values for inhibition are low, it cannot be excluded that stronger inhibition of cholinesterase activity was occurring at some small but essential part of the nervous system; but we nevertheless consider that the results in Table 1 provide evidence against an essential role of cholinesterase inhibition in the insecticidal action of O,O-dimethyl-O-2,2-dichlorovinyl phosphate. We do not claim that this evidence is conclusive, because it is possible that the results in the literature concerning the excess of cholinesterase present in the organism are incorrect. All the latter results are based on inhibition values *in vivo* which, so far as we know, were obtained without protection of the enzyme against excess of inhibitor and, therefore, are probably too high.

Our findings were provisionally confirmed by experiments on cholinesterase inhibition, in which di-*iso*propylfluorophosphonate, parathion and paraoxon were applied. The strong *in vivo* inhibition of the ali-esterase (splitting methyl butyrate) points to this enzyme and the possible role of its inhibition in the intoxication caused by organophosphates.

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Distinction between *Cardium edule* L. and *Cardium lamarcki* Reeve

FROM material gathered by the Danish Institute for Fishery and Marine Research in Danish estuaries I have examined the species of *Cardium* of which there were three types—*A*, *B* and *C*. Type *C* was identified as *C. exiguum*. In the literature the types *A* and *B* are described as varieties of *C. edule*. In my material the two types existed together in some of the estuaries, and they were often found in the same bottom samples, and always without any intermediate types. I have identified type *A* as *C. edule* L. and type *B* as *C. lamarcki* Reeve 1845 [1].

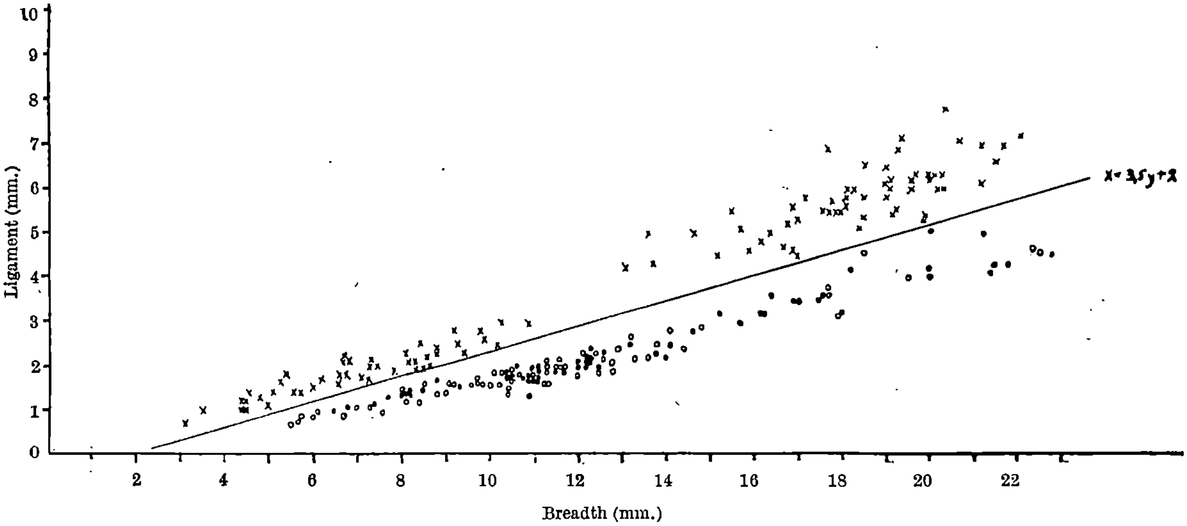

Fig. 1. ×, *Cardium edule*; ○, *Cardium lamarcki*

C. edule and *C. lamarcki* have the following distinctive characters: The ribs on the middle part of the shell of *C. edule* are flat and provided with small scales some distance from each other; in *C. lamarcki* these ribs are sharp and provided with small triangular closely placed scales, formed from the epidermis. The ribs on the posterior part of the shell are fairly well developed in *C. edule* and scarcely developed at all in *C. lamarcki.* Because of this difference the part of the shells around the siphons will close along a wavy line in *C. edule* and along an almost straight line in *C. lamarcki.* The epidermis is very badly developed in *C. edule.* The epidermis of *C. lamarcki* is rather thick and covers about 75 per cent of the surface of the shell. In colour and shape a difference between the two types also exists, *C. edule* being the more whitish and circular one, but as colour and shape vary much, these are not taxonomic characters.

C. lamarcki shows considerable variation, and smaller individuals from the vegetation and brackish water have thin brown shells with flat ribs without scales and broad furrows. This form somewhat resembles *C. exiguum.* At a length of 4–8 mm. they often suddenly change and begin to build the shell with narrow furrows, and sharp ribs with scales. This change in structure may be correlated with a change in habitat, for example, from vegetation to the bottom. *C. lamarcki* is very often found in the vegetation climbing by means of its byssus. I have never seen *C. edule* climbing in the vegetation or using a byssus.

The most distinctive character is the length of the hinge ligament in relation to the breadth of the animal. In Fig. 1 the x-axis represents the breadth of the animal and the y-axis the length of the hinge ligament. The measurements plotted were all made on animals taken from bottom samples in which the two types occurred together. The bottom material was fine sand. In Fig. 1 the two types are clearly separated by the line $x = 3{\cdot}5\, y + 2$. Probably this function will prove to be invalid for the smaller animals, and perhaps the two types are separated by a non-linear function.

In geographical distribution the types are separated also, but they overlap in some localities. Such localities are the mouth of the Mariager Fjord estuary and the Kysing Fjord estuary, both situated at the Kattegat coast of Jutland. The animals used for Fig. 1 are from these localities, in which the salinity is always more than 20 per mille. In more brackish water, as, for example, the innermost parts of Mariager Fjord and Kysing Fjord and the estuaries on the Belt Sea and Baltic coasts, we find only *C. lamarcki,* which tolerates salinities from about 25 to about 5 per mille. *C. edule* does not tolerate salinities lower than 20 per mille. *C. exiguum* is found only in areas with a rather constant salinity about 7–14 per mille.

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Quantitative Gram-staining with Labelled Iodine

The development of a simple quantitative Gram-staining technique has been attempted by numerous observers[1,2], not only for its possible practical uses but also because of its potential value in studies on the mechanism of the staining reaction on intact cells and on extracellular material[3], as well as the relationship between degree of Gram-positivity and physiological state of the organisms. The recent procedure of Barbaro and Kennedy[4] is reasonably accurate but, since it involves measurement of dye nitrogen taken up by a suspension of organisms, it is rather laborious for practical application.

Taking advantage of the fact that iodine is co-operatively bound in the Gram reaction, we have developed a reasonably accurate quantitative Gram-staining technique based on the use of 'Lugol' solution labelled with iodine-131, followed by end-window counting of the stained smear on the slide. Our procedure is to stain a heat-fixed smear, containing about 8–13 µgm. dry mass of bacterial cells, according to the Hucker modification[5], the sole difference being that the 'Lugol' solution contains approximately 25 µc. iodine-131/ml. and is applied by means of a 20-µl. micropipette so as completely to cover the smear. Following are typical results for 15-hr. cultures of several organisms (recalculated for 10 μgm. dry mass of each organism on the slide):

Strain	Degree of Gram-positivity (counts/min.)
Bacillus subtilis	2,856
Micrococcus lysodeikticus	1,320
Saccharomyces cerevisiae	1,068
Lactobacillus casei	883
Proteus vulgaris	245
B. coli	78

It will be noted that *Saccharomyces*, one of the most intensely Gram-positive organisms, is apparently less so than *B. subtilis* and *M. lysodeikticus*. This is, however, due to the variation of degree of Gram-positivity with age of culture and, especially, the decolorization technique used. If the decolorization step in the Gram procedure is increased by 1 min., then *Saccharomyces* show a higher count than other organisms.

The reproducibility of the method is about 5 per cent. The following modifications do not influence the final count: (1) two-fold increase in concentration of primary dye; (2) three-fold increase in concentration of the 'Lugol' solution, the specific activity/mgm. iodine being kept constant; (3) variation in time of application of the primary dye, or the 'Lugol' solution, from 15 sec. to 2 min. This is good evidence that the Gram-complex involves stoichiometric proportions of dye and iodine with some cell constituent(s). Decolorization of a stained smear until the count is almost zero, followed by re-staining, gives a count close to that of the original, so that the reaction is completely and quantitatively reversible. Treatment of a labelled smear with aqueous non-labelled 'Lugol' results in complete removal of radioactive iodine without altering the intensity of staining; subsequent application of aqueous labelled 'Lugol' restores the original count of the smear. In alcoholic 'Lugol' solution this exchange phenomenon does not occur. One may therefore conclude that the staining reaction involves co-operative binding of dye and ionic iodine. It is consequently doubtful whether dye fixation by Gram-positive cells is due to oxidation of cellular material by iodine[6]. The suggestion that iodotyrosine is formed upon application of the iodine[7] is rendered untenable by the rapidity with which the iodine in the Gram-complex is exchanged, for the rate of exchange of ionic iodine with the iodine in iodotyrosine is very low and is preceded by a pronounced lag period[8].

We have found the above technique extremely useful for various quantitative studies on Gram-staining, full details of which will be published elsewhere. We should like, however, to emphasize the considerable advantages to be gained from the general application of labelled substances to quantitative staining reactions as well as to the mechanisms of these reactions.

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Phototropism of *Phycomyces* Sporangiophores

THE communication to *Nature* concerned with phototropism in *Phycomyces* from Curry and Gruen[1] and its extension by Carlile[2] may be considered in relation to the critical study of the phenomenon of adaptation undertaken by Delbrück and Reichardt[3].

The rate of growth of *Phycomyces* sporangiophores can be regarded as controlled by the supply of materials from the substratum mycelium, but it is influenced in the apical region by an unknown photo-sensitive system. The average growth-rate over a period of hours is independent of illumination, though it has a normal temperature coefficient: light favours earlier sporangium formation, but after that growth continues to an extent and for a duration not noticeably affected by visible light. Increase in intensity of symmetrical illumination with blue light leads, after two to three minutes, to a transient increase in the longitudinal growth-rate, Blaauw's[4] positive light-growth reaction. The rate may increase during the next few minutes to twice normal, then diminishes to less than normal even though the brighter illumination continues, and finally resumes its former rate with no net change in the average rate of growth. The sporangiophore has thus become adapted to a higher light flux. (In this respect its light-growth reaction differs from what appears to be usual in young green shoots.) Decrease in illumination produces a corresponding negative reaction and subsequent adaptation.

Phototropic curvatures arise when the rate of effective photon absorption in one side of the growing zone is appreciably different from that in the other side, leading to asymmetry in growth-rate. On a horizontal clinostat such curvatures continue for as long as spatial asymmetry in light absorption is maintained in the growing sporangiophores. This is quite compatible with the phenomenon of adaptation to changes in flux with time, for, while the distribution of growth-rate is not uniform, the average rate of growth in volume continues unchanged.

Curry and Gruen, remarking on the prompt reverse curvature when their cultures, unilaterally illuminated with ultra-violet light, were rotated through 180°, say that "this implies that there is little adaptation to the ultra-violet, the sensitivity remaining high through many such reversals of position". It may be that there is little adaptation, as could well be determined by observing whether the same intensity of response followed each time when a sporangiophore was first illuminated symmetrically with, say, 0·2 ergs/cm.^{2}/sec. of ultra-violet radiation, and then at half-hour intervals the illumination was increased by successive equal increments of 0·2 erg/cm.^{2}/sec. Without adaptation the same response would follow each time; with, it would diminish. Their conclusion is not, however, necessarily implied by prompt reversibility of the phototropic curvature. Adaptation can be regarded not only in relation to the sporangiophore as a whole but as a property varying in level throughout the growing region according to the light flux at each point. For a sporangiophore uniformly illuminated with blue light the flux throughout the apical zone will vary little. Under unilateral illumination with blue light there are, owing to the lens effect[5], rather more photons absorbed in the far half than in the near, so giving positive phototropism, but the gradient is not steep and the levels of adaptation do not greatly differ. Therefore rotation through 180°, reversing this small flux gradient, results in only small changes in the growth-rates of the two sides (by redistribution of the materials being supplied from below) leading to a sluggish reversal of the positive phototropic curvature. When, however, the sporangiophores are illuminated either along one flank by a grazing pencil of light[6], or unilaterally under paraffin (refractive index, 1·47, giving a complete reversal of the lens effect), or are exposed to unilateral ultra-violet light of about 280 mμ wave-length (for which the absorption coefficient, α, is high), then there is a high rate of photon absorption on the illuminated side and a much lower rate on the other. With such marked differences in flux, and consequently in adaptive levels, rotation of the sporangiophore might be expected to lead to the sharp reversal of curvature found in these cases.

Turning now to the suggestion made by Carlile, it should be pointed out that, while it is true that the curve plotted by him shows a good approximation to the absorption spectrum of riboflavin, there is a danger of error in taking the phototropic curvature of a relatively transparent organ as an index of photodynamic effectiveness when determining the action spectrum. This is because the value of the absorption coefficient, α, changes with wave-length, thus changing the gradient of the corresponding photon absorption per unit volume. This, as Carlile suggests, presumably explains the change from positive to negative phototropism with diminishing wave-length in the ultra-violet.

If with ultra-violet radiation of 302 mμ wave-length there is a positive light-growth reaction in previously darkened sporangiophores, but not phototropic curvature because Castle's critical value for α is reached, then clearly the true action spectrum for a photo-response should not drop to zero as does the graph of angle of phototropic curvature that Carlile plots. A better curve for the primary photo-response could be obtained by the lengthy process of measuring the average light-growth response when passing suddenly from darkness to a standard flux of radiation of each of an extensive series of wave-lengths. With relatively transparent organs there is an inherent error when using either phototropic curvatures or null-deflexion methods with opposed sources of light of different wave-lengths as an index of photodynamic effectiveness. Add to this the probability of ineffective absorption in shadow-producing pigments, of which carotene may be one, and it is clear that great caution should be exercised when such results are compared with known absorption spectra.

Brauner[7] suggested that the positive light-growth reaction and phototropism in *Phycomyces* might arise through partial light-induced destruction of a previously supra-optional concentration of indolyl acetic acid. Results of experiments now in progress, some devised in discussion with him, do not seem to support this suggestion. Lanolin paste and sodium alginate gel containing 10 μgm. and 100 μgm./ml. of indolyl acetic acid have been applied with a micromanipulator to one side of the growing zone of sporangiophores which either (1) had previously been subjected to intense illumination with blue light or (2) were, after indolyl acetic acid treatment, illuminated from the side opposite to that treated. Case (1) sporangiophores after further growth in red light having no phototropic action showed no significant response compared with controls treated with plain paste, and in case (2) the positive phototropic response was not reduced: these experiments need to be extended to cover a wider range of conditions.

Riboflavin may indeed be the photoreceptor in *Phycomyces*, and photo-absorption may either reduce the extent to which it checks indolyl acetic acid oxidation, or even directly promote this oxidation, but this assumption is not yet firmly grounded, and there is as yet no good evidence that internal indolyl acetic acid is a myco-auxin regulating the growth of chitin-walled hyphæ.

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The primary purpose of my previous communication[1] was to show that the reversal of phototropism at about 300 mμ reported by Curry and Gruen[2] is explicable in optical terms, and that it was not necessary to postulate a novel photochemical reaction occurring in the far ultra-violet. I also felt that it was useful to point out that Curry and Gruen's results on the relative effectiveness of different wave-lengths when plotted as an action spectrum give a curve similar to the absorption spectrum of riboflavin. I agree with Banbury as to the dangers inherent in this procedure, and realize that observations on the effectiveness of a range of wave-lengths in promoting the light-growth response would, if available, provide a better guide as to the nature of the photoreceptor substance.

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[2] Curry, G. M., and Gruen, H. E., *Nature*, **179**, 1028 (1957).

Limited Multiplication of *M. lepraemurium* in Tissue Culture

M. lepraemurium causes rat leprosy, which possesses many of the characteristics of the human disease. So far, attempts to culture the causative organism of either disease in bacteriological media or in tissue cultures have not provided convincing evidence of multiplication.

The minimum period required to maintain tissue cultures if the growth of *M. lepraemurium* is to be detected, can be inferred from the generation time *in vivo*. This was found to be 13 days[1,2]. Such relatively long periods of maintenance would result in a changing and variable cell population. On the other hand, since *M. lepraemurium* persists in a stainable form, the bacilli would, even without multiplication, become redistributed among the changing cell population. Previous methods for detecting multiplication, which have usually depended on the distribution of bacilli in tissue cells, are open to errors. To determine accurately, therefore, whether multiplication has occurred, we have had to devise a method for counting the total number of bacilli per culture before and after cultivation.

The obligate intracellular existence of the bacillus within reticulo-endothelial type cells led us to use monocytes in our earlier attempts to culture *M. lepraemurium*, but no multiplication of bacilli was shown even after 80 days. However, bacilli recovered from some of these cultures were still infective[3].

We have now shown that multiplication of *M. lepraemurium* can occur in cultures of tissues obtained from previously infected animals. In a representative experiment the spleen was removed from a mouse infected intravenously 8 weeks previously with *M. lepraemurium* (Douglas strain[4]), and was cut, uniformly, into explants of 1 mm.[3]. The explants were pooled and put out in culture tubes (6 per tube) lined with plasma clot to which was added 1 ml. of medium containing 20 per cent horse serum, 5 per cent chick embryo extract and 75 per cent Hanks's balanced salt solution. Before incubation the tubes were randomized into two groups : (*A*) no addition of antileprous drugs, and (*B*) addition of 100γ streptomycin and 1γ isoniazid, a combination expected, from chemotherapeutic observations of rat leprosy[5,6], to inhibit growth of the organism *in vitro*, and so serve as an essential control. The tubes were incubated at 37° C. in roller drums, and the medium changed twice weekly (all medium kept for counting). After 24 hr. three tubes were picked at random from each group, each was trypsinized, the contents homogenized in a Ten Broeck grinder and the bacilli completely released from cells and dispersed by exposure to ultrasonic vibration. Using a modified Breed technique[7], a count was made of equivalent standard samples of homogenates from each culture. This procedure was repeated at 15 and 29 days, selecting the most healthy cultures. To increase the uniformity of the counting technique the homogenates, after immediate sampling, were stored until the experiment was completed and then, after further dispersal by ultrasonic vibration, new coded samples were prepared and counted again in one operation.

The counts are shown in Table 1. Each mean count of bacilli was obtained from three cultures, from each of which two spreads were made and counted in duplicate. The results show a highly significant increase ($P < 0{\cdot}001$) in the number of bacilli in cultures with no streptomycin or isoniazid, by the fifteenth day of incubation; no further increase occurred in cultures maintained for a further 14 days. There was no increase in the number of bacilli in cultures containing high concentrations of the drugs.

Under these conditions, and using precise methods to determine the total number of bacilli present in each culture, it has, therefore, been possible to demonstrate *in vitro* limited multiplication of *M. lepraemurium* in five experiments. Furthermore, the rate of multiplication *in vitro* corresponds closely to that observed *in vivo* in the mouse. In a personal communication from Dr. J. H. Hanks and his colleagues at Harvard Medical School, Boston, we have learned that substantially similar results have recently been obtained using explanted spleen cells from infected mice. Multiplication has been confined to the initial period of cultivation when the cell cultures are healthy. As soon as the infected cells begin to degenerate, increasing numbers of bacilli will be released and exposed to relatively high concentrations of serum, which have been shown to inhibit their endogenous metabolism[8]. It would seem, therefore, that continued multiplication *in vitro* of *M. lepraemurium* requires a regular supply of healthy cells, preferably in a medium containing low concentrations of serum. Methods for providing these cultural conditions are being investigated. A full account of this work will be published elsewhere.

Table 1. MEAN NUMBER OF ACID-FAST BACILLI COUNTED IN STANDARD SAMPLES FROM HOMOGENIZED CULTURES

	Group *A* cultures	Group *B* cultures
Streptomycin	None	100 γ/ml.
Isoniazid	None	1 γ/ml.
Days		
1	111·0	111·3
15	243·0	105·8
29	235·4	108·5

The 1 per cent limits for the ratio of the mean on day 15 to that on day 1 for group *A* cultures are 1·97 and 2·4. (Counts on the fluid changes were very low and are not included in the table.)

We wish to thank Dr. Ian Sutherland of the Medical Research Council's Statistical Research Unit for the statistical analyses.

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The Diatom *Asterionella* in the Krishna Estuary Region

DURING the course of an extensive hydrobiological survey of the Krishna River estuary, standing at the mouth of the northernmost branch of the Krishna River, we noticed that the shore waters and the sea, as far as the eye could see, were coloured deep chocolate brown, and that the intertidal sand was covered with a thick green scum. A sample of the water, taken one mile south of the river mouth, was collected in a bottle of known volume (2½ l.), fixed with formaldehyde and allowed to settle for a day, giving a sediment 30 ml. in volume. On analysis of the sediment by a conventional method (using a Sidgwick–Rafter cell), we found that it contained mainly swarms of diatoms, the majority of which belong to the chain-forming genus *Asterionella* (*Japonica ?*). Other forms like *Biddulphia*, *Thallassiothrix*, *Pleurosigma*, *Fragillaria*, and *Chaetoceros* were also found, but in fewer numbers. The catch represents a total population of 55·568 millions per litre (approximately 55·6 cells/mm.^{3}). Of this *Asterionella* alone accounted for 51·6 cells/mm.^{3}.

The waters of the river emptying into the sea were very low both in salinity and phytoplankton content. The salinity was 0·305 per cent at the mouth of the river, but was as high as 2·69 per cent one mile south of the river mouth. Correspondingly, phytoplankton density also showed an enormous increase from 111 cells/ml. at the river mouth to 55·568 million cells/ml. one mile south of the mouth. In view of the fact that the coloured water contained a very dense population of diatoms of which *Asterionella* accounted for nearly 93 per cent, it is reasonable to believe that the colour of the water was a result of the dense occurrence of *Asterionella*. But to our knowledge *Asterionella* was not previously known to be a causative factor in the production of coloured water.

Bainbridge[1], while considering observations concerning the size, shape and density of marine phytoplankton concentrations, quotes several figures for concentrations of diatoms, chiefly for normal waters, obtained by various workers from different regions. The highest figure he quotes, for *Asterionella*, is 3·6 cells/mm.^{3} and observes that much higher figures of 31·6 cells/mm.^{3} for other naturally occurring diatom densities, as was found by Marshall and Orr[2] in the waters of Loch Striven for 1927, must be considered localized and of limited duration. The densities found by us, when compared with the findings of other workers, referred to by Bainbridge, do not appear to be abnormal for highly coloured water with localized concentration of diatoms.

Such high densities in this particular region and the particular time are probably due to the enrichment of the area of the sea water, near the river mouth, by nutrient salts from the mainland through the agency of the flooded river during the north-west monsoon, which sets in during the latter half of June and continues until early October.

We wish to express our grateful thanks to Dr. Kandula Pampapathi Rao, Sri Venkateswara University, under whose general direction the hydrobiological survey is being carried out, and to Mr. Ch. Srinivasa Rao of Dintimeraka and his local associates for help and co-operation in collecting material.

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2,4-Dichlorophenoxyacetic Acid as an aid to Seed Production when widely separated *Solanum* Species are crossed

After repeated unsuccessful attempts to duplicate Swaminathan's[1] technique for overcoming the cross incompatibility between *Solanum* species, a study was undertaken to determine the causes of seed failure when widely separated *Solanum* species are crossed. This work showed that some pollen germinated in all attempted crosses between several tuber-bearing series of the genus. Apparently normal pollen tubes were even observed at the bases of *S. melongena* L. styles when that species was pollinated by *S. phureja* Juz. and Buk.

The work indicated that a failure in seed production following the crossing of widely separated *Solanum* species could be a result of a failure in fruit formation because too few seeds were present to stimulate growth of the ovary. Without fruit formation to provide the normal environment for development, the few seeds present would be unable to mature. Therefore, attempts were made to devise a method for stimulating ovarian development which would not itself inhibit seed formation. It was found that treating the ovaries 24 hr. after pollination with a drop of 3–6 p.p.m. of 2,4-dichlorophenoxyacetic acid (2,4-D) had the desired effect.

The results obtained from the cross of a diploid hybrid (*S. chacoense* Bitt. × *S. rybinii* Juz. and Buk.) × *S. stoloniferum* Schlecht., illustrate the value of the treatment. Several hundred attempted crosses of this parental combination yielded only three or four very small berries from the non-treated ovaries, whereas several hundred berries were produced by those treated with 2,4-dichlorophenoxyacetic acid. The berries from the non-treated fruit produced no seeds, but thousands of viable seeds were produced by the treated fruit. By means of this technique, viable seeds have also been obtained from several other wide crosses, and selfed seeds were obtained from hybrid clones of very low pollen fertility. Similarly, Fischnich and Lubbert[2] have reported that 2,4,5-trichlorophenoxyacetic acid was useful for producing seeds from difficult intervarietal crosses. However, these studies have shown that higher concentrations of the di- than of the tri-chlorophenoxyacetic acid were necessary to induce fruit formation in *Solanums*. Moreover, the indications were that the optimum concentration of the latter was sometimes inhibitory to seed formation. The full results of these investigations are being published elsewhere.

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Colour Vision of Three Albinos

In 1951 an albino woman was given anomaloscope tests[1] and it was reported that she had a marked deviation in red vision. Recently, two albino men have been tested. The three subjects are unrelated. Tables 1 and 2 indicate the abnormalities of colour vision found in them on the anomaloscope[2].

Table 1. Red–Green Test

Subject's sex and age	Deviation	Matching range
f; 50	6 × sigma to red*	1 × mode*
m; 25	4 × sigma to red	5 × mode
m; 51	8 × sigma to red	5 × mode

* Both tests, about 3 weeks apart

Table 2. Yellow–Blue Test

Subject's age and sex	Deviation	Matching range
f; 50	2 × sigma to yellow	<1 × mode
	<1 × sigma to blue*	<4 × mode*
m; 25	1 × sigma to yellow	4 × mode
m; 51	zero	>2 × mode

* Second test, about 3 weeks later

It will be seen that all three albinos had red deviations almost equivalent to simple protanomaly, while the two men also had enlarged matching ranges, but not quite large enough for them to be classed as extreme protanomals. In none of them was the red end of the spectrum shortened. It is invariably shortened in extreme protanomalous but not invariably in simple protanomalous subjects.

In the yellow–blue test the two men had large matching ranges. The woman had no defect on her first yellow–blue test except a small deviation to yellow, although she was more than fifty years of age; but on her second test she had an enlarged matching range and a very slight blue deviation.

The two men passed the Ishihara test, the younger making only one error. The elder made only four errors. He claimed to smoke seventy cigarettes a day. The woman, although she was less defective than the men, failed on the Ishihara test, with fifteen errors in twenty-four plates.

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[1] *Nature*, 168, 954 (1951).

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Moving Visual Images produced by Regular Stationary Patterns

IT would seem that some of the intriguing visual phenomena discussed by Dr. MacKay[1] may be due, not to cerebral or retinal factors only, but at least in part to preretinal factors, namely, fluctuations of accommodation combined with lack of axial symmetry in the optical system of the eye. Helmholtz[2] described how, when looking at a pattern consisting of black and white concentric circles, and thus similar to one of Dr. MacKay's, a complicated system of darker and brighter radial zones is seen. If accommodation, or the distance from the pattern to the eye, is slightly altered, the positions of the brighter zones vary and the observer sees them rotate rapidly to and fro. According to the above explanation the phenomenon is due to actual changes occurring in the image of the pattern formed on the retina. Unless such changes can be ruled out as a factor in Dr. MacKay's more complicated experiments, it does not seem possible to conclude that subjective impressions of movement received while the pattern is looked at, or in after-images, are necessarily caused by the nervous system responding to a truly stationary light distribution in the optical image formed by the eye.

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[1] MacKay, D. M., *Nature*, 180, 849 (1957).

[2] Helmholtz, H. von, "Physiologische Optik", 1st ed., Part 1 (1856).

WHILE viewing the pattern of concentric circles reproduced in *Nature* of October 26[1], many readers will have noted rapidly fluctuating sectors and they may have speculated about their cause.

This effect was first described by Helmholtz[2], but although he attributed it to accommodation, he did not give a definitive explanation of why the sectors appear to rotate.

When the young emmetrope focuses on a near test object the amount of accommodation exerted is not constant. The lens is constantly undergoing small (± 0·1 dioptre), rapid (2–3 c./s.) fluctuations of power. This has been demonstrated objectively with an infra-red high-speed recording optometer[3] (see Fig. 1). Arnulf *et al.*[4] have shown that these fluctuations are mainly astigmatic, that is, different segments of the circular ciliary muscle probably contract asynchronously. There are, therefore, even in the emmetropic eye, small, variable astigmatic errors that occur in constantly changing meridians. Inspection of Dr. MacKay's Fig. 2[1] clearly shows rotating sectors. The frequency of occurrence of the effect agrees with the objective measurements shown in Fig. 1 herewith. The reader can readily confirm that the cause of these rapidly rotating sectors is irregular fluctuations of accommodation. The rotation ceases if the eye is focused at infinity. This experiment may easily be done by viewing the pattern at 25 cm. or so through a +4 dioptre lens. Similarly, the rotation stops if the ciliary muscle is paralysed with homatropine eye drops. Naturally, the effect will not be reported by a presbyopic observer who is over the age of fifty-five years. The effect will also cease if the pattern is viewed through a 1-mm. artificial pupil, for the increased depth-of-focus of the eye eliminates the perception of the small variable astigmatic errors[5].

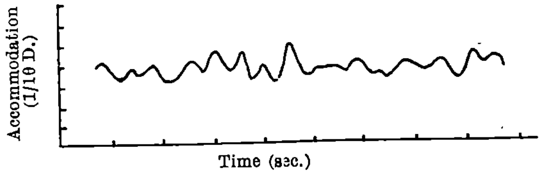

Fig. 1. Variation of power of accommodation measured in the vertical meridian of the eye during steady fixation of a small object (scale in 1/10 dioptre)

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[1] MacKay, D. M., *Nature*, 180, 849 (1957).

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THE phenomenon mentioned by Dr. Pirenne is one of several side-effects of our patterns which are being separately investigated because they seem to be distinct from the complementary response. Helmholtz's "rotating sectors" are, of course, well known and may be considered as moiré fringes due to the superposition of displaced replicas of the pattern either in the optical image or at a neural level or both. In the 'ray' figure described in my previous communication[1] similarly fleeting 'figure of 8' moiré patterns can be seen as accommodation varies. The simplest way of demonstrating their origin is to cover the stimulus figure with a transparency of itself, when similar fringes appear (Fig. 1), and one can in fact measure the amplitude and direction of the effective retinal image-displacement by observing the displacement required in the transparency to produce the same moiré pattern.

The marked differences observed between these moiré patterns and the complementary images provided the first reason for believing that the latter had a different origin. The evidence[1,2] of interocular transfer, especially in random visual noise, and of the limited relevance of eye movement demonstrated by the persistence of the response with a stabilized retinal image and in stroboscopic light, combine to confirm that the complementary image presents a different and separable problem. Furthermore, following Campbell and Robson's helpful suggestion, I have verified that the complementary image is still seen when the ciliary muscle has been paralysed by homatropine. It can be seen also (by seven out of

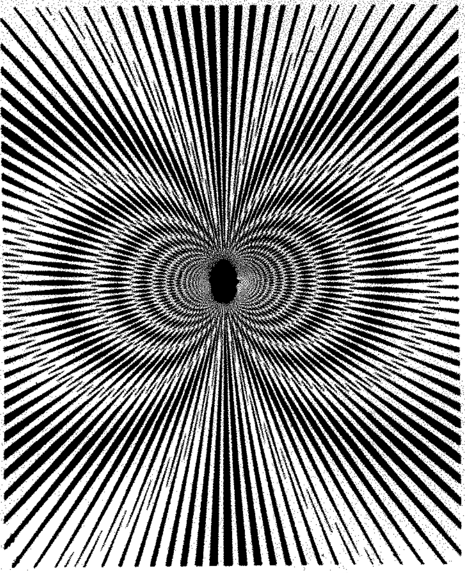

Fig. 1

ten observers to date) in the first few seconds after exposure of the ray-pattern in a single 120-Joule flash lasting less than 1½ msec.

Finally, when the retinal image is deliberately moved in such a way that no moiré figures are generated (for example, by slightly rocking the ray figure about its centre several times per second), the complementary after-image is strengthened (presumably because 'on' and 'off' receptors are stimulated), whereas with other types of artificial motion it is not.

The foregoing evidence would appear to dispose also of a confusion in some early literature[3] between these complementary after-effects and the after-effects of seen movement, caused by the use of striped curtains and the like as moving stimuli. This work, to which my attention has been directed since my earlier communications were published, includes unmistakable reports of complementary images; but writers usually assimilate them to the 'streaming' after-image of movement which they were studying. If one uses a random dot pattern (for example, a photograph of sandpaper) as the moving stimulus, the two effects can be clearly separated.

One interesting side-effect which we are studying is an apparent disturbance of the accommodation reflex by the circular pattern. A hair laid obliquely across its central region may sometimes defy all efforts to bring it into sharp focus, although against a plain background at the same distance it becomes perfectly sharp. It is hoped that experiments in this connexion may yield some clues to the organization of the detector-system which normally enables an out-of-focus image to be corrected.

A fuller account of investigations using these regular stimulus-patterns will be published elsewhere.

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[1] MacKay, D. M., *Nature*, **180**, 849 (1957).

[2] MacKay, D. M., *Nature*, **180**, 1145 (1957).

[3] See, for example, Hunter, W. S., *Psych. Rev.*, 22, 479 (1915).

Coffinite in Cornwall

Coffinite, $U(SiO_4)_{1-x}(OH)_{4x}$, a rare mineral previously reported only from the Colorado Plateau, United States[1], and the Buller Gorge area of South Island, New Zealand[2], has been identified in ore samples from Roskrow United Mine, Ponsanooth, Cornwall.

Here coffinite occurs as a replacement of colloform pitchblende. All stages of replacement occur from incipient alteration along radial fractures and concentric growth bands to complete colloform pseudomorphs measuring up to 5 mm. across.

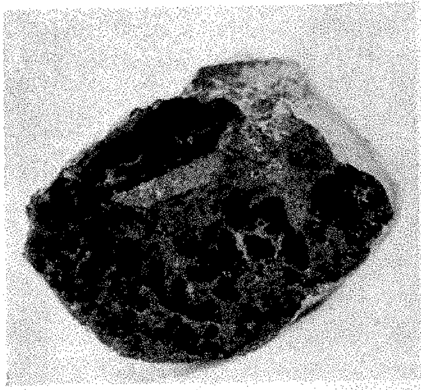

Fig. 1. Colloform aggregates of coffinite (black, lower part of specimen) pseudomorphous after pitchblende. × 0·85

The identification was based on X-ray powder photographs with the strongest lines at 3·49 (v.s.), 4·66 (s.), 2·64 (m.s.) and 1·80 (m.s.) A. A spectrographic analysis showed major uranium and silicon with vanadium and lanthanum among the minor elements.

A full description of the physical properties with a complete chemical analysis will be published elsewhere. The present communication is published by permission of the Director of the Geological Survey.

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Subjective Probability, Gambling and Intelligence

It is well known that subjective ideas of probability differ from predictions made using statistical laws. This has been shown in temporal predictions by Jarvik[1], Cohen and Hansel[2] and others. It has also been shown by me[3] to be the case for predictions about spatial ordering.

It is also well known that persons in general like to gamble. If they have the choice of a number of different courses of action which, on the average, will yield the same benefit, they will prefer to risk some loss in order to chance some gain, rather than to choose a course which has a certain outcome. This preference has been shown in laboratory studies by Edwards[4].

The present communication is concerned with the relation between these two phenomena and intelligence.

I set persons the task of searching for an object which might be in one of a number of places, and related the strategy they adopted to their intelligence. This task could either be carried out systematically, or the person could gamble, he could work at 'random', pitting his confidence in his hunches against the risk of forgetting where he had looked. (The advantage of approaching this task systematically is that it ensures no moves will be forgotten.) Forty subjects were each given three problems; eighteen of them always worked systematically. When they were ranked according to their intelligence test scores, it was found (using Whitfield's[5] method) that these eighteen were of significantly higher intelligence than the rest ($p < 0{\cdot}002$, two-tailed test).

The results posed a question. Did the more intelligent subjects have sophisticated ideas about subjective probability, or did they have the usual ideas but prefer to use the alternative, systematic, approach? In order to throw light on this question the results of my subjective probability study[3] were re-examined from the point of view of intelligence. This showed that intelligence and subjective probability were not related. It would seem, then, that intelligence determined not the hunches the man had, but whether he chose to be guided by them.

H. C. A. Dale

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15 Chaucer Road, Cambridge.

[1] Jarvik, M. E., *Amer. Psychol.* (abstract), 1, 453 (1946).

[2] Cohen, J., and Hansel, C. E. M., *Brit. J. Psychol.*, **46**, 178 (1955).

[3] Dale, H. C. A., M.R.C. App. Psychol. Res. Unit Report No. 280.

[4] Edwards, W., *Amer. J. Psychol.*, **66**, 349 (1953).

[5] Whitfield, J. W., *Biometrika*, **34**, 292 (1947).

Constant Temperature Water-Bath

A STATIONARY manometric respirometer for the simultaneous measurement of oxygen consumption and contraction amplitude of electrically stimulated muscle preparations has been developed[1]. It is necessary to immerse this apparatus in a water-bath having a temperature control of ±0·01° C.

The most compact and efficient unit available ('Circotherm' unit with mercury contact thermometer No. 4110, 25–50° C. in 1/20th divisions. Shandon Scientific Co., Ltd., London), comprising heater, stirrer, thermometer and thermostatic control is found to give an accuracy of only ±0·023° C. under our experimental conditions. However, by including a 'Variac' continuously adjustable auto-transformer (Type *V6 HMT*. Zenith Electric Co., Ltd., London) in the above heater circuit the desired temperature control is easily obtained.

An unlagged 'Perspex' bath (0·32 m. × 0·25 m. × 0·25 m.) containing 20 l. of water is used: this stands on a metal frame in the laboratory at normal room temperature. By reducing the heater input voltage from 250 V. to 75 V. the temperature fluctuations are reduced from ±0·024° to ±0·001° C. in the centre of the bath (Fig. 1) and from ±0·016° to ±0·002° C. in the corner of the bath (Fig. 2). With 75 V. the absolute temperature differences between any two positions in the bath are ±0·006° C. (reducible by the use of lagging and additional stirring devices).

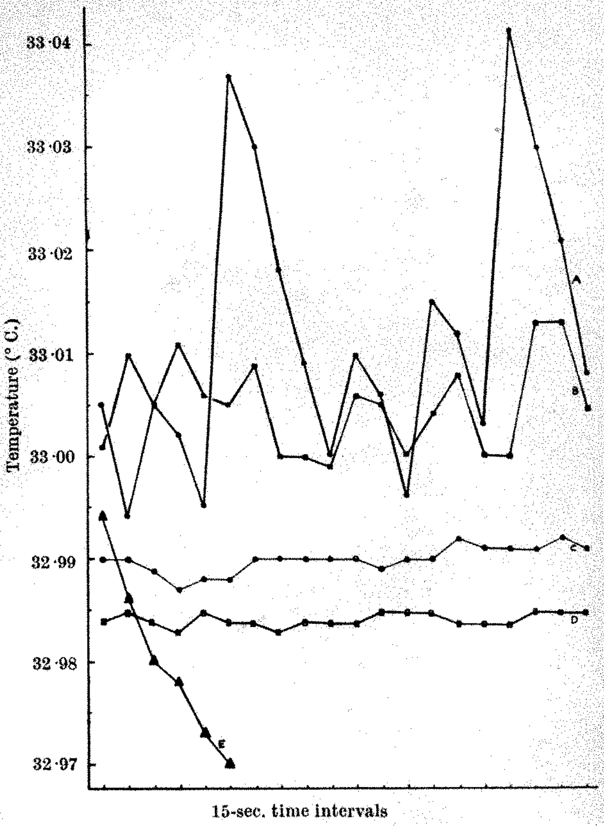

Fig. 1. Temperature fluctuations at centre of bath. *A*, 250 V.; *B*, 150 V.; *C*, 100 V.; *D*, 75 V.; *E*, 50 V.

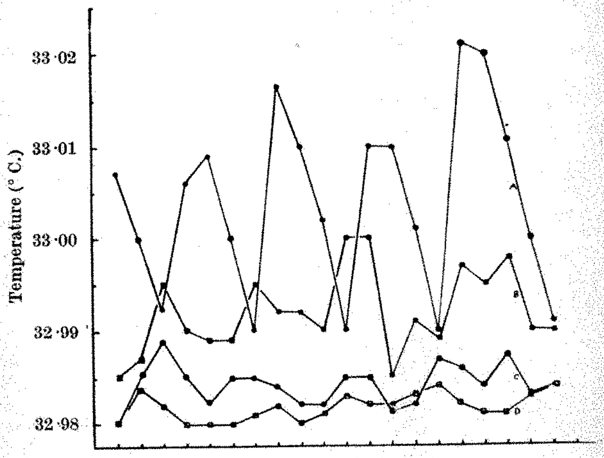

Fig. 2. Temperature fluctuations at corner of bath. *A*, 250 V.; *B*, 150 V.; *C*, 100 V.; *D*, 75 V.

In practice the water-bath is brought to the required temperature with the 'Variac' giving full mains voltage. The voltage is then reduced to the working value of 75 V. The rate of stirring is unaffected. This system avoids the necessity for using both a booster heater and a smaller one.

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R. L. Speirs

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Oct. 30.

[1] Darbre, A., and Speirs, R. L., *Biochem. J.*, **67**, 32 *P* (1957).

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92 Upper Circular Rd, Calcutta

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 3

Institution of Post Office Electrical Engineers (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 5 p.m.—Mr. R. H. Franklin and Mr. M. B. Williams: "Recent Developments in Line Transmission Systems".

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. Robert Clark: Presidential Address.

Society of Chemical Industry, London Section (joint meeting with the Microbiological Group, at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. J. J. H. Hastings: "Microbiological Production of Organic Chemicals".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. John Ward Perkins: "The Ancient Landscape of Southern Etruria".

Tuesday, February 4

Society of Chemical Industry, Agriculture Group (at 14 Belgrave Square, London, S.W.1), at 10.30 a.m.—Nitrogen Meeting.

Institution of Chemical Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Scientific Papers.

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. N. E. V. Viner-Brady and Mr. H. M. Pearson: "The Use of Aerial Photography by Railways".

Institution of Electrical Engineers, Measurement and Control Section (in conjunction with the British Nuclear Energy Conference, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. H. Bowen and Mr. E. F. O. Masters: "Temperature Transients in Gas-Cooled Thermal Nuclear Reactors"; Mr. W. Abson, Mr. P. G. Salmon and Mr. S. Pyrah: "Boron-Trifluoride Proportional Counters" and "The Design, Performance and Use of Fission Counters"; Dr. J. Howlett: "The Application of Digital Computers to Nuclear-Reactor Design".

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Prof. J. Z. Young, F.R.S.: "The Living Body as a Machine". (Further lectures on February 5, 11 and 12. Lectures for Sixth Form Boys and Girls from Schools in London and the Home Counties.)

Society of Dyers and Colourists, London Section (joint meeting with the London Section of the Textile Institute, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Dr. T. Vickerstaff: "Progress in Textiles. A review of developments and their effect on industry and user: Dyeing and Finishing".

Wednesday, February 5

Royal Society (at Burlington House, Piccadilly, London, W.1), at 3 p.m.—Discussion on "Experimental Results with the Zeta Apparatus on Controlled Thermonuclear Reactions" opened by Sir John Cockcroft, F.R.S.

Royal Society of Medicine, History of Medicine Section (at 1 Wimpole Street, London, W.1), at 5.15 p.m.—Sir Weldon Dalrymple-Champneys: "Preventive and Curative Medicine in Ancient Peru" (Presidential Address).

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Dr. P. J. V. Agius and Mr. D. Mulvey: "Mechanism of Sludge Suspension in Engine Oil".

Royal Society of Medicine, Experimental Medicine and Therapeutics Section (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Symposium on "Hæmoglobin". Speakers: Prof. C. Rimington, Dr. A. C. Allison, Dr. H. V. Ingram and Dr. J. Walters.

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Dr. W. J. G. Beynon: "Radio Investigations during the I.G.Y.".

Thursday, February 6

Royal Society (at Burlington House, Piccadilly, London, W.1) at 4.30 p.m.—Mr. S. A. Kitchener and Mr. R. F. Strickland-Constable: "Growth and Evaporation of Crystals from the Vapour Phase"; Mr. R. Hide: "An Experimental Study of Thermal Convection in a Rotating Liquid".

University of London (at the Middlesex Hospital Medical School, Mortimer Street, London, W.1), at 5 p.m.—Prof. T. S. Westoll, F.R.S.: "Pattern and Form in the Vertebrate Skull: a Study in Plastic Deformation and Its Limits".*

Bedford College (at Regent's Park, London, N.W.1), at 5.15 p.m.—Prof. J. Z. Young, F.R.S.: "The Brain and Its Connections".*

Institute of Refrigeration (at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, Westminster, London, S.W.1), at 5.30 p.m.—Dr. Audrey U. Smith: "The Preservation of Living Cells and Tissues at Low Temperatures".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. H. W. Melville, F.R.S.: "High Polymers" (Forty-ninth Kelvin Lecture).

University College, London (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. Colin Clark: "World Population".* (First of the Newmarch Lectures in Economic Statistics. Further Lectures on February 13, 20 and 27.)

Institute of Metals, London Local Section (at 17 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. B. R. T. Frost: "Corrosion by Liquid Metals".

Royal Institute of Chemistry, London Section (joint meeting with the Kingston Technical College Chemical Society, at Kingston Technical College, Fassett Road, Kingston), at 7 p.m.—Prof. H. J. Eméleus, F.R.S.: "The Boron Hydrides and their Potential Uses".

Friday, February 7

Society of Chemical Industry, Road and Building Materials Group (joint meeting with the Institution of Highway Engineers, at the Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1), at 5.30 p.m.—Dr. E. K. Woodford, Mr. R. C. B. Gardner and Mrs. M. W. Spitta: "Planting and Control of Road Verges".

Society of Dyers and Colourists, London Section (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Mr. C. C. Wilcock: "Spun-dyed Fibres, their Properties and Uses".

Society for Analytical Chemistry, Microchemistry Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Annual General Meeting, 6.30 p.m.—Ordinary Meeting of the Society organized by the Microchemistry Group.

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. John Marco Allegro: "The Dead Sea Scrolls".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Analyst (with a B.Sc. degree, preferably with honours in organic chemistry, and an interest in biochemistry and animal nutrition research) in the Nutrition Research Laboratory, Department of Agriculture, Glenfield, N.S.W., Australia, for duties which include the supervision and testing of analytical procedures in biological chemistry (vitamin A blood ketone assays, etc.) involving techniques such as paper chromatography and spectrophotometry—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (February 12).

Reader in Chemical Engineering; Reader in Electrical Engineering (Heavy Current); Reader in Mechanical Engineering; Reader in Physical Metallurgy, Reader in Industrial Metallurgy; Reader in Mathematics or Mathematical Physics—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (February 12).

Research Student (with a good honours degree in engineering or science) in Biomechanics—The Registrar, King's College, Strand, London, W.C.2 (February 14).

Assistant Lecturer in Genetics—The Registrar, The University, Sheffield (February 15).

Assistant Lecturer (with an honours degree in psychology and additional training or experience in clinical psychology) in Clinical Psychology in the Department of Psychiatry of the Faculty of Medicine—The Registrar, The University, Manchester (February 15).

International Paints Research Fellow (preferably with at least two years postgraduate research experience) at the Plymouth Laboratory, to continue biological and chemical research already in progress, including research with radioactive substances, with a view to furthering knowledge of the effect of toxic substances on marine animals and plants—The Secretary, Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, Devon (February 15).

Technician (preferably with experience in workshop practice or histological techniques) at the Marine Biology Station—The Registrar, University College of North Wales, Bangor, North Wales (February 15).

Assistant Lecturer (with qualifications in either pure or applied mathematics) in Mathematics—The Registrar, The University, Manchester 13 (February 17).

Principal Lecturer (with high qualifications in physiology and preferably some experience as a university lecturer) in Anatomy and Physiology—The Principal, Loughborough Training College, Loughborough (February 21).

Senior Lecturer in Zoology at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 21).

Assistant Lecturer or Lecturer in Geology—The Secretary, The University, Exeter (February 22).

Research Fellows (Ph.D., with a special aptitude for research in high or low energy nuclear physics) in Experimental or Theoretical Nuclear Physics—The Registrar, The University, Liverpool (February 22).

Lecturer or Assistant Lecturer (honours graduate, preferably with research interests in mycology and plant pathology) in Botany at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 25).

Lecturer in Biochemistry at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 28).

Professor of Pure Mathematics in the Durham Division of the University—The Registrar, University Office, 46 North Bailey, Durham (March 1).

Head (with an honours or higher degree in science with extensive experience of teaching, advisory work and research in agriculture and dairy bacteriology) of the College Department of Bacteriology—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (March 15).

Research Assistants (2) (theoretical physicists with research experience) in the Department of Theoretical Physics, for special research into fundamental particle and nuclear physics—The Registrar, The University, Liverpool (March 15).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Chemotherapy, Engineering, Metallurgy, Pharmacology and Physics—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

Turner and Newall Research Fellow in Engineering, Inorganic Chemistry or Physics—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

Analyst (with a university degree in chemistry or equivalent qualification in analytical chemistry, for example, A.R.I.C., with two years research experience in pure or applied chemistry) in the Department of Agriculture, Federation of Nigeria, to carry out analysis and testing of soils and plant materials in connexion with the research programme of a soils and crop nutrition team, and to supervise the routine work in the chemistry laboratory—The Director of Recruitment, Colonial Office, London, S.W.1, quoting Ref. BCD. 63/14/037.

Hospital Biochemist, Basic grade (with a B.Sc. degree, with chemistry or biochemistry as main subject or equivalent qualification)—The Chief Pathologist, West Middlesex Hospital, Isleworth, Mddx.

Laboratory Technician (preferably with experience in photography or vacuum techniques) in the Department of Physics, Washington Singer Laboratories, for duties which will include the care and maintenance of laboratories—The Secretary, The University, Exeter.

Lecturer, Assistant Professor, Postdoctorate Fellow, and a Research Assistant in the Department of Physics—Head of the Department of Physics, University of British Columbia, Vancouver, B.C., Canada.

Lecturer (Grade IIa) in each of the following Departments: Mechanical Engineering Department, Physics Department and the Chemistry Department—The Principal, Paisley Technical College, George Street, Paisley.

Physical Chemist, Scientific or Senior Scientific Officer grade (with postgraduate research experience in reaction kinetics, particularly oxidation work), at the Wantage Radiation Laboratory, to work on the development of industrially important reactions initiated by radiation—The Recruitment Officer (1018.Z/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Research Officer (with a university degree in forestry or a university degree in botany and a diploma in forestry) in the Department of Forest Research, Federation of Nigeria, to carry out silvicultural investigations, chiefly in the high forest regions of the Federation, but with a possibility of work in the savannah regions also—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.61/14/06.

Research Student in Physics in the field of microwave spectroscopy of solids, particularly at low temperatures—The Registrar, The University, Nottingham.

Scientific Officers (with a first- or second-class honours degree in an appropriate subject or equivalent) with the Ministry of Supply at research and development establishments, mainly in the south of England, for work in physics, electronics, electrical, mechanical or aeronautical engineering, applied mathematics, metallurgy or chemistry—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.8/8A.

Senior Geologist (with a degree in geology and not less than ten years experience in geology, including water geology and drilling) in the Water Development Department, Government of Cyprus, to take charge of the drilling section of the Department, which includes geology, and to carry out miscellaneous geophysical and other research work, and to work in close collaboration with the Hydrological Section of the Water Development Department—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.140/17/06/T.

Senior Physicist to take mainly sixth form work including university scholarship level; and a Physicist to teach throughout the school to the advanced level standard if necessary—The Warden, Trinity College, Glenalmond, Perthshire.

Senior Scientific Officer or Scientific Officer (Thermodynamics) (with a first- or second-class honours degree and a knowledge of current and future developments in aircraft and missile propulsion systems) with the Air Ministry, for work concerned with deducing performance characteristics of propulsion systems of the world's latest types of aircraft and missiles, and involves personal liaison with Fighting Services Experimental Establishments and firms in the U.K. and the United States—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.21/8A.

Senior Technologist (with a university honours degree in science, applied science or chemical engineering, together with some postgraduate research experience) with the Bread Research Institute of Australia, to initiate and expand investigations into the physical properties associated with the mechanical manipulation of dough, the high and low temperature storage of bread, temperature and humidity factors in oven performance—The Director, Bread Research Institute of Australia, 111 Pacific Highway, North Sydney, N.S.W., Australia.

Specialist Officer (Statistician) (with a good honours degree in mathematics and two years postgraduate experience in statistics as applied to agricultural research) with the Federation of Nigeria, for duties which will include the building up and supervising of a statistics branch in the Department of Agricultural Research—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/14/048.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Forestry Commission. Forest Record No. 35: The Use of Home-Grown Timber in Packaging and Materials Handling. By J. R. Aaron. Pp. 32. (London: H.M. Stationery Office, 1957.) 2*s*. 6*d*. net. [1211

Statement by the Forestry Commission of Great Britain prepared for the British Commonwealth Forestry Conference, 1957. Pp. 24. (London: Forestry Commission, 1957.) [1211

Department of Scientific and Industrial Research. Road Research Laboratory. Road Research Technical Paper No. 38: Some Safety Aspects of Pedal and Motor-Assisted Cycles. By Dr. H. J. H. Starks and R. D. Lister. Pp. iv+40+4 plates. (London: H.M. Stationery Office, 1957.) 2*s*. 9*d*. net. [1211

The Life and Work of Frederick Winslow Taylor. Pp. ii+17. (London: Urwick, Orr and Partners, Ltd., 1957.) 2*s*. 6*d*. [1211

Building Research Station Digest, October 1957: Plastics for Building. Pp. 8. (London: H.M. Stationery Office, 1957.) 3*d*. net. [1211

Journal of the West African Science Association, Vol. 1, No. 1 (October, 1954). Pp. 72. (London: Charles Knight and Co., Ltd., 1954. Published for the West African Science Association.) 12*s*. 6*d*. [1211

Glasshouse Crops Research Institute. Annual Report, 1954–1955. Pp. 108+6 plates. (Littlehampton: Glasshouse Crops Research Institute, 1957.) [1211

Tube Investments Limited. Chairman's Statement—Annual General Meeting, Birmingham, 9th December, 1957. Pp. 12. (London: Tube Investments Limited, 1957.) [1211

Library Association. Special Subject List No. 22: Vintage Cars. Pp. 18. (London: Library Association, 1957.) 2*s*. 6*d*. [1811

National Physical Laboratory. MSF—Standard Frequency Transmissions from the United Kingdom. Pp. 7. (Teddington, Mddx.: National Physical Laboratory, 1957.) [1811

The Leverhulme Trust. Leverhulme Research Awards: First Report. Pp. 72. (London: The Leverhulme Trust, 1957.) [1811

Memoirs of the Royal Astronomical Society. Vol. 68, Part 1: Radial Velocities of Southern B Stars Determined at the Radcliffe Observatory (Paper 2). By M. W. Feast, A. D. Thackeray and A. J. Wesselink. Pp. 35. (London: Royal Astronomical Society, 1957.) 16*s*. [1811

British Iron and Steel Research Association. Survey, 1957. Pp. 16. (London: British Iron and Steel Research Association, 1957.) [1811

Imperial College of Science and Technology (University of London). Research Report of the Royal School of Mines, 1954–57. Pp. vi+46+10 Plates. (London: Imperial College of Science and Technology, 1957.) [1811

Other Countries

Illinois Natural History Survey Bulletin. Vol. 27, Article 1 (August 1957); Ecological Life History of the Warmouth (Centrarchidae). By R. Weldon Larimore. Pp. 83. (Urbana, Ill.: Department of Registration and Education, Natural History Survey Division, 1957.) [1211

Fisheries Research Board of Canada. Bulletin No. 111: Report of the Atlantic Herring Investigation Committee. By A. H. Leim, S. N. Tibbo, L. R. Day, L. Lauzier, R. W. Trites, H. B. Hachey and W. B. Bailey. Pp. viii+317. (Ottawa: Fisheries Research Board of Canada, 1957.) [1211

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 38 (September 1957): Sex Difference in Mortality Increasing. Longevity of Industrial Population at New High. Geographic Variation in Fatal Accidents. Recent Progress in Control of Maternal Mortality. Pp. 12. (New York: Metropolitan Life Insurance Company, 1957.) [1211

Colony of Mauritius. Meteorological Observations and Climatological Summaries, 1956. Part 7: July, 1956. Pp. 12. Part 8: August, 1956. Pp. 12. Part 9: September, 1956. Pp. 12. Part 10: October, 1956. Pp. 12. Part 11: November, 1956. Pp. 12. Part 12: December, 1956. Pp. 12. (Port Louis: Government Printer, 1957.) [1211

Sveriges Geologiska Undersökning. Avhandlingar och Uppsatser. Series C, No. 539: Skredet vid Intagan ar 1648. Av Björn Järnefors. Pp. 18+2 plates. 2 kronor. Series C, No. 541: Nya Geologiska Undersökningar vid utö Järnmalmsfält. Av Nikolaj Pilava-Podgurski. Pp. 54. 3 kronor. Series C, No. 542: On the Occurrence of Ignimbrite in the Pre-Cambrian. By S. Hjelmqvist. Pp. 12+12 figures. 1 kronor. Series C, No. 543: Ein Beitrag zur Stratigraphie und dem Bau des Skelleftefeldes, Nordschweden. Von Gunnar Lautsky. Pp. 65+4 plates. 6 kronor. Series C, No. 544: Petrology of the Uppsala Region, Eastern Sweden. By P. H. Lundegårdh. Pp. 74+1 plate. 6 kronor. Series C, No. 545: An Earthquake Catalogue for Fennoscandia for the years 1891–1950. By Markus Båth. Pp. 52. 3 kronor. Series C, No. 546: De Glasiga Diabasgångarna i Djupviks Kalkbrott, Björkviks Socken, Södermanland. Ac Erik Åhman. Pp. 18. 2 kronor. Series C, No. 547: On the Stratigraphical Value of the Megaspores of *Lycostrobus scottii*: Preliminary Report of Some New Finds and Their Interpretation. By Britta Lundblad. Pp. 11+1 plate. 1 kronor. Series C, No. 548: A Petrological Investigation on Lake Norra Dellen by Means of Frog-Man Equipment. By Leonardo L. Redaelli. Pp. 22. 2 kronor. Series C, No. 551: Geokronologiska Undersökningar i Värmland. Av Jan Lundqvist. Pp. 28+1 plate. 2.50 kronor. Series C, No. 554: C14-Dateringar am Rekurrensytor i Värmland. Av Jan Lundqvist. Pp. 22. 2 kronor. Series C, No. 557: C14-Analyser i Svensk Kvartärgeologi, 1955–57. Av G. Lundqvist. Pp. 25. 2 kronor. Årsberättelse för År 1954. Pp. 8. Årsberättelse för År 1955. Pp. 9. Årsberättelse för År 1956. Pp. 8. (Stockholm: Kungl. Boktryckeriet P. A. Norstedt & Söner, 1956 and 1957.) [1811

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Applications, with curriculum vitae, to Dr. J. H. Burgoyne, Department of Chemical Engineering, Imperial College, S.W.7.

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Applications should be sent before March 15, 1958, accompanied by university transcript and letters of recommendation from two professors, to Dr. H. Kleerekoper, Chairman, Department of Biology, Hamilton College, McMaster University, Hamilton, Ontario, Canada.

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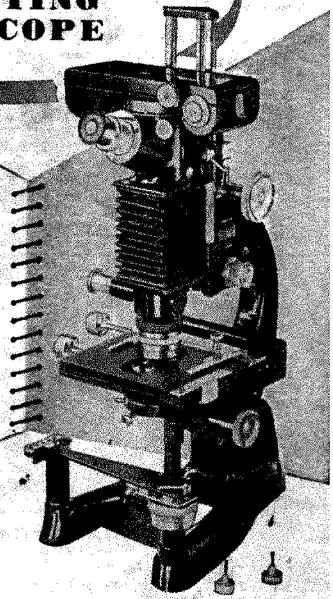

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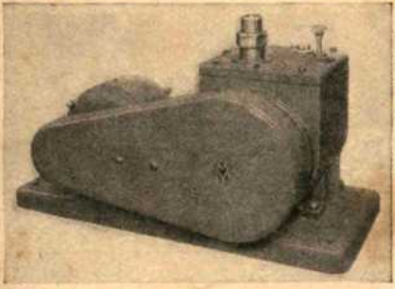

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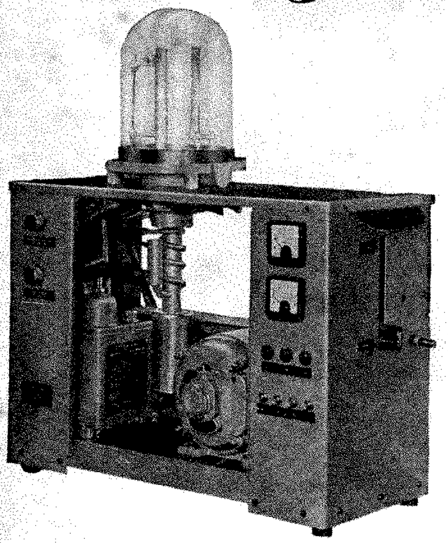

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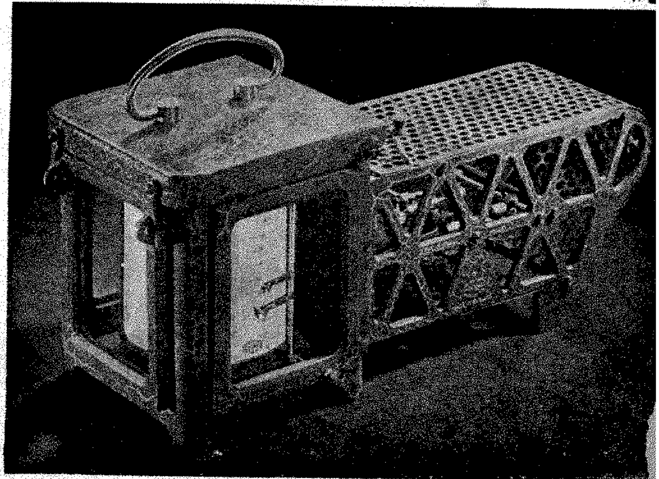

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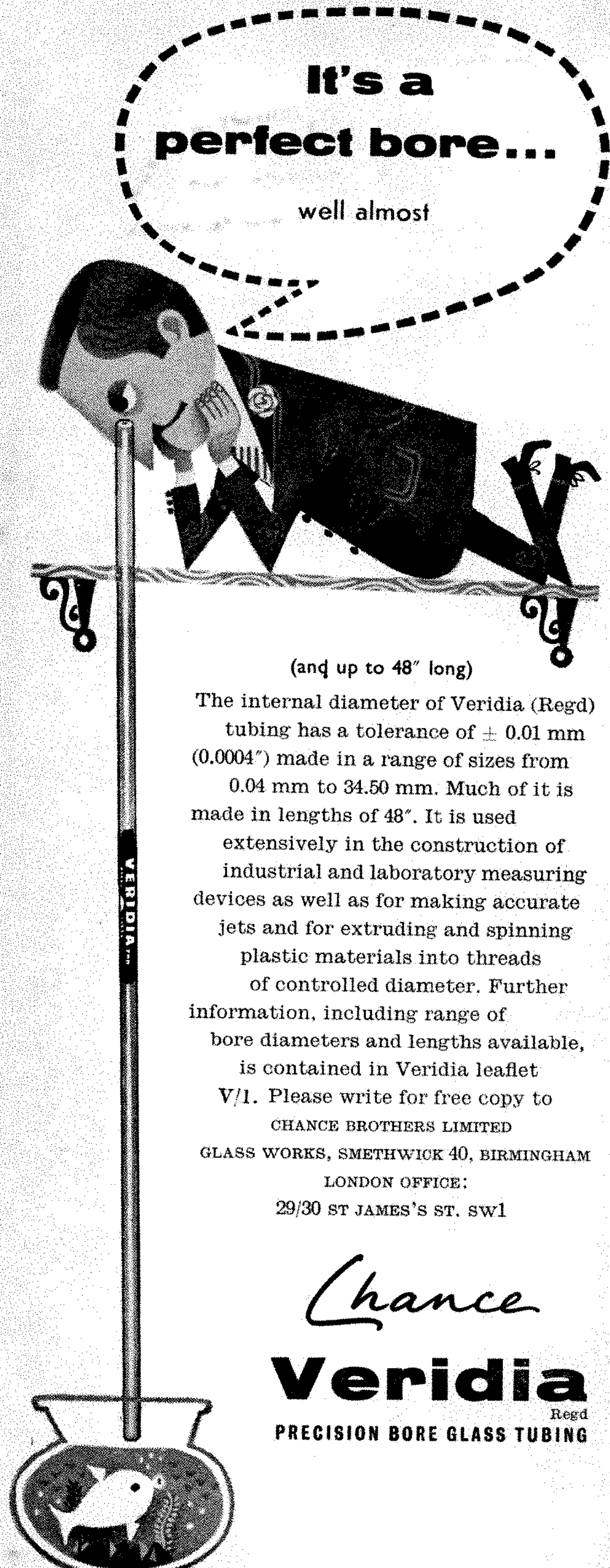

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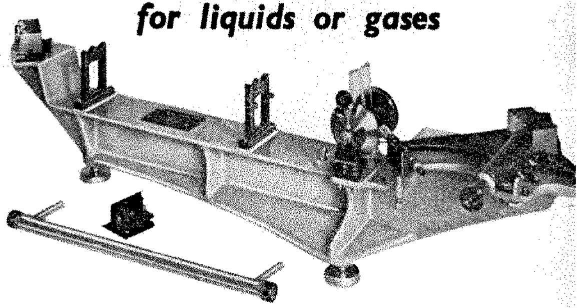

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ARTIFICIAL EARTH SATELLITE, 1958 ALPHA

ON October 4, 1957, the launching of the first artificial Earth satellite, 1957 Alpha, was announced (*Nature*, October 12, 1957); and this was closely followed by the news that the second artificial Earth satellite, 1957 Beta, had been launched on November 3, 1957 (*Nature*, November 7, 1957). Both these *Sputniks*, as they were then called, were successfully launched, presumably from Russian territory.

Now comes a third announcement to the effect that the third artificial Earth satellite, Alpha 1958, at present known as *Explorer*, was successfully launched from Cape Canaveral, Florida, on January 31.

1958 Alpha is apparently travelling on a larger orbit than that of either 1957 Alpha or 1957 Beta, for it is taking twenty minutes longer to encircle the Earth than the 1957 satellites. The reported minimum height is about 200 miles and the maximum about 1,700 miles. Its mass is about 18 lb., and that of the final stage of the rocket, after burning out, is estimated to be 12·67 lb. Both have been designed to travel along the orbit as one unit.

Because 1958 Alpha, having a total mass of about 29·7 lb., is small compared with 1957 Alpha and Beta (184 and 1,118 lb., respectively) the instruments which it carries are also miniature, but they will probably yield results as valuable as the larger ones. The new satellite is a 6-in. tube about 80 in. long. Apart from radio transmitters, it carries instruments for measuring temperatures, cosmic rays and the effect of space dust on its outer surface.

Once again, therefore, it is *Nature's* pleasant task to convey to the scientists concerned the congratulations of all their colleagues throughout the world. Science and technology are advancing in great strides, though clearly the launching of these three satellites, like the control of thermonuclear fusion, are just the beginnings of developments in space technology on one hand and atomic technology on the other with all their scientific and technological complications. Yet now is the time to draw morals and learn lessons from these achievements which, without doubt in the none-too-distant future, will exert profound impacts on man and his civilization.

During the past few months, three great achievements in science and technology have justifiably received world acclaim: (1) the launching of artificial Earth satellites by scientists in the U.S.S.R.; (2) the development and control of thermonuclear fusion by scientists in Great Britain and the United States; (3) the launching of an artificial Earth satellite by scientists in the United States. We have used the expression 'by scientists in' deliberately, for the implications and interpretations already attached to these great scientific achievements, especially by the more sensational or politically biased newspaper Press, may do much harm to scientific reputation. It is therefore important to recognize that not one of these great achievements can be looked upon as wholly Russian or American or British. There is every reason for believing that the great work which led to the launching of the satellites in the U.S.S.R. was carried out by teams which comprised some scientists of Western birth and/or training. Among those who have brought about the control of thermonuclear fusion in the United States is one of British birth and training, whereas among those in Great Britain are an Australian and a Canadian. Germans are outstanding among the scientists who were responsible for the successful launching of the satellite from American soil.

Some branches of science, especially the physical sciences, are becoming more and more the tools of diplomatic intrigue and political pressures. Certainly, scientific achievement is being thrust forward quite sensationally in the mad rush for national prestige. Yet scientific discoveries are not suddenly made by men who, by birth or consent, are entitled to claim a certain nationality; they are the results of good training, patient and sometimes long-continued work often fraught with disappointment, team-work sometimes spiced with real personal genius, and all these are based on the work of previous generations. The nationality of the scientists plays no part whatever, though we must give credit to those countries which, in their wisdom, give financial and other support to such scientists. It is therefore of the utmost importance at this stage to recognize that men born and trained in the United States, Germany, the U.S.S.R., Canada, Australia, New Zealand, Great Britain and possibly other countries have teamed up and produced these recent gratifying results; and it is about time that credit should be given to these scientists and due recognition awarded to them, instead of to the countries in which they happen to be working.

This false 'nationalism' of science can do nothing but harm in the long run, for it tends to force scientists under still stronger political control (thus gradually depriving them of that freedom under which science has always flourished best) and has already led to ill-informed interpretation and presentation, and not a little acrimony. All this is due mainly to fear of giving away secrets to a potential enemy (in spite of the fact that science moves so fast that what is a 'classified' secret to-day becomes 'unclassified' world news to-morrow); anxiety to enhance national prestige (on false premises); and the determination of politicians and Service brass-hats to keep science under their control in order to achieve their own short-sighted objectives. In this false presentation of scientific achievement, this artificial moulding of public opinion, truth (the main objective of science itself) becomes the first casualty.

It may be of interest now to reveal that, after the 1957 satellites were launched, British and American scientists willingly came forward with their observations and results for publication to the world. Some of these appeared in *Nature*; yet, in spite of long-continued efforts on the part of the Editors, nothing could be obtained from the Russians themselves, though the work was supposed to be part of the Russian contribution to the *International* Geophysical Year. In fact, the only contacts that could be made were with Soviet diplomats (and these contacts proved sterile). Two direct communications to one of the leading men of science in Moscow who was closely connected with the scientific work involved still remain unanswered. This compares unfavourably with President Eisenhower's pronouncement that results from 1958 Alpha will be given to the world, and reveals a deplorable reluctance on the part of the Russian authorities to allow their scientists to work in collaboration with scientists in other countries. This international race in science may achieve some good in that it might enhance respect for science among political and other authorities and the public; but by and large, it is not good for science, which has always flourished best in an atmosphere of freedom and collaboration. Moreover, it is bound to cause duplication of scientific effort (and nowadays scientific research can be a very expensive item in any nation's budget); this is a waste of time which must inevitably slow up world advancement of science. The fact that this is not recognized by some is indicated in one British newspaper's leading article commenting on the launching of the third Earth satellite when it asks: "Why is Britain left helpless and earthbound in this conquest of space? What are our leaders doing?", and gives the answer as "utterly shameful".

Similar reactions occurred when the results of research on the control of thermonuclear fusion were announced. It is true that the scientists working in Britain were ahead of those working in the United States, and this is now recorded in *Nature* and elsewhere. We are in no position to express any opinion on the criticisms hurled at American authorities and the accusation that they deliberately planned the holding up of announcements from Britain for the sake of their national prestige. In any event, in the long run it will not matter who was first in the field, provided, for the sake of history, credit is given to those who have earned it. But the immediate effect of such international squabbling can be very harmful and distressing. Moreover, it inspires ill-feeling and bad faith where neither is deserved; and this all too often leads on to misunderstandings, false accusations and even the deliberate masking of the truth. For example, quite unknown to the Editors at the initial stages, it was agreed among the scientists concerned (of several nationalities) and others closely connected, that the first scientific details concerning the work on thermonuclear fusion in Britain and the United States should be published in *Nature*. This was indeed a compliment to *Nature*, though it was obviously realized by those concerned that, by publishing in this journal, the news and results would quickly reach most scientists throughout the whole world.

The articles were eventually published in *Nature* of January 25; but not before there had been some severe criticism from certain sections of the newspaper Press, mainly from writers who anyhow could scarcely be expected to understand and interpret what appears in *Nature*. A further criticism came along after publication, when *The New Scientist* in its issue of January 30 suggested that the Editors of *Nature* had substantially departed from accepted practice by omitting the dates from the articles published, and implied that thus they were helping those to claim priority which was not their due. Actually, throughout its long history, *Nature* never has published dates on its main articles. All seven of the articles on thermonuclear fusion were received at *Nature* office in the normal way within a few days of each other and treated in the normal way.

All this attempted 'nationalization' of science for the achievement of political prestige, this squabbling among Press and public concerning who came first, are very childish indeed. It must be disconcerting, if not discouraging, to the scientists; and, as has been seen, is bound to lead to distortion of the truth. The stark facts are that quite a number of countries are training scientists, some of whom have proved their worth and even genius in the past few months. The fact that their proving grounds were in the United States, the U.S.S.R. and Great Britain is, fundamentally, of little consequence to science itself, for, as we pointed out in our article congratulating the scientists in Russia on their magnificent achievement last October (*Nature*, October 12), there is no such thing as Communist science or American science or British science: there is just—science, the search for the truth. It is unfortunate that though many countries are now supporting this material search for the truth, too many of them are interfering with its exposition.

The *New York Times* of February 1, in commenting on the launching of 1958 Alpha, gives a firm warning that: "This is a good time for us to remember that neither Russians nor Americans can claim any kind of exclusive credit for the progress made towards man's conquest of space. Like all man's greatest scientific adventures, the march of humanity towards the cosmos is the product of many men of many nations over many centuries. . . . To realize the possibilities now before us we shall have to show that all humanity is capable of rising to the challenge". This can only be done by looking upon the march of science as an endless, moving picture in which many characters have a part to play; where star actors can give of their best only when they are supported by a good and well-trained cast; and where, as occasion demands, praise or blame be accorded to the actors for their acting and not their place of birth.

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TECHNOLOGICAL HUMANISM

THE address given by the Duke of Edinburgh in Manchester on November 22 when he opened the new extensions to the Manchester College of Science and Technology included some welcome comments, and it may be reasonably hoped that his lucid and cogent argument will bring home certain truths and facts to quarters which have long ignored them. The dependence of the welfare and security of Britain upon an adequate supply of properly trained and educated scientists and technologists could scarcely have been better put. Nor did the Duke mince his words. Lagging production, he said, is properly equated with chronic poverty, and he gave neither encouragement nor opportunity to those who advocate excessive specialization or argue that it is inherent in a scientist or technologist.

Very clearly, but firmly, the Duke of Edinburgh pointed out that a clash between science and technology and the humanities is not inevitable, and his advocacy of technology does not lead towards technocracy. He insisted that a specialist of any kind, whether in science or in the arts, is not necessarily the well-educated man that we need to produce, and that it is doubtful whether sufficient science is included in the general education of the humanist for the latter to be described as well educated to-day. Science, or any other branch of knowledge, is only an educational tool the use of which depends on the character and outlook of the individual possessing it. Furthermore, he reiterated the truth that our limited scientific and technological man-power can only be efficiently and economically used by administrators who know enough to recognize for themselves the fields of research and development likely to prove most fruitful.

Apart from thus commending the attention being given in the College to management, the Duke of Edinburgh stressed three points which apply no less to the current expansion of technological and scientific education generally than to the particular developments at Manchester. First, there is needed the whole-hearted support and co-operation of industry as a whole, with money and equipment and in terms of part-time teachers. Secondly, there is required the understanding of individual industrialists in formulating their needs for people with specific qualifications, and then in seeing that, when trained, these graduates do, in fact, obtain posts which offer full scope for their qualifications and talents. Thirdly, scientists and technologists should seek to dispel the present unreasoning prejudice against their subjects.

Apart from this last point, on which the Duke of Edinburgh laid perhaps his main stress, his address emphasized the arguments of recent addresses by Sir Eric Ashby on technological humanism and by Dr. R. P. Linstead on an education for our times. The goal should be the production of a well-educated citizen, capable of independent thought and initiative. To this end, the full co-operation of scientists and technologists both as individuals and corporately through their professional associations will still be necessary to overcome prejudices which would hinder the development of a system of education capable of providing the nation with the administrators, scientists, technologists and technicians as well as ordinary citizens, who can take full advantage of the opportunities of to-day. Even in securing the full co-operation of industry with the universities and technological and technical colleges, there are prejudices to be overcome; indeed, it is difficult to believe they are not the real reason why the Manchester College of Science and Technology has had to curtail its plans for expansion, because of a disappointingly small grant from the University Grants Committee. The position may also be due to the anomalous arrangement under which the development of higher technological education in Britain is only partly the responsibility of the University Grants Committee; but in the present financial stringency, the removal of any anomalies which hinder the wisest and most economical use of Britain's limited resources should be a principal object of Government policy.

The Manchester College of Science and Technology is seeking to meet its difficulty by an approach to local industrial firms, which it is hoped will enable it during the coming year to wipe off its existing mortgage of nearly £1·5 million, and this appeal could well result in much closer co-operation and understanding between local industry and the College. Nevertheless, the contribution which the College could make to the expansion of technological education is so considerable and unquestioned that there are strong grounds for supporting an alternative proposal that the University Grants Committee should be authorized to make a capital grant towards the discharge of the outstanding mortgage.

The sincerity of the Government's intentions in regard to the expansion of technological education are, in fact, better shown by the support it gives to the three major institutions—the Imperial College of Science and Technology, the Royal Technical College, Glasgow, and the Manchester College of Science and Technology—than by the progress of the expansion on which Mr. Geoffrey Lloyd, Minister of Education, gave a further interim report in the House of Commons on November 28. Apart from the anomaly in regard to the University Grants Committee already noted, the plea of regionalism is scarcely consistent with the development of the Salford Technical College while expansion at Manchester is frustrated, particularly in view of the proposed devolution of responsibilities for training technicians and craftsmen which is proposed at Manchester. In all these circumstances, Mr. Lloyd's statement, so warmly welcomed in the House of Commons, is disturbing rather than reassuring. Besides eighteen new technical colleges and seventy-nine major extensions of existing colleges in Britain since February 1956, plans for a further five colleges and seventeen major extensions have been approved and a further fourteen new colleges and twenty-eight major extensions are contemplated. Mr. Lloyd gave no indication as to the balance between technical and technological facilities, nor could he report on the technological developments at the universities, which, like those at the three major institutions already named, are outside his department. Indeed, as Sir David Anderson implied in his address in Dublin to Section G of the British Association, the country's requirements for technicians are scarcely known. It may be that, until the Carr Committee reports, the requirements for training craftsmen and technicians cannot be formulated with any precision, although a useful estimate could be made from the number of scientists and technologists which it is estimated that we require. It is on this basis, however, rather than on the programmes of other countries, that the expansion of technological and technical education in Britain should be considered.

It is most desirable that financial support for the expansion of the Manchester College of Science and Technology and other colleges of technology and technical colleges should be drawn from industry as well as from the Government and local authorities. That £100,000 should already have been received from local industry in response to the Manchester appeal (made in the first instance to meet the expected deficit in the current academic year) is a healthy sign. It is understood, however, that the College is likely to need £850,000 from industry during the next five years, and it is important to remember that the expansion of technological and technical education depends on co-operation from industry in other ways, some of which are even more important than direct financial assistance and may themselves be costly to industry.

This is apparent from the recently published report* of the second National Conference between Industry and the Technical Colleges arranged last May by the Federation of British Industries (see also *Nature*, **179**, 1226; 1957). Indeed, the report makes much more encouraging reading than Mr. Lloyd's statement, and it is noteworthy how far the ideas which Sir Eric Ashby, for example, had just expressed in his May Lecture to the Institute of Metals and which Dr. Linstead developed in his Hinchley Memorial Lecture in November were reflected on all sides at the Conference. There was overwhelming support for the view that the primary task is to produce well-educated men and women whether they are scientists or technologists or not, and Lord Hailsham's address at the formal opening of the Conference was far more reassuring than recent speeches of his successor as Minister of Education, Mr. Lloyd.

One point made by Lord Hailsham deserves to be widely noted. The Government would expect industrialists, he said, to play an important part on governing bodies of technical colleges, and this is the more important in view of the Government's proposals in regard to local government reform. The close co-operation between industry and technical education which is so essential can scarcely be secured unless industry itself comes to participate directly in the management of the colleges, and this came out quite as clearly in the subsequent discussions at the Conference on sandwich courses, as in Lord Hailsham's remarks. Moreover, in referring to the need for a two-way exchange of ideas between Government and industry to obtain a satisfactory solution to some problems of sandwich courses, Lord Hailsham stressed the bearing of an informed public opinion upon the financial question. Technical education, he believes, is at last capturing the imagination of the public, and if public opinion takes education seriously, there will be no difficulty about getting the money.

Another main discussion at the Conference centred around á challenging paper by Dr. P. F. R. Venables on "Liberal Technical Education: an Economic Necessity". Lord Hailsham himself insisted that a good general education is the first essential of a good technical education, and stressed the importance of a liberal element in technical education, which is the principal means of further education for most young people; he also pointed out that we have the difficult task of providing an industrial society which, by virtue of its moral structure, can lead the world to a smoother and more rational future. The divorce between the scientist and the student of the humanities must end. In an industrial age, everyone needs a general knowledge of the capabilities and characteristics of scientific investigation and mathematical discipline; but everybody, however specialized, needs also to recognize that this specialization is only part of a more general life in which the intellectual, moral, spiritual and æsthetic qualities have an essential place.

That such views should be expressed by a Minister of Education, as he then was, is in itself encouraging, and although Lord Hailsham said nothing about the importance of concentration of limited resources for the development of technological education, Sir Harry Pilkington, in his survey of technical education, at least recognized the need, and his figure of eight is a much more realistic number for the colleges of advanced technology that we can for the present expect to staff and equip adequately. Moreover, the question of quality becomes more important as we attempt to give effect to the ideas about a liberal technical education which Dr. Venables developed in his paper. Particularly during the period of transition, experiment and development into which we have entered, it is essential that adequate resources for experiment and for trial of new ideas should be assured in a few colleges rather than that available resources should be spread too widely. The most superficial development of Dr. Venables's reference to the contribution of the technical college library should indicate the immense possibilities inherent in a liberal policy to such libraries, and the way in which it could react on adult education generally and facilitate a more effective use of resources.

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* Federation of British Industries. Report of the Second National Conference between Industry and the Technical Colleges, 15 May, 1957. Pp. vi+71. (London: Federation of British Industries, 1957.) 5s.

Dr. Venables argued convincingly that a utilitarian philosophy is an insufficient basis for human beliefs and sympathies, for æsthetic experience, for human action and as a bond for society, and that it is therefore quite inadequate as a basis for education, knowing little of virtue and perhaps even less of creative imagination. It is probably the main factor responsible for starving the technical college libraries —and probably also those of universities and other libraries. But that is only one of the reasons why utilitarianism is a major danger against which we must guard in attempting to develop a broadly based education adequate for our times. The three main characteristics of a liberal technical education stressed by Dr. Venables—diversity of experience confronting the student, of subjects to be studied, disciplines to be mastered, and methods to be used; intensity of illumination of the student's mind and experience; and proper timing of the phases of education in relation to the student's personal development—all demand staff of high quality and open-mindedness, and conditions in which students have the opportunity to enrich their lives and develop their personalities.

All this bears, too, on the difficult questions of the selection of students and the amount and conditions of student grants, though not always in the way that the sponsors of the National Union of Students' recent survey of student expenditure might expect. Dr. Venables points out that the basic scientific subjects should be taken mainly in the earlier part of a professional course, though not to the exclusion of technological subjects, and that is a prime reason for liberal treatment of technological subjects. Moreover, if a diversity of appropriate teaching methods is to have its full effect, we must be concerned to see that the system of selection of students and awards does not in itself discourage the student from thinking and reflecting on his work, or hinder the strengthening of his powers of thought or the deepening of his penetration so essential either in mastery of a specialism or fostering a liberal education.

What is encouraging in Dr. Venables's paper and its reception by the Conference is the challenge to thought and the acceptance of that challenge by the Conference. It was recognized that full-time and sandwich courses provide the opportunity for experiment, and his assertion that we have relied too long and too much on part-time education was unchallenged. Sir Norman Kipping, in his summing up, showed as clearly as Sir Harry Pilkington the extent to which industry is prepared to co-operate and to work out the most effective means of co-operation. Moreover, he welcomed the Minister's stress on the promotion of education as distinct from its administration, and the address of Mr. A. A. Part, Under-Secretary of the Ministry of Education, showed that the permanent officials at the Ministry were just as alive to the real issues.

With such an enlightened attitude on the part of the Government and its officials, with increasing readiness on the part of industry to co-operate and to follow the lead of Sir Harry Pilkington, Sir Alexander Fleck, Lord Weeks, Lord Hives and others, and with educationists like Dr. Venables, Sir Eric Ashby and Dr. Linstead pointing the way, it may well be asked wherein the danger lies that the present plans may be ineffective or not realized. Despite the unsatisfactory character of the administrative arrangements, the University Grants Committee cannot fairly be blamed for deficiencies in the technological education of Britain. Lord Simon of Wythenshawe, in a valedictory address to the Court of Governors of the University of Manchester, recently remarked that the generosity of Government grants to universities is not always appreciated, and added that in a letter regarding the next quinquennium the Committee had emphasized the need to strengthen teaching rather than research and especially the teaching of technology.

It is true that, as regards the question of general education, the universities themselves could do something more to help the schools to make the necessary adjustments, and that there is room for better co-operation and clearer understanding at this level, though Dr. Linstead emphasized the delicate and sympathetic handling which these borderland problems require. The Duke of Edinburgh's speech, however, and the difficulties of the Manchester College of Science and Technology, point to the real need. First, there is the need for wider public understanding of what is required and what is at stake, and a deeper appreciation of the place and worth of technician, technologist and scientist alike. That is an essential condition for the creation of an informed public opinion that will ensure an adequate financial provision for education at all levels, from the Treasury or from local government sources, and also a continuing supply of students for technical and technological as well as scientific courses. This itself is in part a problem of adult education, but such an enlightened public opinion provides the ultimate means of overcoming the political, sectional and local prejudices which hinder the rational planning of resources and the elaboration of a national, regional and local system of education.

INFLUENCE OF WAR ON THE PRODUCTION AND USE OF FERTILIZERS

The World Fertilizer Economy

By Mirko Lamer. (Studies on Food, Agriculture, and World War II.) Pp. xvi+715. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1957.) £5 net.

THE agricultural output of the United Kingdom increased greatly during the Second World War, mainly due to a large increase in the acreage under tillage crops. This change in farming resulted in a near-revolution in many of the techniques used; outstanding examples were marked increases in mechanization and in the use of fertilizers. The

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War stimulated progress in many other countries, but in some others the use of fertilizers was seriously curtailed by war-time damage to plants or by restricted supplies. The main purpose of Dr. Lamer's book is to state and to discuss the changes in production and consumption of fertilizers which occurred during the war period in all the important fertilizer-using countries. Reviews of the fertilizer position in the pre-war and post-war period have already appeared for a few countries, but this book provides the first account on a world-wide basis of the industrial, agricultural, social and economic factors which were involved.

The first few chapters set the stage by giving general accounts of fertilizer history, the forms in which fertilizers are prepared, their role in plant nutrition, and their values for crops. Yield responses in relation to profit are discussed with special reference to the mathematical equations which have been derived for fertilizer response curves. There is little in this section of the book which has not been published previously.

In succeeding chapters fertilizer production and consumption are dealt with exhaustively, country by country; features of pre-war trade in fertilizers are discussed in relation to the changes imposed by the War and to the re-establishment of trade afterwards. An interesting section is devoted to the trade agreements which existed before the War between the producers of fertilizers in individual countries, and also in different countries. Most of the old cartels were broken up during the War, and the author discusses the possible establishment of trade agreements in the future. Changes in the forms in which fertilizers are produced, due to the development of new processes and to the exploitation of new raw materials, are described.

The patterns of fertilizer production and use in Allied and Axis countries are compared, and the effects on fertilizer use in neutral and non-belligerent countries are stated. Special attention is given to the arrangements made by the United States, the United Kingdom and Canada to promote co-operation in fertilizer production and trade for the benefit of all the Allies. Most countries controlled the sale and use of the fertilizer supplies that were available; the methods used for achieving this are stated and estimates are made of their success.

Two chapters are devoted to the use of fertilizers in the Soviet Union; they are particularly valuable since it is difficult to obtain any reliable information on fertilizer production and consumption in the U.S.S.R. Full documentation is given and the maximum use has been made of information from both official and unofficial sources. In 1913, Russia's fertilizer industry was practically non-existent—only a few hundred thousand tons were used and most was imported from Germany. Domestic fertilizer production rose from 180,000 tons (of products) in 1928 to 3·7 million tons in 1938. The War reduced output and the 1938 level was not again attained until 1948. Production in the U.S.S.R. in 1955 was estimated as 9·6 million tons of products of all types.

The book is concluded by a brief assessment of the future of fertilizer use in relation to economic, industrial, and agricultural factors. The author concludes that "in all countries of the world, fertilizers are one of the most important strategic weapons of modern agriculture"; he considers that: "Increasing food production by increasing the use of fertilizers seems often to be a better road to agricultural and national welfare in under-developed countries than building electric power plants, roads, and machine industries, and relying on gifts of food from well-to-do countries".

Full statistics for production, consumption and foreign trade are given and there is very adequate documentation throughout the book. The amounts of information available for different countries have, inevitably, varied and the account given is therefore fragmentary in places, and there are many gaps. A criticism is that related subjects are often widely separated in the text. It would have been easier for a reader to have had all information on the British Commonwealth or the U.S.S.R. in adjoining chapters; the layout adopted separates information on any one country or group of countries by a number of chapters dealing with other subjects. In spite of this the book is of very real value and interest, and is recommended to all who are concerned with the wider aspects of the manufacture, supply and use of fertilizers.

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SIR ERNEST SHACKLETON

Shackleton

By Margery and James Fisher. Pp. xvi+559+46 plates. (London: James Barrie Books, Ltd., 1957.) 30*s*. net.

DURING the years between the two World Wars, polar exploration in its heroic age held the palm for adventure; and many a schoolboy's hero was Sir Ernest Shackleton. I still remember the thrill when, not many years after his death, I found "The Heart of the Antarctic" in my preparatory school library and how I trudged every mile with him (by torchlight, under the pillow), when he got so near to, and yet turned back so far from, the Pole.

I next turned to "South", the account of his *Endurance* expedition, which, appropriately enough, must surely rank as one of the most extraordinary feats of human endurance of all time. More than forty years before Dr. Fuchs, Shackleton had conceived the idea of crossing the Antarctic continent from the Weddell Sea to the Ross Sea. Unfortunately, ice conditions that year were exceptionally severe and his ship became trapped in the pack at the base of the Weddell Sea just short of his landfall. How the expedition drifted north in increasing pressure until the ship was crushed like match-boarding before their eyes; how, after sledging across disintegrating pack-ice and then taking to the boats, the whole expedition landed safely on Elephant Island; how Sir Ernest himself, with five companions, sailed in an open ship's lifeboat across 800 miles of the world's stormiest ocean to South Georgia and crossed that completely unmapped island in search of help and how ultimately the entire party was saved without loss of life must surely remain an epic in leadership at its best.

Behind the explorer lay the man, and the demands of an expedition brought out all that was best in him—the fantastic physique, which enabled him to man-haul sledges for weeks on end in sub-zero temperatures on a twenty-ounce diet; the judgment which persuaded him to turn back when only a few marches from the South Pole; the improvizing genius which helped him to bring back his crew of the *Endurance*; the strong sense of the romantic without which no great deed is accomplished.

Back at home in settled life these gifts did not serve him so well, and whether it was mining concessions in Hungary, shares in a cigarette company or taxi business, or wild-cat schemes to search for hidden treasure, it was obvious that there was bound to be one outcome—yet another expedition to the Antarctic. To him, fulfilment could only come through polar exploration, and the tragedy too often occurring in such cases of an ageing man becoming more and more of a misfit in civilization, yet less and less capable of following his bent, was averted in Shackleton's case by his early death.

All these facts of a complex character and a detailed description of the four polar expeditions in which he took part, the last three as leader, are fully and, indeed, admirably set out in this definitive life, which is both timely and well written. Just as Wolsey and Roberts never disliked each other (indeed, they scarcely met, the rivalry was created by their respective staffs) so I think it is extraordinarily unlikely that Shackleton and Scott were so antagonistic as some of their more ardent supporters would have us believe. The evidence is examined scrupulously, and neither figure emerges with discredit.

The only fault of this book lies in its almost too-detailed approach. If ever there was a life of heroic achievement calculated to bring tears to the eyes, then surely it was Shackleton's. Yet it is not until his death in South Georgia, back again in his old haunts, chasing the rainbow with the same zest as twenty years before, that this tale ever becomes really moving, though through every one of the 559 pages there emerges one who was truly a man among men.

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SUPPLY AND QUALITY OF CRAFTSMEN

Recruitment of Skilled Trades

By Prof. Lady Gertrude Williams. (International Library of Sociology and Social Reconstruction.) Pp. vii+216. (London: Routledge and Kegan Paul, Ltd.; New York: Humanities Press, 1957.) 23*s*. net.

CONCERNED with the continuing shortage of skilled workers in industry, Lady Williams has made an inquiry to determine the reasons for the deficiency. Since most skilled workers are to be found in engineering, ship-building, the motor-repair industry, printing and building, the inquiry was confined to these industries and, since the number of skilled women workers is extremely small, it dealt only with male apprentices. Questionnaires were sent to some 9,000 firms and 550 of them replied; personal interviews were carried out in some of them. Making no claim for the statistical accuracy and significance of the inquiry, Lady Williams has still been able to substantiate her findings from many talks with individuals of wide experience in industry. All who are familiar with recruitment and training in industry and who love their country would like to deny the depressing story she tells; what she writes is all too true.

In the renowned engineering industry of Great Britain, for example, there are comparatively few firms with well-established training schemes for craftsmen run by competent people; the number of well-equipped training centres where teaching is the prime concern can be counted on the fingers of four hands. Where training is systematically carried out it is in the large firms which bear the responsibility of training not only enough skilled men for themselves but also for a very large number of small firms; many firms, including electrical firms employing thousands of workers, employ no apprentices at all. In the building industry the position is worse than in engineering, although Lady Williams concedes that the nature of the industry makes it extremely difficult to organize effective apprentice schemes. To promote interest in training young skilled building workers, the Government has encouraged the development of suitable training schemes which have had a little success.

In printing, less attention is paid to the training of apprentices than in engineering or building. It is rare for a firm to have anyone specially responsible for the training of apprentices, and, as Lady Williams observes, it may be that there are some firms in the printing industry with well-organized works schools but they did not come to light in the inquiry. "For the most part the apprentice is put in the care of an adult craftsman and it is a matter of chance whether or not his teacher is an interested and capable teacher."

The motor-vehicle repairing industry is preponderantly composed of small units, is comparatively new, and has no tradition of apprenticeship or other regulated entry to the trade. It has an attractive scheme of training drawn up not only to attract additional workers to the industry but also because those concerned feel that they have a considerable responsibility for the safety of the general public. No mechanic is recognized as fully trained in the industry unless he has taken a part-time motor mechanic's course at a technical college, has passed the appropriate Intermediate City and Guilds examination and has successfully passed a practical examination set by the industry itself. The difference between this industry and others is that it has not been strangled by tradition.

After reviewing the present system of recruiting and training young workers for skilled jobs, Lady Williams turns to the future. In all essential points, she writes, the present system is exactly the same as the method introduced in the twelfth century; the old system of training has been carried on without any question of its suitability for a profoundly different situation.

Lady Williams is to be warmly commended for carrying out this first detached investigation into methods used by Britain's industry for training its young workers; their continuation along present lines could easily bring the nation to bankruptcy. As she disturbingly points out, it is astonishing that we still accept a system whereby apprenticeships must last five years, must begin at 16 and end at 21; in which each craft needs five years to master it; in which a boy who does not decide to become a craftsman at the age of 16 may, in general, never become one.

That the British method of producing skilled workers is not the only way is shown by experience in other countries. In the United States, for example, formal apprenticeship must last at least two years, but the period varies from one industry to another and may last five years. The age at which apprenticeship must begin is equally flexible. In many of the States there is no upper age limit for entry; in some it is 24 with allowances for higher age limits for ex-servicemen. Nor does an apprenticeship come to an end merely with the passage of time; in some trades an apprentice has to pass certain tests of competence before proceeding to further training or passing out as qualified.

What can be done by a determined nation has been shown by France. Before the Second World War the training of skilled workers was not in a very satisfactory state. The need for rebuilding a shattered economy exposed the extreme shortage of skilled workers; and as employers were afraid to commit themselves to a long period of training for young people, the technical section of the Ministry of Education undertook to provide a complete craft training in a full-time course lasting three years and covering a wide range of skills. The result has been to create a system of craft training which makes the British method one which the economy can no longer afford. The story is the same in Germany, Holland, Switzerland and other industrial countries.

Lady Williams's book should help to loosen some of the smugness and complacency which bedevils some sectors of British industry. It should be placed on the agenda for consideration of every board.

T. H. HAWKINS

FOUR-DIMENSIONAL GAS

The Relativistic Gas

By Prof. J. L. Synge. (Series in Physics.) Pp. xi+108. (Amsterdam: North-Holland Publishing Company, 1957.) 15 guilders.

THIS book is valuable, both in itself and as an addendum to the author's recent "Relativity: the Special Theory". That excellent treatise was remarkable for its combination of breadth and single-mindedness. All was based on four-dimensional space-time as a geometrical entity; and we were skilfully persuaded that flat four-dimensional geometry is as natural for non-gravitational theory as curved space-time is for general relativity. We may have qualms, however, when now we meet a direct four-dimensional approach to gas theory; for when the equations are automatically Lorentz-invariant one hesitates to enclose the gas in a three-dimensional bottle. A Lorentz transformation would send the bottle flying. Thus we should be happier if we fixed the bottle in our own space-frame, and merely examined the statistical effect of the relativistic variation of the masses of the gas particles with their individual velocities. F. Jüttner in 1911 and R. C. Tolman in 1914 had treated the equilibrium distribution from this point of view. Jüttner, coming closer to Synge, had transformed the distribution integral into a modified Bessel function, and also had noted incidentally the relevance of four-dimensional momentum-space to his transformation.

Prof. Synge begins directly with space-time and four-vector momentum. The 'points' of space-time are 'events', and the 'lines' the histories of free particles. Thus we have in a single picture the history of a gas of particles displayed as a 'broken discrete complex'—line fragments concurring in fours in collision-events. (It is suggested that this picture supports the notion that point-particles manage to collide because they are 'fated' to.) The gas is *not* bottled, and attention is concentrated first on the momentum distribution near some general point-event *A*. This is calculated by assuming that the 4-momentum has the most probable distribution for an assigned total flux over an elementary null-cone at *A*. The energy tensor then serves to identify the pressure of the gas (as a perfect fluid), and by its space-time conservation laws to give the equations of motion. Temperature is identified primarily as a common parameter in a gas mixture; but more thermodynamics appears in the last chapter, which treats the theory of shock-waves. This is of great interest, and the four-dimensional picture here is perspicuous. The mathematics of the shock velocity and temperatures involves the modified Bessel functions characteristic of relativistic distributions, rather awkwardly; but the author (assisted here by Mr. H. F. Sandham) completely overcomes the obstacles.

A basic tool in the earlier part is the "absolute 2-content of a 3-cell" on the pseudo-sphere of momentum of a particle. This 2-content is, rather strangely, proportional to the product of three differentials (being dimensionally the ratio of a 3-volume element to a length), but has the vital property of retaining significance when the rest-mass tends to zero and the pseudo-sphere to the null-cone. This concept enables the author to transfer the whole theory to zero-mass particles, which may be described as Maxwell–Boltzmann photons; the results are, as he says, too attractively simple to leave out. This characteristic lightness of touch serves as a foil to the solid achievement represented by the book, which provides a strong stimulus towards relativistic procedures and modes of thought.

N. B. SLATER

GUIDE TO ARCHÆOLOGY

Archæology and Society

Reconstructing the Prehistoric Past. By Prof. Grahame Clark. Third edition, revised. Pp. 272+24 plates. (London: Methuen and Co., Ltd., 1957.) 25*s*. net.

"ARCHÆOLOGY AND SOCIETY" was first published as long ago as 1939 and a second edition appeared in 1947. It is not surprising that ten years later a third edition has been called for. The first two-thirds of the volume are concerned with accounts of how discoveries can be made and what sort of direct evidence as to the life and outlook of our remote forerunners and ancestors can be deduced from them. This section has been entirely brought up to date and should be read and digested by every would-be prehistorian. The last third of the book attempts to probe deeper into the daily lives of prehistoric man. Unfortunately only certain materials can survive and only objects made of these materials can help us. Again, whether on the economic plane or on that of religion, some of the evidence that has survived can often be interpreted in many different ways. It is all too easy tacitly to assume that our modern outlook on things, or even that of modern primitive man, is the same as that of these prehistoric folk. It is all-important, therefore, that anyone who tries to tackle these problems should himself have the widest possible knowledge and, living as it were with them, should have almost come to see life through their eyes. No one could be found better qualified for this purpose than Dr. Grahame Clark, and his conclusions on these matters can, therefore, be accepted as very reasonable. The book is illustrated with line blocks and full page illustrations. It is very satisfactory that a third edition of this well-known work is now available.

M. C. BURKITT

A HYPOTHESIS FOR THE BIOSYNTHESIS OF RIBONUCLEIC ACID AND PROTEIN

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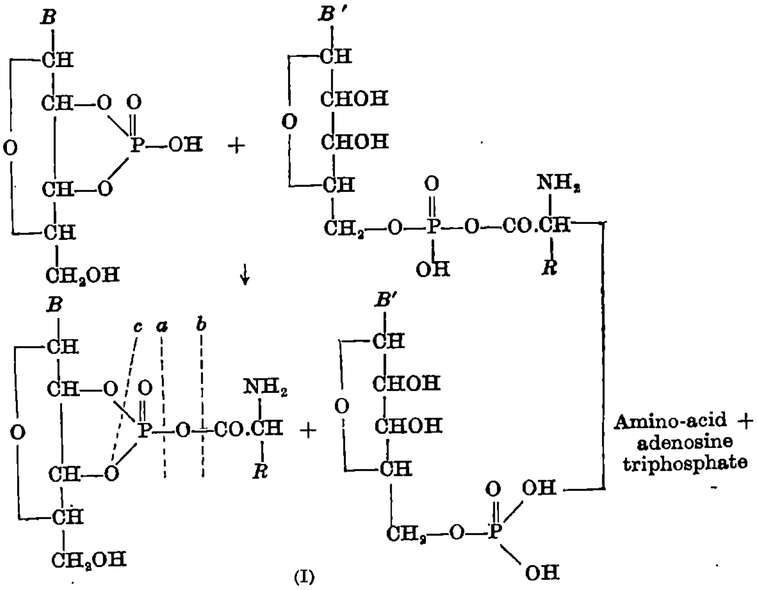
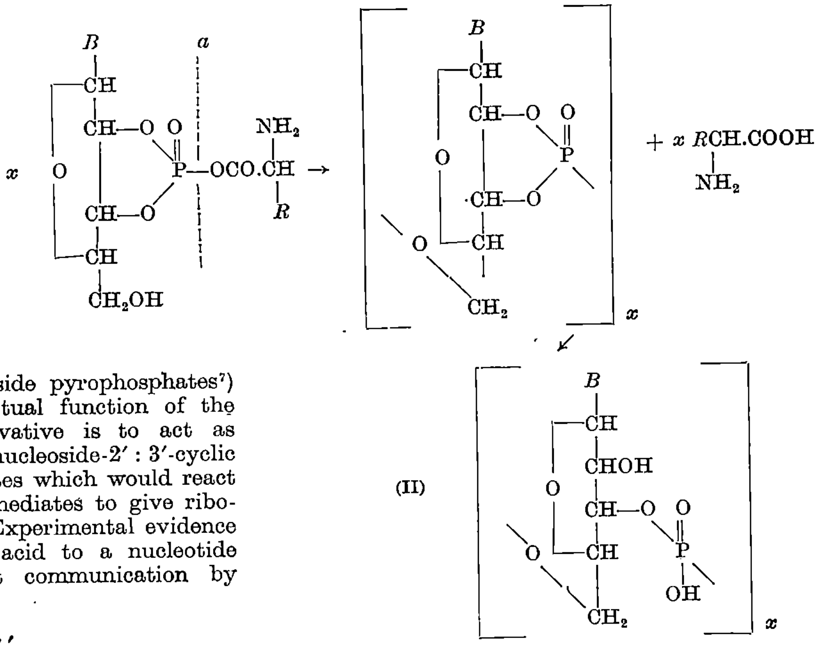
THE polymerization of nucleoside-2′ : 3′-cyclic phosphates by the action of acid anhydrides[1] is in some ways analogous to the enzymatic synthesis of di- and tri-nucleotides from pyrimidine cyclic phosphates by the action of ribonuclease[2] and may also have a bearing on the biosynthesis of both ribonucleic acid and protein. Amino-acid anhydrides of 5′-nucleotides have been described[3,4] and postulated as intermediates, as have non-identified precursors involving both an amino-acid and a nucleotide[5]. While it has been suggested[6] that polynucleotide formation occurs from the 5′-phosphate to a 3′-hydroxyl (as is the case in Ochoa's enzymatic polymerization of nucleoside pyrophosphates[7]) it is as feasible that the actual function of the 5′-nucleotide amino-acid derivative is to act as a specific anhydride on the nucleoside-2′ : 3′-cyclic phosphates to give intermediates which would react rapidly with other such intermediates to give ribonucleic acid and/or protein. Experimental evidence of such a transfer of amino-acid to a nucleotide factor is given in a recent communication by Webster[16].



(I)

Cleavage of this postulated intermediate could occur at each of the lines marked *a*, *b* and *c* (I). Fission at *a* or *b* is analogous to the acid or alkaline hydrolysis, respectively, of acetyl phosphate[8], while that at *c* is comparable with the hydrolysis at all *p*H's of dialkyl esters of uridine-3′-phosphate[9]. The consequences of such cleavage can be summarized as follows.

(1) Fission at *a* (acid catalysed). Attack at CH_2OH group. Synthesis of ribonucleic acid (reaction II).



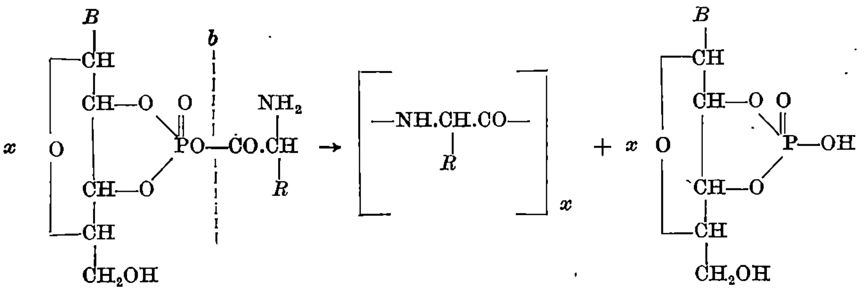
(II)

(2) Fission at *b* (base catalysed). Attack at NH_2-group. Synthesis of protein (reaction III).

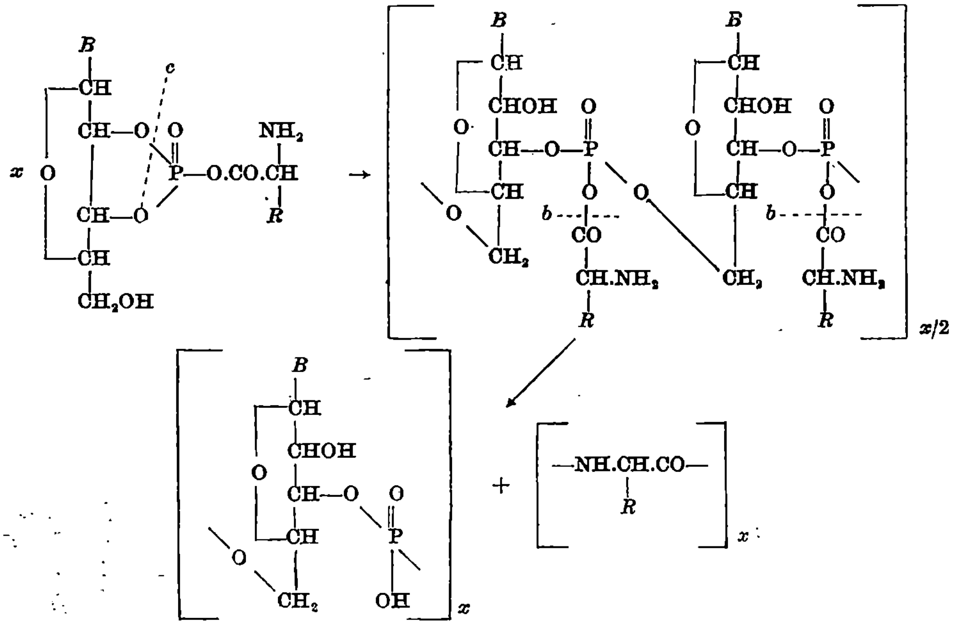
(3) Fission at *c*. Attack at CH_2OH group. Fission at *b*. Attack at NH_2-group. Synthesis of ribonucleic acid and protein (reaction IV).

Cleavage at *a* or *c* and attack at the amino-acid NH_2-groups would produce phosphoramidates, themselves reactive intermediates for mixed anhydrides[10,11], and can therefore be disregarded.

Earlier hypotheses[12,13] have postulated the transfer of amino-acid (activated through the carboxyl group) to a nucleic acid template to form an acyl anhydride with each internucleotide linkage, followed by formation of peptide bonds. With such hypotheses it is difficult to account for the inhibition of polynucleotide metabolism by inhibitors of protein synthesis which do not inhibit the incorporation of precursors into soluble nucleotides, that is, an effect concerned with the actual conversion of nucleotide into polynucleotide[14]; neither do they provide a ready explanation for the varying rates of protein and nucleic acid synthesis.

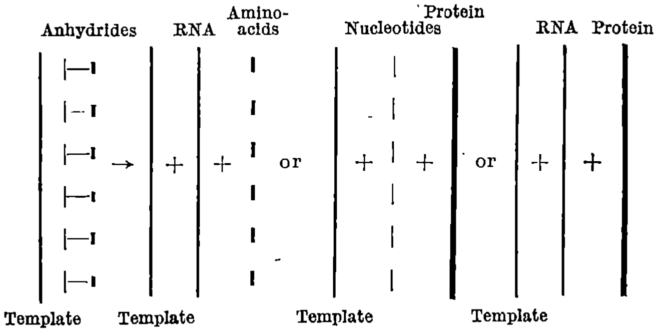


(III)



(IV)

It is suggested in the present hypothesis that biosynthesis occurs by the addition of nucleoside-2′ : 3′-cyclic phosphate–amino-acid anhydrides. The nucleotide bases are held by hydrogen bonding to a strand of nucleic acid in an order complementary to it, or to the enzyme itself. As each polymer (ribonucleic acid and/or protein) is formed the products peel away to assume their own characteristic configurations. Depending on the type of cleavage, directed enzymatically, possibly by control of effective local *p*H, either ribonucleic acid or protein or both ribonucleic acid and protein are formed. It is conceivable that small oligonucleotides would act as primers for such reactions, as with the polynucleotide phosphorylase of Ochoa[15].



The specificity of the process can be based not only on spatial considerations and bonding to a template, but also on the differences in acid strength of each component of the nucleoside cyclic phosphate–amino-acid anhydride and the basicity of each amino-acid, factors of possible significance under physiological conditions. In some degree each addition will be governed by the nature of both the terminal nucleotide–amino-acid and the succeeding nucleotide and its amino-acid. To some extent the template may only be necessary for limited 'active core' portions of the synthesized nucleic acid or protein, the other portions being restricted to a not too rigorously defined order and composition by purely chemical effects. While for cytoplasmic biosynthesis the template is the enzyme or ribonucleic acid, at some stage the information stored in the chromosomal deoxyribonucleic acid must be transferred to the cytoplasm. A tempting explanation is that the initial transfer is via such a mechanism as outlined above, a molecule of deoxyribonucleic acid or part of such a molecule being the template.

The essential part of this hypothesis accommodates most of the recorded biochemical data on the biosynthesis of peptides, proteins and nucleic acid[6,12] and is based on reasonable chemical analogies. It is hoped to develop such chemical aspects as the synthesis of oligonucleotide-peptides and ribonucleoprotein.

Thanks are due to the directors of Arthur Guinness, Son and Co. (Dublin), Ltd., for permission to publish this communication.

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THE INFLUENZA VIRUS NEURAMINIDASE

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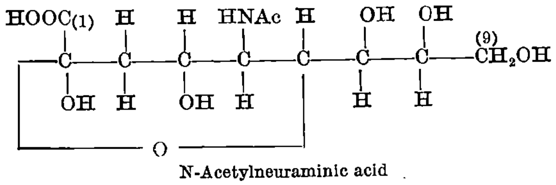
VIRUSES in their simplest form (tobacco mosaic virus, coliphages, polio virus) are nucleoproteins, the nucleic acid carrying the genetic information for the make-up of the virus generation to come, and the protein coat protecting the genetic material on its way from host cell to host cell. With increasing size the chemistry of the viruses becomes more complex. Irrespective of their composition, the viruses proper have no metabolism of their own. They integrate themselves into the metabolic pattern of their host cells. By imposing their code of sequence on the arrangement of the host building blocks in the enzymic synthesis of nucleic acids and proteins, they re-direct the chemical reactions to their own end[1]. The first serious challenge to the prevailing view that viruses are devoid of enzymes was the observation by Hirst[2] that chicken erythrocytes adsorbed influenza virus and by doing so were agglutinated. Whereas at 4° C. the virus remained attached to the red cells for 18 hr. or more, at 37° C. spontaneous elution of the virus from the cells soon occurred. The virus liberated was intact, leaving behind, however, the red cells inagglutinable by fresh virus. Hirst's interpretation, logical and ingenious, was that a receptor substance present at the surface of the red cell attracted and bound the virus, which in turn by virtue of an enzyme embedded in its coat acted upon the receptor. The viral enzyme-receptor interaction was envisaged as resulting in a chemical change of the receptor substance concomitant with the release of the unimpaired virus particle. The same sequence of events—adsorption and spontaneous elution of the virus—was demonstrated[2] with the system influenza virus and surviving host cells deprived of their normal blood supply (respiratory cells of the excised ferret lung).

Much weight was added to Hirst's interpretation by subsequent discoveries made by Burnet and his co-workers[3]. They showed that a variety of materials secreted by mucus membranes such as gastric and intestinal mucin, bronchial mucus, ovarian cyst fluid, cervical mucus, etc., strongly inhibited hæmagglutination by indicator virus, that is, virus treated (by heat) in such a way as to prevent it being eluted spontaneously from erythrocytes. When digested with active virus, these inhibitory mucins lost their biological activity. Most useful and important was the preparation by Burnet *et al.*[3] from the culture filtrate of *Vibrio cholerae* of an enzyme imitating the effect of the influenza virus on the cellular receptors and the inhibitory mucoproteins. Pretreatment with the vibrio enzyme rendered the erythrocytes inagglutinable, the mucoproteins non-inhibitory and the intact host cells non-susceptible to virus infection.

The biochemical approach to the problem of the viral enzyme was initiated by the finding[4] that living influenza virus, when acting upon hæmagglutinin inhibitory mucoproteins and reducing their inhibitory capacity by 99 per cent, released from them a compound of low molecular weight separable by dialysis from the digest. On purification this compound (split product) was shown to have reducing power, to contain nitrogen and to form in the Morgan–Elson reaction a purple-coloured substance indistinguishable spectrophotometrically from that given by N-acetyl D-glucosamine under similar conditions[4]. However, in contrast to amino-sugars, the split product gave a direct Ehrlich reaction and a positive Bial's orcinol test, and it decomposed with formation of humin on treatment with mild acid[4,5]. The split product was the same whether a mucoprotein fraction of hen egg-white (ovomucin) or an electrophoretically homogeneous mucoprotein from human urine was taken as substrate, whether influenza virus or vibrio enzyme was used as catalytic agent. Appropriate controls with heat-inactivated virus were negative[4]. These results left no doubt about the enzymic nature of the process. Moreover, it was established that the enzyme is an intrinsic compound of the virus particle itself and that a similar enzyme is not present in the host cells of the virus[1].

A compound with the same properties as those described for the split product was first isolated from bovine submaxillary gland mucoprotein by Blix[6]. This compound, termed by Blix *et al.*[7] sialic acid, was eventually proved to have the composition $C_{13}H_{21}O_{10}N$ and to contain an N-acetyl group, an O-acetyl group which is easily split off, a carboxyl group, an α-keto or α-hydroxyl group, a primary alcohol group and a group titratable by hypoiodite[7]. Klenk and Lauenstein[8], treating bovine submaxillary gland mucoprotein and human urine with 5 per cent methanolic hydrochloric acid, obtained methoxyneuraminic acid, a substance resembling sialic acid in the reactions carried out at acid *p*H, but differing from it in being non-reducing, alkali-stable, ninhydrin-positive, free of acetyl and in possessing a methoxy group. The close relationship between sialic acid and neuraminic acid became obvious when N-acetylneuraminic acid was isolated from the hydrolysate of bovine submaxillary gland mucoprotein[9]. Confirming the earlier observations on the release of the split product from human urine by virus action, Klenk *et al.*[9] crystallized the product and identified it as N-acetylneuraminic acid. It seemed that the latter differed from sialic acid only in the lack of an O-acetyl group. Therefore, N-acetylneuraminic acid and methoxyneuraminic acid would be expected to have the composition $C_{11}H_{19}O_9N$ and $C_{10}H_{19}O_8N$, respectively. Instead, Klenk *et al.*[8,9] assigned to them the formulæ $C_{12}H_{21}O_{10}N$ and $C_{11}H_{21}O_9N$.

The molecular structure of N-acetylneuraminic acid, exhibiting properties of both an amino-sugar and a 2-deoxyhexose, remained obscure until a well-defined degradation product was prepared. Bovine submaxillary gland mucoprotein and human urine, on treatment with alkali, yielded pyrrole-2-carboxylic acid, and the same pyrrole derivative was obtained from the split product[10]. On this basis and on the other information available, neuraminic acid was envisaged as an aldol-condensation product of D-glucosamine (or D-galactosamine) with pyruvic acid, methoxyneuraminic acid as the methylglycoside of neuraminic acid, N-acetylneuraminic acid as the N-acetylated neuraminic acid and sialic acid as ON-diacetylneuraminic acid[10]. This concept was strengthened by the synthesis[10] of pyrrole-2-carboxylic acid from D-glucosamine and pyruvate at pH 11·0 and was confirmed by the reverse aldolization of N-acetylneuraminic acid to N-acetylglucosamine and pyruvic acid[11] or pyruvic acid degradation products[12]. Its final proof was derived from the synthesis of N-acetylneuraminic acid from N-acetyl D-glucosamine and carboxylated pyruvic acid (oxaloacetic acid), the synthetic compound being chemically and stereochemically identical with the crystalline compound of biological origin[13]. By the method of synthesis the carbon skeleton, the nature and position of the functional groups are determined and Blix's formula proved to be correct. The stereochemistry at C_2 and C_4 of crystalline N-acetylneuraminic acid was recently elucidated[14]. The pyranose structure and the position at C_7 of the O-acetyl in diacetylneuraminic acid follow from the results of periodate oxidation[7].



N-Acetylneuraminic acid

It was early recognized that the inhibitory mucoproteins are conjugated proteins containing as prosthetic groups polysaccharides or oligosaccharides of small size distributed in numbers along the polypeptide chain[1]. Sialic acid, in the new terminology[15] the group name for all acylated neuraminic acids, occupies a terminal position in the prosthetic groups and is linked through its potential keto-group glycosidically to the adjacent sugar unit[10]. Bovine submaxillary gland mucoprotein contains about 17 per cent diacetylneuraminic acid and an equimolar amount of N-acetylgalactosamine besides very small quantities of N-acetylglucosamine, galactose, mannose and fucose. At pH 1·0 and 80° C., 78 per cent sialic acid—and sialic acid only—is released; vibrio enzyme splits off 64 per cent of the sialic acid present in bovine submaxillary gland mucoprotein. The prosthetic group may be detached by very dilute alkali. It has been obtained as a white substance in an analytically pure state; its formula is $C_{19}H_{32}O_{14}N_2$ and it consists of N-acetylneuraminic acid linked ketosidically to N-acetylgalactosamine. The viral enzyme and vibrio enzyme split the disaccharide into N-acetylneuraminic acid and N-acetylgalactosamine (Gottschalk, A., and Graham, B., in preparation). The ready conversion even at room temperature of the disaccharide at pH 10 and at pH 2 to chromogen-disaccharides, that is, disaccharides the N-acetylgalactosamine moiety of which is transformed to a chromogen in the direct Ehrlich reaction, would suggest linkage of N-acetylneuraminic acid to C_5 of the amino-sugar (in its furanose form), though linkage to C_6 cannot be excluded. A furanose structure of N-acetylgalactosamine within the disaccharide would also account for the direct Ehrlich reaction of the latter in the cold and for the ease with which N-acetylneuraminic acid is released from bovine submaxillary gland mucoprotein at its own pH. These new findings may necessitate re-interpretation of previous observations on the prosthetic group[16].

The specificity of the virus enzyme and vibrio enzyme is not absolute. Thus the above disaccharide, three chromogen-disaccharides and sialyl-lactose, a reducing trisaccharide consisting of diacetylneuraminic acid, linked α-ketosidically to lactose[14], are readily hydrolysed by the enzyme. N-glycolyneuraminic acid, the sialic acid of porcine submaxillary gland mucoprotein, is split off from this mucoid by vibrio enzyme[9]. The influenza virus enzyme and the isodynamic vibrio enzyme may, therefore, be defined as neuraminidases cleaving the α-ketosidic linkage joining the terminal acylated neuraminic acid to another sugar or sugar derivative.

Finally, it may be mentioned that N-acetylneuraminic acid has been obtained crystalline from human erythrocytes by the action of vibrio neuraminidase[9]. This achievement suggests that the cellular receptors are sialylmucoproteins like their chemical analogues, the hæmagglutinin inhibitory mucoids. The sialic acid component of both the cellular and the soluble receptors is instrumental in attracting and binding the virus, and the release of sialic acid from both types of receptors by the action of neuraminidase results in the loss of their biological activity.

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THE SPECIES: YESTERDAY AND TO-MORROW

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W. H. CAMP[1] has given powerful voice to the view that the species and other categories below the rank of family recognized in the codes of zoological and botanical nomenclature may well prove unserviceable as an instrument to describe the rich complexity of the units revealed by modern studies in micro-evolution and experimental taxonomy. "Our present system of nomenclature," he wrote, "was designed to fit a concept of static genera and species. Tinker with it as we will, we cannot re-tailor this mouldy shroud into something which will serve as an adequate nomenclatural covering for the complex, living groups which we are now beginning to realize must be defined. No one knows exactly what this system will be; as yet, one can see only a general outline, for our knowledge is too scant to permit a filling in of all the details."

In a communication to the British Association at Edinburgh in 1951[2] I strongly supported this view, and in a more recent paper[3], Prof. J. Heslop Harrison and I have put forward a tentative scheme, based on the suffix 'deme', for a new system of categories to express the findings of experimental taxonomy. In this last paper, the position of the species in relation to the deme terminology was briefly discussed. We stated that, in constructing our terminology, we had "rigidly excluded the categories of orthodox taxonomy", but we emphasized this did not mean that "we regard the terms genus, species, etc., as in any way outmoded. On the contrary, they will continue to remain essential as expressing the basic outline of living things and as a framework into which other classifications can be fitted". This view was further developed by both of us at a conference organized by the Botanical Society of the British Isles in 1954[4].

In the present article, I want to discuss more fully this question of the position of the species in relation to a system of categories for experimental taxonomy, and to put forward suggestions as to the future role of the species concept in biological taxonomy.

The term 'species' was first used more or less in its modern sense during the seventeenth century, and John Ray, in 1674, was among the earliest to lay down criteria for the assessment of specific differences. During succeeding years the concept gradually became stabilized to denote the basic units of biological classifications—the units, in fact, on which classification operated. These units were regarded by the great majority of biologists as static entities, created once and for all; the task of the systematist was to look for them, to recognize them for what they were, and to group them into higher categories. John Lindley, who took a more naturalistic view of plant classification than many of his contemporaries and who described "genera, orders, classes, and the like, as mere contrivances to facilitate the arrangement of our ideas with regard to species", looked upon species themselves as "created by Nature", and this view, with varying degrees of theological adornment, may be taken as typical of the pre-Darwinian systematic biologists. The idea of species as discrete, specially created, entities was no doubt unconsciously reinforced by binary nomenclature with its superficial resemblance to personal human names like John Smith, and, by the middle of the nineteenth century, the species had become unshakeably enthroned in the centre of taxonomic thought.

With the general acceptance of the theory of evolution during the second half of the nineteenth century the history of the species concept entered a new phase—a phase from which it has not yet emerged. In view of its firm entrenchment, it was inevitable that the term species should have become at once accepted for the basic unit of evolutionary change—an acceptance that was, of course, of great value during the formative years of evolutionary theory and without which the theory could scarcely have developed.

It was not long, however, before it became clear that the species of pre-Darwinian taxonomists represented a number of very different types of unit from an evolutionary point of view. The existence of such different types had, of course, long been recognized, and the 'lumpers' and 'splitters' represented two extreme reactions to this fact; but it was not until the acceptance of evolution, and especially the development of genetics and cytology during the past fifty years, that the reasons for these differences began to be appreciated.

The reaction to this appreciation took the form of attempts both to define the species in modern evolutionary terms, and to set up new categories to supplement or replace it. With regard to the former, there has been a growing realization that, owing to the disparate nature of the units usually classed as species, it is not practicable to choose an evolutionary definition that is of use in more than a very limited sphere. For example, a definition based on inter-sterility leads, in some cases, to the separation of individuals practically indistinguishable morphologically. Such a definition clearly renders the species concept virtually useless to general biologists and others requiring an easily applicable and stable basic unit for taxonomy. These difficulties led to the second type of reaction, namely, the construction of special categories to express the new knowledge that was being accumulated. Such categories took the form either of modifications of the term 'species' (for example, Turesson's "ecospecies" and "coenospecies"), or of completely new terms (for example, Danser's "commiscuum", "comparium", etc.), but in either case their relationship to the species itself was far from clear and has led to much subsequent controversy.

In our paper on the deme terminology[3], Heslop Harrison and I gave reasons, based on the nature and purpose of classification in general, for favouring a complete separation between the categories of nomenclatural taxonomy and those of experimental taxonomy. This course has, I think, very definite advantages for both of the resulting category systems. With regard to experimental taxonomy, there is no doubt that the term 'species', however conscientiously one tries to forget its past associations and to adapt it to modern ideas, still comes to us trailing clouds of special-creation glory, which, as Camp has indicated, tend to bedevil its use in an evolutionary setting. It is largely these wisps from the past that have caused so much controversy over the relationship between nomenclatural and experimental taxonomy. The problem of whether to adapt or to abandon a particular term is a familiar one in the history of thought, and which course should be taken depends on the adaptability of the term and the extent of the change that has taken place. For example, the humours of medieval medicine developed quite happily into the present-day bad and good humour of our dispositions, whereas phlogiston, which could not be adapted to modern science, is dead—and the word 'dryads' is not now employed to explain the behaviour of *Quercus robur*. On balance, the abandonment of the term 'species' as a category to express the findings of experimental taxonomy, reflecting a clean break with the non-evolutionary past, would seem to be the right policy. The reluctance of geneticists and others to take this step is, perhaps, bound up with a lingering belief that species are, in some way, 'real entities', not 'artificial constructs of the human mind' as are other taxa. This belief makes it seem unthinkable to abandon the term for such an important branch of biology as the study of micro-evolution. If, however, 'real entities' and 'artificial constructs' are regarded, not as mutually exclusive, but as alternative descriptions, each valid in its own context, this difficulty disappears. Such an approach has recently been fully developed by R. Crawshay-Williams in a most stimulating book[5].

The policy I am advocating is strongly reinforced by a consideration of the continued use of the term in nomenclatural taxonomy. Clearly, there will always be a need for a general-purpose classification, based primarily on morphology, for those who require a broad map of the diversity of living things. For this purpose, the nomenclatural categories of genus, species, variety, etc., are excellently suited, and it would be a great advantage if they were not subject to continued attempts to bring them up to date and to re-define them in evolutionary terms. Let them be regarded, frankly, as mainly morphological categories based on degree of difference and they will perform their proper function in biological classification. Such a view would lead to a reduction in the number of name changes made for taxonomic, as opposed to nomenclatural, reasons. For if it was agreed that genera and species should be regarded as broad, flexible categories, with a considerable element in them of convenience, biologists would not be so constrained to alter the limits of existing taxa in order to fit them to a particular taxonomic theory. This policy will, I know, strike many biologists as lessening the stature and importance of nomenclatural taxonomy. This is true only in the sense that, at the specific, or in some cases the generic, level detailed micro-evolutionary knowledge, when available, would be embodied in special categories, leaving the nomenclatural categories free to give a general purpose account of the variation of the organisms concerned. This does not mean, however, that attributes such as intersterility and chromosome number would be rigidly excluded as criteria for the nomenclatural categories; if they can be incorporated as supplementary to morphology without destroying the general utility of the classification the additional information thus embodied would be, of course, a valuable asset.

The suggestions outlined in this communication are an attempt to crystallize into a definite policy some of the rather ill-defined ideas that are in the air on the defects of present-day taxonomic theory and practice. They are put forward in the hope that others will be stimulated to think about them and discuss them, too, with the view of evolving a generally agreed policy.

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[5] Crawshay-Williams, R., "Methods and Criteria of Reasoning" (Routledge and Kegan Paul, 1957).

PHYSICS OF WATER AND ICE

THE discussion on "The Physics of Water and Ice", held at the Royal Society on November 14, was particularly timely. In the past two years there has been a renewed interest in both the experimental and theoretical aspects of ice and water in relation to their physical properties and their structure. On the theoretical side it has been evident for some time that the picture of ice and water as essentially regular and irregular arrangements, respectively, of water molecules tied together tetrahedrally by hydrogen-bonds is only a rough first approximation. Certainly it is inadequate for the degree of detail now required to define the properties of these substances. It is especially true for the properties that are so-called 'structure sensitive', that is, that depend on the variation of the crystalline material from its ideal state. At the same time, the practical interest in ice and water has been increasing from a number of fields, notably from glaciology, from the technical aspects of the icing of aircraft and aircraft engines, and perhaps most of all from meteorology, where it is now evident that the processes of conversion of water-drops into ice is fundamental for the phenomena of rain and thunderstorms. In the latter connexion it is interesting that a new type of interdepartmental co-operative research has now been going for three years at the Imperial College of Science and Technology, London, some of the main results of which were reported at the meeting. The meeting was not primarily concerned with the theoretical aspects of the hydrogen-bond, which had been recently covered in a discussion of the Section of Physical Chemistry of the International Union of Chemistry, at Ljubljana; nor with that of aqueous solutions, also recently dealt with at the Faraday Society meeting at Oxford. However, some of the leading Continental experts attending both those conferences also took part in the Royal Society discussion, and gave more details of their work in the field of pure water and ice.

Underlying all studies of ice is the knowledge of its structure at different temperatures. A critical survey of the data now available was given by Dame Kathleen Lonsdale (University College, London) in the opening paper, in which she discussed the results of the latest X-ray, electron and neutron diffraction experiments, both for ordinary and for heavy ice. Both substances show some degree of differential contraction along the a- and c-axes on cooling, tending to make all the intermolecular distances of the water molecules in ice more nearly equal at the lower temperatures. This result, however, seems to contradict that reported by Dr. R. W. Powell, of the National Physical Laboratory, on the basis of careful interferometric measurements of the coefficient of expansion of large single crystals of ice in two directions. Such discrepancies, however, are not unknown in other instances, and there seems to be a systematic difference between X-ray and macroscopic measurements of thermal expansion, possibly due to crystal imperfections. However, the work ought to be repeated by both methods, preferably on the same specimen.

The neutron-diffraction work of H. A. Levy, of which a report was heard at the Discussion, indicates an almost completely random position for the protons along the hydrogen-bonds, corresponding to the picture given by Pauling, but Dame Kathleen Lonsdale pointed out that slight deviations from randomness could not easily be detected by this method.

Dr. G. B. B. M. Sutherland reported studies on the infra-red absorption of single crystals of ice, which he had carried out in conjunction with Dr. Ockmann. Over most of the frequencies concerned there seem to be very little preferred orientation and this would also favour an almost isotropic random hydrogen-bond structure for ice.

Prof. W. C. Price (King's College, London) reported some infra-red absorption studies of water adsorbed on alkali halides. Observed shifts in the frequencies of the 3,000-cm.$^{-1}$ band were interpreted in terms of water molecules attached by hydrogen-bonds to the negative ions. With thicker layers of adsorbed water, bands appear in the 2,000-cm.$^{-1}$ region, corresponding to molecular deformation plus a libration of the molecule against the forces of association with other molecules. Body-centred alkali halides show additional bands which suggest attachment of water to positive ions.

Dr. G. J. C. Frohnsdorff and Dr. G. L. Kington, working in Prof. R. M. Barrer's department in the Imperial College, reported some interesting thermodynamic and spectroscopic properties of water contained in the pores of synthetic zeolites, where up to twenty-one molecules of water can be accommodated. Here a transition can be observed between a predominantly adsorbed pattern on slight hydration, to a water-like pattern occurring close to saturation.

An important paper was read by Dr. H. Gränicher, reporting the studies of the Zurich school on the relaxation process, particularly dielectric relaxation in ice. Dr. Gränicher attributes part only of these phenomena to the presence of hydrogen ions in the form of oxonium and hydroxyl ions. He also postulates the presence of what he calls L- and D-protonic defects in ice in which the oxygen atoms are only slightly displaced. L-defects consist of two neighbouring oxygen atoms between which there is no proton ; in D-defects two protons are more or less collinearly arranged between oxygen atoms. These types of defects are assumed to wander through the crystal structure, to be created and to neutralize each other. In this way good agreement is achieved with the new experimental results on the variation with frequency of the dielectric constant of ice at different temperatures. A theoretical treatment of lattice defects in relation to the mechanical relaxation of ice was given by Dr. R. Bass of Stuttgart.

The work of the Göttingen school was presented by Dr. L. De Mayer—Dr. M. Eigen, who is largely responsible for it, being unfortunately too ill to attend. It has long been known that the electrical conductivities of pure water and pure ice are of the same order of magnitude, and it is assumed that this is because the mechanisms operating in the two cases are similar. The Göttingen workers have managed to measure separately the number of ionic carriers, namely $(OH_3)^+$ and $(OH)^-$ groups, and their apparent velocities. They find that the number in ice is only a small fraction of that in water, and consequently the apparent velocity of hydrogen ions in ice must be many times as great as in water. As the velocity of hydrogen ions in water is already much higher than that of any other ion, and is clearly due, as Fowler and Bernal showed twenty-five years ago, by some form of relay mechanism, proton-transfer in ice must be by a similar mechanism, operating not over one hydrogen-bond but over a chain of hydrogen-bonds. This is very similar to electron-transfer in metals, and a close analogy exists between the two phenomena. It is even possible, by the introduction of fluorine ions, to produce what are equivalent to p- and n-junctions for ice, with protons taking the role of electrons in semiconductors. This work obviously opens up a very exciting field of theory which may have particular application in biology, following some recent suggestions by Szent-Györgyi.

Prof. H. S. Frank (United States) discussed the significance of some of the results already reported in terms of the nature of the hydrogen-bonds in water and ice, pointing out that the influence of the bond itself on the lone-pair electrons on the other side of the molecule leads to a general strengthening of the bond, and provides some explanation for the closer approximation of the properties along the a- and c-axes at low temperatures. This also goes some way to explain the very peculiar fact that the cubic form of ice, which has a diamond structure at first sight essentially similar to the wurzite structure of hexagonal ice, is not stable above − 110° C.

Turning now to the structure of water, Dr. C. L. van Pantaleon van Eck reported some very careful work recently carried out at Amsterdam on the X-ray diffraction patterns of water and on its infra-red absorption. His conclusions are that in the water-structure there are approximately six molecular neighbours at distances varying from 3·0 to 3·4 A. from any given molecule. It is not clear why this result is different from that obtained by Warren and Morgan in 1938, who found four molecular neighbours at 2·85 A. Dr. van Eck's interpretation would imply a collapsed tetrahedral structure not unlike that of metallic tin in relation to grey tin. He bases an independent calculation of the intermolecular distance in water on the absorption spectrum of HDO, in which the band at 3,500 cm.$^{-1}$, unlike the corresponding bands for ordinary and heavy water, is free from overlapping and permits an estimate leading to the value 2·85 A., as opposed to the hydrogen-bond distance of 2·76 A. found for ice. If this is the case then the hydrogen-bond in water would be considerably weaker than that in ice, of the order of 5 instead of 6 kcal./bond mole, and it would not be necessary to postulate any actual breaking of hydrogen-bonds on melting. These results throw open once more the whole question of the structure of water, and clearly much more experiment and calculation are necessary.

Dealing with the transitions from water to ice, and from water-vapour to ice, two papers were read by Dr. B. J. Mason, representing the work of the Imperial College group. In the first Dr. Mason gave a full acount of the extremely beautiful method which he has developed for growing small crystals of ice at controlled temperatures and water-vapour concentrations in a thermal-gradient air box. He has shown that temperature alone determines the particular habit adopted by ice crystals, except at high supersaturation when dendritic growth occurs. In the temperature ranges from 0° to − 3° C., from − 8° to − 12° C. and from − 16° to − 25° C., hexagonal plates are the rule. On the other hand, from − 3° to − 8° C., and below − 25° C., the predominant form is either the elongated hexagonal prism or the hollow prism which sometimes has a spiral structure. The fern-like dendritic crystals occur only between −12° and − 16° C. By growing crystals successively at different temperatures Dr. Mason has succeeded in producing combined forms which reproduce many of the beautiful effects long known in snowflakes, which may be interpreted as indicating the various temperature regimes through which the snowflakes moved during their formation. These observations are of fundamental meteorological importance and also of great physical interest, because until now very little work has been done on the influence of temperature on crystal-form, and it would appear that the sharp changes of habit with temperature indicate that we are dealing here with a thermodynamic phenomenon depending on the relative values of the free energy of growth in different habits, as Prof. J. D. Bernal suggested at the meeting.

Dr. Mason's other paper described a series of carefully controlled experiments, on the supercooling and freezing of water drops. He showed two curves relating the volumes of drops to the temperatures at which they froze—one for freezing induced by nuclei, and another for the case in which nuclei are absent. In the latter case supercooling for drops as small as 1μ in diameter can be effected down to − 41° C. and for 1-mm. drops down to − 33° C. Crystallization at these temperatures is an almost explosive process, resulting in the fracture of the frozen droplet and its shattering, a phenomenon which may be of great importance for the rapid spread of nucleation through super-cooled clouds in the atmosphere.

Dr. M. Blackman (Imperial College, London) reported a study by electron diffraction of epitaxial growth of ice on silver iodide crystals. Silver iodide is the only substance at present known to be capable of producing rapid nucleation of ice. By controlled growth of single crystals of ice, Dr. Blackman has been able to show the crystal formation of the ice with sufficient penetration to bring out the underlying silver iodide lattice.

J. D. Bernal

MIDDLE EAST TECHNICAL UNIVERSITY, ANKARA

By Dr. TURGUT YAZICIOGLU

THE foundation stone of the Middle East Technical University in Ankara was laid on October 3, 1957, in the presence of the President of the Turkish Republic, the Prime Minister, the Minister of Education, the heads of the foreign aid committees, the Ambassadors of Great Britain and of the United States of America and other distinguished guests.

The University has, in fact, been working temporarily in a building in Ankara for two years. In 1956 there were 175 students attending the Colleges of Architecture and Administration, and in February 1957 the College of Engineering was established, followed in September by the creation of a research department for nuclear physics.

Foundations for colleges of mining, geology, agriculture and forestry were laid in 1956, and in 1958 students of electrical engineering, mining and geology will be admitted.

There are at present five foreign professors at the University, but arrangements have been made for further staff to be recruited through the United Nations (including two professors of architecture and one of administration), through Unesco (including professors of construction engineering, and of machinery), and through the technical aid programme of the British Government (professors of physics and of electrical engineering).

Thus by this year there will be altogether twelve foreign professors on the University staff; the Turkish teaching staff will number thirty.

The site designated for the construction of the Middle East Technical University is about three miles from Ankara and covers an area of about 4,500 hectares (11,115 acres). The University campus will comprise, besides the college buildings, dormitories, faculty housing, libraries, a theatre, sports grounds, restaurants and other accommodation. All the plans and projects have been drawn up by the Turkish Ministry of Works in co-operation with the University of Pennsylvania.

According to the first ten-year programme, the University will have about 6,000 students, 2,500 teaching and research staff, and forty departments (including teaching and research units) at the end of the first decade.

During this ten-year period the Turkish Government is to make grants to the University totalling 265 million Turkish lira (about £33 million), of which almost half will be invested, while over the same period foreign aid will be available to a total of 26·5 million dollars. In addition, the British Ambassador, in his speech during the inaugural ceremony, promised a further sum of £25,000 from the British Government in the present year.

The University is designed to fulfil the need for an international centre of higher learning to serve the requirements of the developing Middle East. It is founded on the belief that the development of the region in a manner satisfying the demands of a progressive society requires the integration of techniques with human needs and aspirations. The University considers its major responsibility to be the training of a growing number of educated men and women, able to work creatively on the problems of the Middle East, using the most advanced techniques of our era.

History of the University

Constituted as a university only since January 13, 1957, the Middle East Technical University now has two faculties. From the single group of fifty students, with which the teaching programme opened in November 1956, the Government of Turkey plans that the University shall grow to major size, involving six faculties, with a complete research establishment matching the academic activities of each department with a programme of applied research and development work in industrial and agricultural problems. The University's teaching programme, conducted in English, with its emphasis on unity of thought and action, and on the correlation of teaching and research, should make it an institution unique in the Middle East.

The first step in the establishment of the University was taken in 1953, when a survey of building and planning legislation revealed the need for university-trained technical people in the professions. As a result of this survey, a school of architecture and town-planning was suggested, to be integrated with research institutes in building and planning. A complete programme for the school was prepared by a United Nations Mission, under the direction of Dr. G. Holmes Perkins, dean of the University of Pennsylvania School of Fine Arts.

The Perkins Committee received not only the enthusiastic and energetic support of the President of Turkey, the President of the Grand National Assembly and the Prime Minister, but also the effective co-operation of a committee for the school, headed by the Minister of Education, and having as members Mr. Vecdi Diker, Mr. Ahmed Tokus, Mr. Mihat Yenen and Mr. Adli Yener.

Following the Perkins Committee recommendations, a request was submitted to the United Nations for assistance in establishing the first faculty. In the autumn of 1956 the Committee was reactivated by the Minister of Education as an acting Board of Trustees. Under its guidance, the programme of the University has been developed and its teaching operations begun. Fifty students first received instruction in architecture on November 1, 1956, in a rented building at 18 Müdafaa Caddesi, in Ankara. The formal inauguration ceremony was held on November 15.

During the winter, plans were made for expansion of the teaching facilities and the acquisition of a campus. On January 13, 1957, a provisional law authorizing the establishment of the University was passed by the Grand National Assembly. The Minister of Education has set aside a magnificent site for the development of a teaching and research centre, and plans for the construction of University facilities are moving ahead at top speed.

Since the beginning of the spring term 1957 the second faculty, that of engineering, has been in operation. Its first Department, of Mechanical Engineering, was joined by a Department of Civil Engineering last autumn. At the same time, the faculty of administration was opened. Continuing to develop in this way, all six faculties with their research institutes will, it is hoped, be in existence within five years, permitting rapid expansion toward the goal set by the Government.

University College of Science
PHYSICS Dept.
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OBITUARY

Viscount Waverley, G.C.B., O.M., G.C.S.I., G.C.I.E., F.R.S.

There have been many tributes to the outstanding qualities of mind and character which made John Anderson, the first Viscount Waverley, one of the greatest, beyond all question, of the many great public servants of Great Britain. It may be doubted, however, whether any of the numerous accounts of his remarkable career have yet done full justice to the special nature of the service which he was qualified to render to the nation, especially in two world wars, by his experience as a student of science at Edinburgh and a postgraduate research worker at Leipzig, before he entered the Civil Service. It should be understood that this course of scientific studies and practice in research did not serve him as a mere introduction, or a stepping-stone, to an official and ministerial career of such extraordinary distinction, in which he became a permanent Under-Secretary of State (Home Office) by the time that he was forty, governor of Bengal ten years later, and then, as Member of Parliament for the Scottish Universities, Minister for Home Affairs and Home Security, Lord President of the Council and, finally, Chancellor of the Exchequer, during the Second World War. Through it all, and with his imperishable and comprehensive memory as a background, the supreme importance of scientific progress had remained with him a matter of central interest and conviction. It was no mere matter of curious coincidence that the subject for his postgraduate researches and Ph.D. thesis at Leipzig had been the chemistry of uranium, and that nearly forty years later, and behind the densest curtain of war-time secrecy, he had found himself charged with the chief responsibility, on behalf of the War Cabinet, for Britain's part in the development of researches on atomic energy—primarily, of course, for purposes of war, but with an ultimate view, even then, to peaceful applications.

My first encounter with the future Lord Waverley was soon after the outbreak of the First World War, in 1914. Sir Robert Morant, as chairman of the English Health Insurance Commission, had found himself suddenly faced with the abrupt disappearance of all the important drugs which had been obtained from Germany; and he promptly recognized that in John Anderson, a brilliant young Civil servant, with the then almost unique qualification of scientific training and experience, he had the man to deal with the position thus created. I had newly joined the scientific staff of the then embryonic Medical Research Committee (now Council), and its first secretary, Walter Fletcher, had asked me to act on its behalf with reference to the same emergency; so that Anderson and I naturally met and kept contact over problems of common interest and responsibility. He also became a member, and a most important one, of a Royal Society Committee, appointed to enlist scientific co-operation to meet sudden needs of the same kind. Thereafter he was swept away to heights of administrative promotion where I lost direct touch with him; and it was not, indeed, until the Second World War that I came again into even closer scientific and personal contact with him, and then mostly 'behind the scenes'.

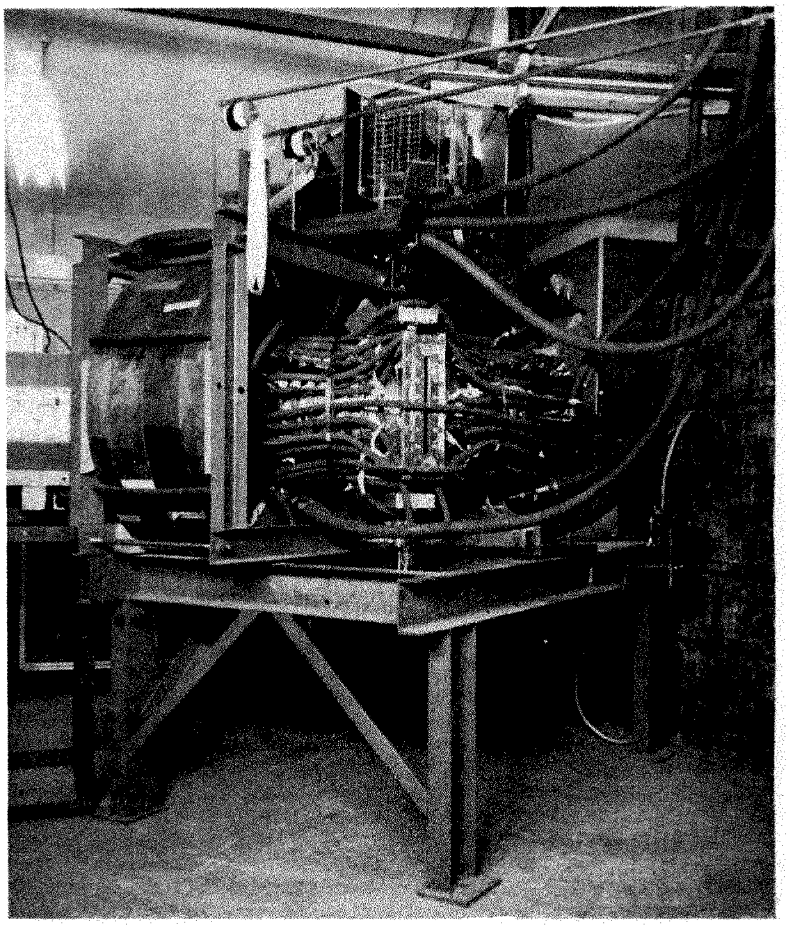
When the university memberships were abolished, Sir John Anderson, having no real interest in party politics, retired from parliamentary life until he entered the House of Lords. He became chairman for his remaining years of the Port of London Authority; and he continued to give practical evidence of his interest in scientific matters, not only as a director of Imperial Chemical Industries, Ltd., but also through a variety of honorary services to science, such as those of chairman of the Parliamentary and Scientific Committee, treasurer of the Lister Institute and president of the Research Defence Society. Nobody who was privileged to work closely with him could have failed, I think, to become aware that, behind the mask of his almost legendary reserve and quiet assumption of authority, Lord Waverley retained a generous and even emotional attachment to science and its claims, though an open display of such an enthusiasm was scarcely within his range.

H. H. Dale

NEWS and VIEWS

SCEPTRE III

Following the article by Allen, Allibone *et al.* in *Nature* of January 25, p. 222, we publish a photograph of SCEPTRE III. The photograph shows part of the 4-ton strip steel core threading the torus. Each half of the core has an eight-turn winding carrying 50 amp. d.c. to provide flux biasing. The primary, consisting of eight separate windings of eight turns each, is wound as uniformly as possible over the surface of the torus. The torus has a bore of 12 in. and is made of ½-in. thick aluminium in four quadrants, or sectors, separated by four straight sections each 6 in. long, which provide viewing and pumping facilities. The eight insulating gaps are protected by eight pairs of interlaced copper liners, and double vacuum gaskets made from indium wire are used throughout. Quartz-covered slits—one in the vertical plane and one horizontal—allow the discharge to be viewed by a high-speed rotating mirror camera. The primary windings are arranged to obscure these slits as little as possible. The toroidal magnetic field is created by providing a d.c. supply to 102 layer-wound coils placed around the torus perimeter beneath the primary winding, and at pumping and viewing ports the field is maintained constant by compensating coils. At the maximum B_z field of 1,000 gauss some 125 kW. are dissipated, and since these coils are not water-cooled the time of operation of the apparatus is limited by the temperature rise of these coils. The capacitors can be discharged into SCEPTRE III 40 times a minute, and about 100,000 discharges have been produced without noticeable deterioration of the torus lining. The terminating-circuit of the radio-frequency pre-ionizing supply is seen mounted above the core, and the water-cooling feed lines and a lead chamber containing the nuclear detectors are on the right.



Dr. J. R. Killian, jun.

As special assistant for science and technology to the President of the United States, Dr. James Killian brings to that post, specially created for him last November, a good deal of scientific and administrative experience. The position was described by President Eisenhower, in his address on "Science and National Security" on November 7, as one in which the incumbent, "aided by a staff of scientists and a strong advisory group of outstanding experts . . .", would "have the active responsibility of helping me follow through on the (scientific and development) programme". Thirty years ago, at the age of twenty-three, Dr. Killian took his degree of bachelor of science in business and engineering administration. The course for that degree covered many aspects of engineering and science and also comprised training in engineering and scientific management. Since then, his work in research and administration has won for him many honours and awards, including the President's Certificate of Merit in 1948, the Freedoms Foundation Award in 1952 and a Certificate of Appreciation from the Department of the Army in 1953.

Dr. Killian is a Fellow of the American Academy of Arts and Sciences and a member and former vice-president of the American Society for Engineering Education. In 1951, he was appointed chairman of the Army Scientific Advisory Panel and a member of the Scientific Advisory Committee of the Office of Defense Mobilization. Dr. Killian went to the Massachusetts Institute of Technology from Trinity College (now Duke University) in 1923, and while he was editing its newspaper, *Technology Review*, was made executive assistant to the Institute's president, the late Dr. Karl T. Compton. Two years after this appointment, in 1939, he was helping Dr. Compton to organize the Institute's vast programme of training and research for war purposes; ten years later, Dr. Killian succeeded Dr. Compton as president of the Institute.

College of Aeronautics, Cranfield : Prof. John Loxham

Mr. John Loxham has been appointed to the chair of aircraft economics and production in the College of Aeronautics, Cranfield. He will take up his appointment on April 1. Mr. Loxham, as managing director of the Sigma Instrument Co., Ltd., has been responsible for the development of a wide range of fine measuring equipment specially suited to the production methods of modern industry, and those of the aero-engine industry in particular. His work in this field has earned him an international reputation, and machines made to his designs are used in all the industrialized countries of the world. Before joining the Sigma Company in 1939, Mr. Loxham was head of the Engineering Production Department at the Northampton Polytechnic, London, where he established the first National Certificate course in production engineering, and set up the first technical college machine tool laboratory. He is chairman of the British Standards Institution Committee for Limits and Fits, and a member of several other committees. He has lectured in Great Britain and abroad on subjects associated with management, technical education and the control of quality in engineering production. In 1946, he was awarded the Sir Joseph Whitworth Prize by the Institution of Mechanical Engineers for his paper on "An Experiment in the use of a Standard Limit System", and the City and Guilds of London Institute has recently conferred upon him the Insignia Award in Mechanical Engineering for 1957 in recognition of his work in the field of precision engineering.

Horticulture at Reading : Prof. O. V. S. Heath

Dr. O. V. S. Heath, who has been appointed to the chair of horticulture in the University of Reading, graduated in botany in 1925 at the Imperial College of Science and Technology, London, and proceeded to the Imperial College of Tropical Agriculture, Trinidad, for a course in tropical crop botany. During 1927–36 he held the post of plant physiologist at the Cotton Experiment Station, Barberton, South Africa, and carried out developmental studies on cotton in relation to soil moisture, rotations, and cultivation methods. In 1936 he returned to the Imperial College as Leverhulme Research Fellow and began work on carbon dioxide assimilation in relation to stomatal aperture, and the mechanism of stomatal movement which from then on became his major field of work. In 1939, he was appointed to the staff of the Research Institute of Plant Physiology at the Imperial College and attained the rank of senior principal scientific officer. During 1940–45 he carried out research on morphogenesis in the onion plant, especially the effects of day-length and temperature on bulb formation and flowering. Techniques for producing onion sets and for preventing bolting by storage treatment were devised, and low-bolting strains selected. From 1945 onwards Dr. Heath resumed his stomatal investigations. The discovery of the effects of carbon dioxide concentration led to work on the minimum concentration of carbon dioxide in illuminated leaves. In the field of stomatal physiology Dr. Heath's work is unrivalled. His recent demonstration of the role of chelation in the action of growth substances has opened a new line of approach. He took an active part in the work of the department both as lecturer and supervisor of postgraduate students.

The Atomic Energy Authority

Replying for the Prime Minister to a question in the House of Commons on January 24, Mr. R. A. Butler said he had no reason to suppose that the Prime Minister would dissent from the action proposed by the Atomic Energy Authority in a letter received from its chairman. In that letter, of January 21, Sir Edwin Plowden said that the Authority endorsed and will follow the principles of organization laid down in the report of the Fleck Committee appointed to inquire into the organization of certain parts of the Authority, and it also accepts in general the scheme of organization recommended for the Industrial Group and expects, in large measure and over a period of time, to implement the Committee's recommendations. It will endeavour to approach as nearly as possible the organization visualized by the Committee, having regard to the individuals who hold or could be found to fill the senior posts. The Authority is already embarking on a programme of recruitment from outside and of transfer within its own organization. On January 27, Mr. Maudling, replying to a parallel question, said that the Government and the Authority are still considering the implementation of the recommendations of the report of the Fleck Committee which investigated the health and safety arrangements of the Authority.

In reply to a further question about nuclear power station contracts, Mr. Maudling said that besides the four consortia formed in the earlier stages of preparation for the nuclear programme and trained by the Atomic Energy Authority in collaboration with the Central Electricity Authority, a fifth consortium has since been formed and trained at its own request. For technical reasons the design and construction of a nuclear power station can best be undertaken at present by such groups of companies. No exclusive rights are granted to the use of the Authority's information. The system will be kept under review, and more conventional methods may be possible later.

Exchange of Information on Thermonuclear Fusion

A JOINT United States–United Kingdom conference to exchange classified information on research in the field of controlled thermonuclear reactions was held during February 3–5 at the Naval Research Laboratory in Washington, D.C. The exchange of information is under provisions of the agreement for co-operation on civil uses of atomic energy between the two countries. This is the sixth such meeting since the co-operative programme between the two nations was inaugurated in October 1956.

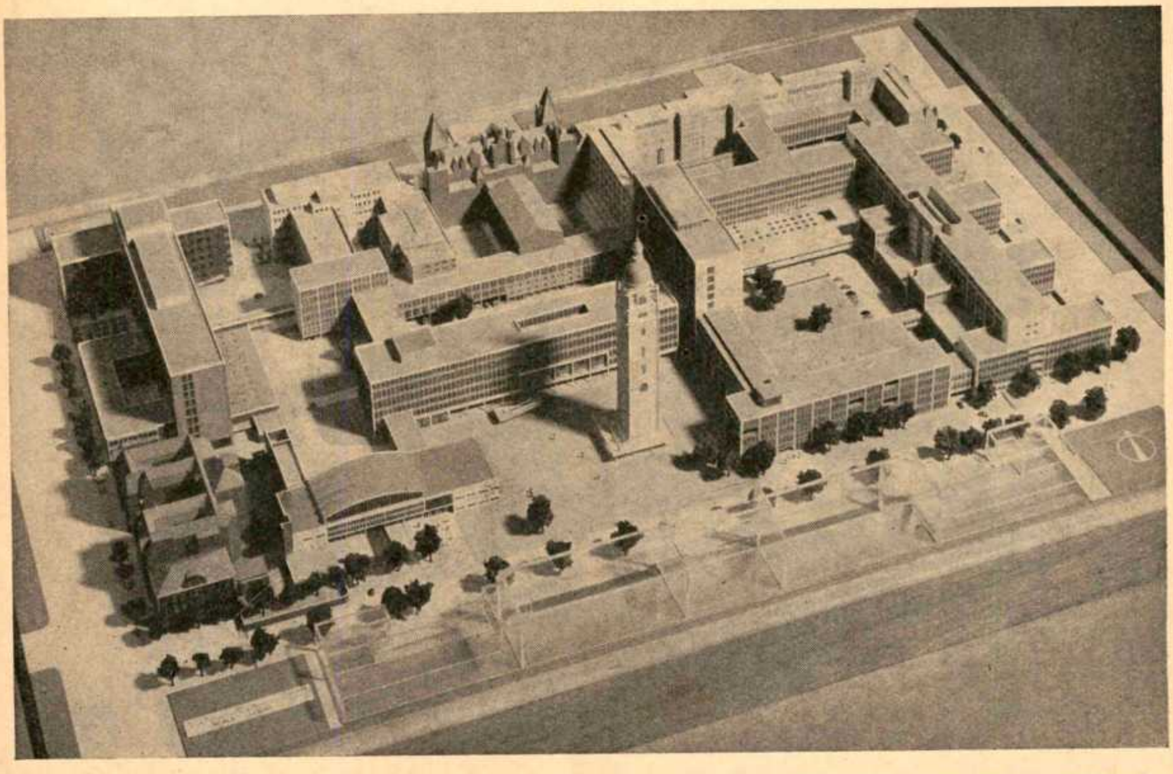
In the British delegation were: J. R. Bickerton and G. N. Harding, Atomic Energy Research Establishment, Harwell; R. F. Hemmings and B. S. Liley, Associated Electrical Industries, Aldermaston; H. Bodin, Atomic Weapons Research Establishment, Aldermaston. The United States were represented by teams of scientists led by A.E.C.-supported projects, including the Los Alamos Scientific Laboratory, Oak Ridge National Laboratory, Princeton University, the University of California Radiation Laboratory, New York University and the Naval Research Laboratory. Leaders of the groups attending were: Dr. James L. Tuck, Los Alamos Scientific Laboratory; Dr. E. D. Shipley, Oak Ridge National Laboratory; Dr. Lyman Spitzer, jun., Princeton University; Dr. Chester Van Atta, University of California Radiation Laboratory; Dr. H. Grad, New York University; Dr. W. R. Faust, Naval Research Laboratory.

Development of the Imperial College of Science and Technology

THE revised scheme for the development of the central site of the Imperial College of Science and Technology, London (see *Nature*, **177**, 723; 1956; and **178**, 123; 1956), in the rectangle bounded by Exhibition Road, Imperial Institute Road, Queen's Gate and Prince Consort Road, has now been placed before the London County Council for planning approval. The scheme retains the tower of the Imperial Institute Building, designed by Collcutt, as a central feature in the form of a free-standing campanile rising from the central court, in accordance with the recommendation of the Royal Fine Arts Commission. The Royal School of Mines building designed by Aston Webb, and the new building for the Departments of Chemical Engineering and Aeronautics designed by Norman and Dawbarn, have been incorporated into the scheme together with certain other buildings which do not form part of the College, notably the Royal School of Music on the northern side of the site. When completed, the new buildings will accommodate 3,000 students and will have a daily working population of more than 4,000 people. Work on the scheme, recently approved by the London County Council, for the development of Prince's Gardens, just off Exhibition Road, as halls of residence for the College is due to start this year. It will provide, in the first instance, residential accommodation for nearly 1,000 students. The plans embody a new conception of halls of residence, interpreting in contemporary terms the staircase system of the older universities.

Liberal Education in Technical Colleges

SOME useful suggestions about the place of liberal studies in technical education were made by Mr. A. A. Part, head of the Further Education Branch of the Ministry of Education, at King's College, Newcastle upon Tyne, on November 19. The education of a free man, he suggested, should be concerned with four



Model of the revised plan for the development of the Imperial College of Science and Technology: view from the south-west essential features. First would be the development of self-respect. Second would come the stimulation of independent thought, and thirdly, closely allied to it, the fostering of the spirit of enterprise and imagination. Fourthly, the free man, in the circumstances of to-day, when all activities are becoming increasingly complex, must be able to work as a member of a team. In addition, many people would consider that to be truly free, a man needs the support of religion; one of the greatest reforms of the Education Act of 1944 was to secure for every schoolchild the opportunity for religious worship and religious instruction in school.

Institute of Information Scientists

At a meeting held at the Institution of Electrical Engineers on January 23, which some 125 persons (mostly graduate information officers) attended, Dr. G. Malcolm Dyson took the chair, and opening speeches were made by Mr. J. Farradane (Tate and Lyle, Ltd.) and Mr. C. W. Hanson (British Scientific Instrument Research Association). The proposal "That a professional body be, and is hereby, set up to promote and maintain high standards in scientific and technical information work and to establish qualifications for those engaged in the profession" was carried. The new professional body has been named the Institute of Information Scientists, and a temporary working committee has been appointed to devise a constitution for approval by a later meeting, when the permanent officers will be elected. Further information about the Institute can be obtained from Mr. J. Farradane, "Torran", Crofton Road, Orpington, Kent.

International Instrument Show

The International Instrument Show will be held in Caxton Hall, London, during the last week of March, opening on March 24. It is expected that more than sixty factories from ten countries will be participating, and their products will include a number of the latest technical achievements in the fields of printed circuits, ultra-violet television microscopy, electron paramagnetic-resonance spectroscopy and telemetry. This year greater emphasis has been placed on the attendance of factory engineers. Normal day opening hours will be from 10.30 a.m. to 6.30 p.m., but to facilitate the attendance of parties of students and apprentices, the show will remain open until 9 p.m. on March 26 and also until 12 noon on the following Saturday morning. Admission is free to *bona fide* applicants. Tickets are available from the sponsors, B. and K. Laboratories, Ltd., 57 Union Street, London, S.E.1.

Humphry Davy Lectures

The London Section of the Royal Institute of Chemistry is sponsoring a new series of lectures, to be called the Humphry Davy Lectures. The first, entitled "Purity and Purification of Chemical Substances", will be given by Prof. Arne Tiselius (University of Uppsala) at the Royal Institution, 21 Albemarle Street, London, W.1, on February 19 at 6.30 p.m. The chair will be taken by the president of the Royal Institute of Chemistry, Prof. W. Wardlaw.

Dr. W. J. Jongmans

Prof. John Walton, of the University of Glasgow, writes: The obituary notice by Alan Wesley which appeared in *Nature* on January 18 gave an interesting account of the work of Dr. Jongmans, but it should also be recorded that Jongmans was largely responsible for organizing the very successful and memorable series of congresses on Carboniferous stratigraphy held at Heerlen in 1927, 1935 and 1951. The idea of holding such a Congress was the result of conversations between Jongmans, Prof. Armand Renier and Prof. Walther Gothan. Jongmans, however, was responsible for practically all the organization and the editing of the voluminous *Comptes Rendus*. The congresses brought together those interested in Carboniferous geology from many parts of the world and the delegates received much hospitality from the City of Heerlen and the State Mines. In 1938 the University of Glasgow conferred on Jongmans the honorary degree of LL.D.

Dose-Rate Effects in Radiation-induced Chemical Reactions

Referring to this article by Dr. H. C. Sutton and Prof. J. Rotblat (*Nature*, 180, 1332; 1957), Mr. J. P. Keene (Physics Research Department, Christie Hospital and Holt Radium Institute, Withington, Manchester 20) writes: "I have already published (*Rad. Res.*, 6, 424; 1957) an account of some measurements of G^{Fe} at 10^{10} rads/sec. The value obtained was 14·3, which is probably not significantly different from the value of 15·45 obtained by Schuler and Allen (*J. Chem. Phys.*, 24, 56; 1956) for dose-rates in the range 10^{2}–10^{6} rads/sec., and values in the region of 15 obtained by other workers at lower dose-rates. Thus we may conclude that most of the fall in the ratio $G^{\mathrm{Fe}}/G^{\mathrm{Ce}}$, due to electron irradiation in the range 10^{8}–10^{10} rads/sec. observed by Sutton and Rotblat was in fact due to an increase in G^{Ce}".

Announcements

Dr. G. E. R. Deacon, director of the National Institute of Oceanography since its foundation in 1949, has been elected a foreign member of the Swedish Royal Academy of Sciences.

Dr. Detlev W. Bronk, president of the U.S. National Academy of Sciences and also president of the Rockefeller Institute for Medical Research, has been awarded the Gold Medal of the International Benjamin Franklin Society.

A conference on "Fundamental Aspects of the Dehydration of Foodstuffs" will be held at the University of Aberdeen during March 25–27. Further information can be obtained from the Assistant Secretary, Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

The Institution of Electrical Engineers Faraday Lecture for 1957–58 will be given at the Central Hall, Westminster, at 6 p.m. on February 12. The subject will be "The Electrification of Railways". The Lecture was prepared by the late Mr. G. H. Fletcher and will be delivered by Mr. R. Ledger. Admission is free, by ticket obtainable from the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

The title of the book by L. Saunders and R. Fleming noticed in *Nature* of January 18, p. 147, was given incorrectly: it should read "Mathematics and Statistics for Use in Pharmacy, Biology and Chemistry".

FLOW NOISE

DURING the latter part of the last century, the great scientists who studied acoustics attacked and solved most of the problems of acoustic excitation and propagation, the one notable exception being that of sound created by moving air. Since that time, partly because of its relative unimportance, but chiefly because of its intractability, the acoustician has only tackled the problem in a physical manner to explain the discrete frequencies which occur when air blows over wires (aeolian tones) or on to a sharp edge (edge tones) and has not at any time appealed to mathematics to obtain quantitative solutions. Since the Second World War, the greatly increased power used in civil airliners, made possible by the invention of the jet engine, has brought forth a noise situation in which the enormous power developed has more than outweighed the inefficiency of conversion of kinetic energy and has precipitated a major conflict between the flying and non-flying public. A detailed study of jet noise has thus become urgent, and this has brought into the field of acoustics those scientists who have, by tradition, been most knowledgeable about the details of the source, namely, the fluctuating flow in the jet as it mixes with the surrounding air. Since the acoustic output of a typical jet engine consists of only one-hundredth of 1 per cent of the total engine-power, this has involved a highly mathematical treatment. Hence, in Britain, the acoustician with his physical interpretation and the aerodynamicist with his mathematical approach have tended to keep apart, even while dealing with the same problem.

Thus it was that, at the joint meeting of the Acoustics Group of the Physical Society and the North-eastern Branch of the Institute of Physics held in Newcastle upon Tyne during November 15–16 under the joint chairmanship of Prof. E. G. Richardson and Dr. O. P. T. Kantorowicz, the major outcome was the cross-fertilization of ideas arising from these two groups. Indeed, as Prof. E. J. Richards (Southampton) pointed out in his introductory address, noise suppression has now become a study of turbulent mixing and has moved some way from pure acoustics. Thus, whereas the two-day conference was split into sessions on noise in air and in water, respectively, the natural gulf was, in fact, that between papers on turbulence and on discrete-frequency sound.

In the first category, considerable interest was aroused by three papers concerned not with noise and its propagation but with the aerodynamics of jet flow. In his talk, Dr. G. M. Lilley (Cranfield) examined the terms of Lighthill's equations and from them put forward valuable ideas regarding the essential parameters on which jet noise is based. He also examined in more detail than in the past the nature of the turbulence of the stream and its significance in contributing to the quadrupole sources of sound. Probably his most interesting proposal concerned a suggestion recently made by Townsend, that eddies emanating from a jet can be likened to long vortices stretching downstream with their axes along the line of the jet. He speculated that since these supply the major energy-carrying eddies, they are probably the greatest sources of sound; the obvious corollary to this is, of course, that noise-suppression techniques should be based on the deliberate destruction of these toroidal vortices, presumably by cross-flows and quick mixing systems.

In this category of papers on turbulence and its relationship to noise were also two papers from the United States: Dr. R. H. Kraichnan, of the University of New York, talked about the pressure and sound fields of turbulence with high Reynolds number, while Dr. E. Skudryzk, of Pennsylvania State University, presented some most interesting results regarding the noise produced by the boundary-layer turbulence of a rotating cylinder. Undoubtedly these three papers, involving the relationship between wide-spectrum noise and turbulence, indicate the direction of future flow-noise researches at least for the next five years.

The other papers presented in this two-day conference dealt almost exclusively with discrete-frequency sound phenomena. Such phenomena are, of course, much easier to picture physically and were received with considerable interest by the less mathematical members of the conference. Edge tones in water were described by Mr. M. Gross (Newcastle). Dr. J. H. Gerrard (Manchester) described his experiments on the singing of wires (aeolian tones); the hydrodynamic oscillator was described by Dr. G. G. Parfitt (Imperial College of Science and Technology, London) and the effect of nicking on organ flue pipes by Dr. D. M. A. Mercer (Southampton). It is impossible in the space available to describe these interesting contributions, nor the general survey by Mr. M. P. Tulin of the water-noise researches being carried out in the U.S. Naval Research Laboratories, in any detail. Dr. Parfitt's description of the work at Harvard in developing a hydrodynamic oscillator which provides a sound level of 165 decibels in air for the expenditure of only 14 watts in energy shows how noise and pressure resonances, normally a nuisance, can also be harnessed to provide a very efficient means of energy-transfer.

As would be expected in the study of sound by aerodynamicists, optical schlieren techniques have become the accepted method of studying discrete-frequency phenomena. One of these phenomena arises from the sound which is given out when an eddy passes through a shock wave. Since this sound

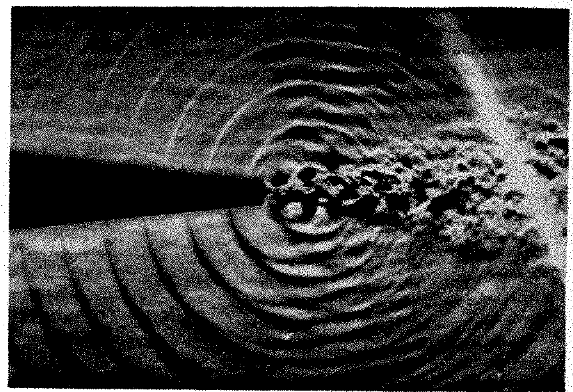


Fig. 1

wave proceeds upstream and produces a fluctuating flow, it is easy to see that for some frequency a self-sustaining system or resonance will occur. Two somewhat similar papers on this subject were presented at the conference, one by Mlle. Merle (Marseilles) and Mr. M. G. Davies (Liverpool). Both authors described their work on the 'back reaction' or resonance mechanism, Mlle. Merle showing a most interesting film of the cellular pattern in the jet. Mr. Davies gave more attention to the geometry of the system and a method of prediction of the frequency. The standard of photography was excellent in both cases; a typical photograph by Mr. Davies showing the sound waves emanating from the choked jet stream is shown in Fig. 1.

During the conference, members were conducted around the laboratories of the Pametrada Research Station and the cavitation tunnel at King's College, Newcastle. It is to be hoped that this meeting will be only one of a series drawing together workers in acoustics and aerodynamics, separated as they are now by the wide gulf of tradition.

ENZYME CHEMISTRY

An international symposium on enzyme chemistry organized by the Science Council of Japan was held under the auspices of the International Union of Biochemistry in Tokyo and Kyoto during October 15–23. The president of the symposium was Dr. Seiji Kaya, president of the Science Council of Japan, and Dr. Keizo Kodama was chairman of the organizing committee. The meeting was reported to be the largest international gathering of scientists held in Japan since the War, 108 non-Japanese from twenty-one countries and 816 Japanese being present. The attendance from Western European countries was regrettably small, about half the overseas visitors being from North America, eight from the Soviet Union and numbers of from one to four from other countries. The thoughtfulness of the Japanese in presenting their work for the most part in English went a long way towards overcoming the language barrier, and their friendliness and the very great care with which our Japanese hosts had evidently planned every detail of the excellent organization made for an exceptionally smooth-running conference. Both at the University Club at Tokyo and within the University buildings at Kyoto, large and well-equipped reception and meeting rooms were provided. All participants received on arrival a massive volume containing the text of some 150 communications; the printed proceedings are to be published later and will include the discussions which followed the presentation of these papers.

Special lectures were given by Britton Chance on cytochromes in living cells, by H. Tamiya on the koji as a source of enzymes in Japan, by W. A. Engelhardt on enzymology and mechanochemistry, and by F. Lynen on the phosphate cycle and the Pasteur effect. H. Theorell and F. Lipmann, who were to have delivered conference lectures, were, unfortunately, unable to attend.

The proceedings were grouped under four main topics: mechanism of enzymic group transfer; enzyme systems of hydrogen, oxygen and electron transfer; formation of proteins and enzymes; enzymes and industry.

It would be impossible to mention here more than a few of the individual contributions, most of which maintained a high scientific level. The enzymic synthesis of polynucleotides was described in papers by A. Kornberg and S. Ochoa; lipoic acid and its functions in keto-acid metabolism by L. J. Reed and I. C. Gunsalus; pyridoxal-catalysed enzymic metabolism of amino-acids by E. E. Snell, A. E. Braunstein and K. Ichihara and their colleagues. Japanese work on cytochromes was reported by K. Okunuki, M. Ishimoto and S. Minakami, among others. A striking feature of the exhibition held in connexion with the symposium was the display of crystalline cytochromes by Japanese workers. In the same exhibition was a surprising range of crystalline proteolytic and other enzymes, of which some were commercially available, large samples being generously presented to visitors. Japanese work of industrial importance on the fermentative production of adrenaline and glutamic acid was presented at the scientific meetings.

Further papers concerned oxidative phosphorylations, to which subject outstanding papers were contributed by D. E. Green, B. Chance, A. L. Lehninger and E. C. Slater; while various other aspects of phosphoryl group transfer were described by A. H. Ennor, H. Tamiya and O. Hoffmann-Ostenhof. Biosynthesis of peptide bonds in relation to cell-structure was described by N. M. Sissakian and by T. Peters, and W. E. Knox gave a valuable account of adaptive enzyme formation in animals. The three members from the United Kingdom (F. Dickens, M. R. Pollock and C. Rimington) also presented papers.

At the closing session, Prof. A. Akabori, chairman of the Executive Committee, to whom must go much of the credit for a splendid job of organization, summed up the events of the symposium, and Prof. M. Florkin as president of the International Union of Biochemistry eloquently put the appreciation of the Union. The thanks of non-Japanese members were expressed by Prof. A. K. Balls who, on their behalf, presented to Prof. Kodama an illuminated scroll containing the signatures of the overseas members together with a brief message of appreciation in Japanese, offering their thanks and congratulations on a remarkably valuable and enjoyable symposium.

A full and varied programme of social events was provided, including a number of receptions, displays of Japanese dancing, the tea-ceremony and other picturesque traditional Japanese customs. Many overseas visitors were also able to enjoy the unique experience of life in a ryokan, or Japanese-style hotel, a charming and restful contrast with the bustle and noise of modern Tokyo.

Very attractive glimpses of the beautiful Japanese countryside were provided by excellent rail and bus excursions to the National Park at Nikko, to the ancient city of Nara and to the extremely interesting pearl-fisheries at Kashikojima.

After the symposium, three short further meetings were held. In Kyoto, Prof. Yas Kuno presided over a first-class two-day conference on water-soluble vitamins, organized by the Vitamin B Committee of Japan, which was attended by about fifty people. This is, of course, a field of intense Japanese activity, and some good Japanese papers were presented.

In Osaka, a one-day meeting on starch and amylases was held under the chairmanship of Dr. Shiro Akabori. At another informal but valuable discussion, on "The Metabolism of Cyclic and Sulphur Amino-acids", also held at Osaka on October 26, the contributors included A. Braunstein, [the late] C. Fromageot, W. E. Knox and K. Ichihara. All three of these meetings served to confirm the strong impression already formed by the visitors of the great energy and numerical strength of biochemists in Japan, and of their often outstanding technical ability which enabled them triumphantly to surmount the rather widespread difficulties due to old equipment and laboratories, many of which were not really adequate as judged by current European and American standards. In spite of these handicaps, to which must be added the low salaries of academic workers and the difficulty experienced by younger scientists in obtaining suitable posts at home and, still more, grants for travel abroad, the visitor could scarcely fail to be filled with admiration on observing the tenacity with which the Japanese workers pursued their researches, undaunted by these somewhat formidable difficulties. I am grateful to my two English colleagues at the symposium for their comments on this necessarily incomplete report. On the whole, this was a most rewarding symposium and a unique experience for most Western visitors.

F. DICKENS

RESTORATION OF AGRICULTURAL AND OTHER SOILS

ONE of the problems in connexion with the restoration of soil that has suffered a major disturbance is the length of time which elapses before full fertility can be restored. Two papers dealing with aspects of this problem were read at a meeting of the Association of Applied Biologists in Leeds on September 19. The first of these was by R. Holliday and D. R. Hodgson on "Restoration of Land covered by Pulverized Fuel Ash". This paper dealt with investigations in progress at the University of Leeds under a research grant from the Central Electricity Authority, which is the main producer of fuel ash of this type.

The ash occurs in lagoons, into which it is washed after separation from the spent gases with which it is discharged. Utilization or disposal of this deposit after the lagoons are full is a major problem; its use for filling quarries involves costly transport, and wide-scale industrial use appears unlikely. Possible agricultural uses are therefore under investigation.

The agronomic problem posed is one of growing plants in material with the following properties: it consists mainly of spherical particles between 0·2 and 0·002 mm. in diameter, chiefly silica but with various metals incorporated; normal soil structure is lacking; it sets hard when dry but can be eroded by wind unless sealed with soil; the *p*H is high, varying between 8·5 and 10·5; it is deficient in plant nutrients and contains toxic ingredients; microbiologically it is completely sterile.

The problem of making it suitable for crop growth at a low cost is being investigated along these lines: reclamation through the use of a soil cover and fertilizer application; amending the ash as a growing medium by making up nutrient deficiencies, correcting toxicities and improving the structure; selection of crop plants tolerant to the adverse conditions.

Results are now available on soil cover trials using depths of up to 2 ft. of subsoil and 1 ft. of surface soil with four different surface concentrations of complete fertilizer. The crop-yield was affected with cover depths of less than 2 ft. of soil plus subsoil, but little beyond this level. The highest yields were obtained with a deep soil cover and a high fertilizer rate. Moderately good yields were obtained, however, from either a deep soil with moderate fertilizer rate or a shallow soil covering with a high fertilizer rate. Soil is often a scarce commodity and transport is costly, therefore the second alternative is more economical. All rates of fertilizer application gave poor results where no soil cover was used. The material was found to be deficient in nitrogen and phosphate, but potash is generally adequate.

Different crop plants have shown marked variation in the degree of root tolerance to the ash, but it is not clear whether this is a toxicity tolerance or a reaction to the physical structure of the growing medium.

Various methods to reduce alkalinity have been tried, in most cases with beneficial results. The question of cost, however, rules them out for large-scale use.

Dilution of the ash by the addition of bulky materials, including neutral and acid organic materials, shales and sewage sludge has given promising results in some cases.

Field trials on the capacity of various crops to grow in the ash have shown some plants of the orders Chenopodiaceae, Cruciferae and Leguminosae to be reasonably tolerant to the adverse growing conditions. Other crucifers and grasses have intermediate tolerance, while a wide range of economic plants, including cereals and pulse crops, are exceedingly sensitive. It has been shown that a period of weathering makes the growing conditions less unfavourable, and allows more of these plants to be grown with reasonable success on the ash.

The second paper, on "Some Biological Aspects of Opencast Coal Working", by H. W. Thompson, dealt with changes which occur in surface soil during opencast operations, resulting in lowered fertility and other undesirable qualities which persist for some years. Many factors are involved, some of which follow upon changes in the fauna of the soil.

Biological problems may arise in various ways. Many restored sites suffer from wetness, because permanent drains destroyed by opencast mining cannot be replaced until soil settling has ceased. Crops grown on undrained land frequently lack vigour and so are more liable to suffer pest injury, particularly by such pests as leather-jackets or slugs. Similarly, frit fly attack has often ruined spring oat-crops which, because of adverse soil conditions, have been slow in establishment, with poor capacity for producing tillers.

Serious loss of crops arising in this way can often be avoided by care in cropping or, where appropriate, by the use of insecticides. The wetness problem may be solved in some cases by mole draining until such time as permanent drains can be replaced.

A different type of problem occasionally arises through the introduction of harmful organisms to an area not previously affected. There is an obvious risk, for example, of cyst-forming eelworms being spread when infested and non-infested soils are stored together and later distributed. Cysts of some of these eelworms can survive for twelve years or more in the soil. This aspect is therefore being studied, particularly in the case of the potato root eelworm.

This problem is not common at opencast sites, but has arisen in Lancashire where opencasting is in progress in an intensive arable area. Potatoes are an important crop and fields free from infestation are therefore particularly valuable. The spread of infestation is being studied at one such site. Samples of all fields to be worked were taken before scraping commenced. These showed some fields to be free from measurable infestation while others yielded high cyst counts. These fields will be re-sampled after restoration has been completed.

It was thought possible that cyst viability falls off more rapidly under spoil heap conditions than it would normally in arable land, especially where storage continues for several years in large heaps. At one site there was a definite indication that this does occur. Hatching tests on cysts collected from the top foot of soil showed moderate viability; samples from 8 ft. depth yielded cysts of very low viability, and those from 3 ft. depth showed intermediate larval emergence. The evidence so far from this, and from other sites where soil from heavily infested fields was stored, shows that the risk of spreading serious eelworm trouble as a result of opencasting is not very great, especially in view of the long rest from potato growing which is involved.

Another factor which is regarded as very important in its effect on soil structure and fertility is the great reduction in numbers of earthworms brought about by opencast working. Work on this aspect was therefore started in 1956. The object is to study the number of earthworms during the operation itself and to continue to do so after restoration until fertility is restored or the earthworm population has reached stability. Earthworm collection is carried out by hand digging because of the unusual conditions prevailing in spoil heaps.

A site near Wigan is being used, the soil being a sandy loam with an earthworm population estimated at 609,800 per acre before stripping commenced in May 1956. Counts on two spoil heaps and on an unworked area alongside have been made at roughly monthly intervals since. One spoil heap with a surface area of 1·2 acres is made up of surface soil from 11 acres, and the second, of 0·61 acres, from 4·8 acres.

Estimates made in August—four months after heaping—showed a low survival of earthworms, but by the following March numbers had increased to an estimated 77,000 in heap 1, and 43,000 in heap 2. Apart from a fall during the hot, dry period in June, numbers have remained at a relatively high level since, the highest estimates in both heaps and in the control area being obtained in March and October. A more complete picture of earthworm survival will be available after restoration has been carried out.

The opportunity was taken to study the earthworm position at a Barnsley site restored in 1952 after opencasting and cropped since then under twelve experimental rotations. Counts made in 1956, that is, four years after soil replacement, indicated that an earthworm population that could be regarded as normal for this type of soil had become re-established. The highest estimates were obtained from grazed leys with a population of 315,800 worms per acre, and nine of the twelve series of plots had counts exceeding 150,000 per acre. The information obtained from this site therefore suggests that re-establishment of earthworms after opencasting can be much more rapid than is generally believed to be the case.

H. W. THOMPSON

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THE SCIENCE MASTERS' ASSOCIATION

ANNUAL MEETING

THE annual meeting of the Science Masters' Association, which was held during December 31, 1957–January 3, 1958, in the University of Leeds, was attended by more than five hundred science masters. Among those who came into residence in the University Halls were masters and students from Canada, South Africa, and Tasmania; the Royal Navy also sent its usual numbers from naval educational establishments.

The first evening began with the Association dinner, at which the toast of the Association was proposed by Prof. F. S. Dainton, chairman of the University School of Chemistry; this was responded to by the chairman of the Association, Mr. W. G. Rhodes, education and training officer of Arthur Lee and Sons, Ltd., steelmakers, of Sheffield. The members then assembled in the Parkinson Hall, where the presidential address was given by Sir Charles Morris, vice-chancellor of the University of Leeds.

Sir Charles was concerned with the fact that the external examinations undergone by schoolboys tend to be a test of the schoolmaster rather than of the pupils; a good master can cause indifferent pupils to pass; and he wondered whether science is not being taught too well. He thought also that too many facts are being taught, and that it is more essential to teach fundamental principles: as a philosopher, he thought that over-reliance on the memory is a very grave fault. This over-reliance is due largely to the great mass of facts which modern pupils are expected to assimilate: it is high time that dons and schoolmasters came together to reduce the content of the syllabuses. Sir Charles then dealt with the problem of what science should be taught to those who will not become professional scientists. Whereas the training in arts needed by the scientist is comparatively easily met by giving him a broad education in the use of language and the appreciation of literature, it is not so easy to determine the solution of the converse problem. It is not sufficient to let the non-scientist do badly some diluted version of the scientist's course; what is needed, it seemed to Sir Charles, is the philosophical approach, whereby the great steps in the history of science, the modern applications of science, and its future possibilities are all freely discussed. He thought that science teachers tend to like to teach what they know with certainty, and that they are "deeply unwilling to go outside the field of precise knowledge". It is most important that the misunderstandings between scientists and humanists should be recognized as a deep and serious problem of education; it is something that we had even begun to think about it.

The mornings of the three succeeding days were occupied by lectures. These were by Prof. J. G. Wilson on cosmic ray astronomy, by Prof. L. N. Pyrah on scientific methods in urological research, Prof. F. W. Spiers on "Radiation and Man", Prof. J. T. Whetton on science applied to mining problems, Prof. E. A. Spaul on hormones and behaviour, Prof. E. G. Cox on magnetism and chemistry, Dr. F. E. Hoare on low temperatures as a research tool, Dr. Dorothy H. Rayner on problems of palæontology and evolution, Prof. R. D. Preston on physics applied to botanical problems, and Prof. J. B. Speakman on the chemical revolution in textile technology. Guest lecturers from outside the University were Mr. A. B. Thompson, of the Imperial Chemical Industries Terylene Council, who dealt with the physico-chemical principles underlying fibre-making processes, and Prof. L. Rosenfeld, of the University of Manchester, who spoke on Hellenistic science; the growth of interest in the history of science was shown by the size and membership of his audience.

The second evening-lecture, held under the auspices of the Science and Civilization Lecture Fund, was given in the Parkinson Hall by Mr. Ritchie Calder, who spoke on "The Presentation of Science to the Public". Mr. Calder dealt first with his own experiences in Israel when he was engaged in making plain to the Israeli public that a costly research institution was an asset to the State, even at a time when the State was fighting for its existence, and when the value of the scientific work undertaken might not have been immediately obvious. He found that the research scientists themselves are all too apt to think that any indulgence in publicity would lead to a lowering of their scientific standards. He went on to give other instances, not in Israel, where famous scientists had to be persuaded that it was very well worth while to give accounts of their work which could be understood by the ordinary newspaper reader.

The afternoons were occupied by visits to university departments and to factories and other works near Leeds; there were twenty-four of these, a record number. On the third evening the University held a reception for the Association; at this some three hundred members and their ladies were welcomed by the Chancellor, H.R.H. The Princess Royal.

An exhibition by publishers, manufacturers, and members occupied a large space in the chemical and physical laboratories; there were also special exhibitions by the Atomic Energy Research Establishment, the Aluminium Development Association, and the Copper Development Association.

A programme of scientific films, rather larger than usual, included one entitled "Galileo's Law of Falling Bodies", made by Encyclopædia Britannica Films, Ltd., in the United States in conjunction with the Ford Foundation; this forms part of a filmed teaching course of physics, which will be obtainable in Britain from the Gaumont British Film Library.

The final morning session ended with a demonstration and a discussion, which, owing to limitations of time, had to be held simultaneously.

The very striking demonstration, entitled "Biology for Non-Biologists", was given by Mr. C. H. Bailey, senior lecturer in science at Didsbury Training College; his experiments were carried out with simple apparatus and are intended for those teaching in secondary modern schools, where only a minimum of equipment may be available.

The discussion was held by the Association's Science and Religion Group, and was initiated by the Rev. G. W. Burningham, who acts as chaplain to the Anglican students at the University of Leeds. He emphasized how much greater was the interest of students in religion than it was twenty years ago, and that, if anything, the science students were more keen than the others; there is now more realization of the interdependence of scientific discoveries and religious beliefs. The ensuing discussion ranged over such subjects as miracles, the nature of the soul, and definitions of Heaven and of eternal life.

At the business meeting, Sir Lawrence Bragg was elected president for the ensuing year, and Mr. Charles Holt, of Harrow Weald County School, was elected chairman. The treasurer, Mr. S. W. Read, reported a very favourable balance on the year's working; and it was announced that the next meeting would take place in University College, London, during December 30, 1958–January 2, 1959.

THE METEOROLOGICAL OFFICE

ANNUAL REPORT, 1956–57

SOME years ago a prominent authority was heard to suggest that the annual report of the Meteorological Office might well provide a splendid subject for discussion at a meeting of the Royal Meteorological Society; for every year it gives food for thought. Englishmen regard the weather as their common property; and informed scientists cannot but admire the determination with which the public service endeavours to remain free from perturbation, whatever difficulties attend their efforts to cope with the vagaries of atmospheric behaviour. The Meteorological Office, in the nature of things, is always on guard duty. Day by day its actions, like those of the sentries at Buckingham Palace, are subject to every variety of comment from the bystanders. Fortunately there are always some with enough knowledge to admire a difficult task well done; and to recognize that the demands of a modern community continue to add to the difficulties. Forecasting the winds for a jet bomber at 50,000 ft. is a requirement far beyond the conceptions of those who, sixty years ago, were willing to estimate in what parts of the country the term 'muggy' might apply, on the assumption that the oncoming depression would resemble Abercromby's classical model.

The annual report of the Meteorological Office for the year ended March 31, 1957*, shows admirably, with a subdued but unmistakable note of confidence, that the public service continues to make that sober progress which is to be desired on the part of those who study turbulent motion. As Sir Graham Sutton says, the meteorological problem is probably the most difficult in classical physics, and progress can only be made with the utmost diligence. Forecasting naturally attracts most attention; and efficient accomplishment in dealing with stupendous quantities of incoming factual material will be greatly aided as newly installed electronic computers come more into use. The development and direction of an active cadre of young research workers will ensure that in an accelerating world we shall not only keep up with our neighbours, but may here and there set the pace.

Readers of the report cannot fail to be impressed by the variety of services provided and by the diversity of research; for example, "experiments with the release of silver iodide from ground generators on Salisbury Plain continue with no result yet detectable". Elsewhere is mentioned the work on forecasting the outlook for periods up to a month ahead; "the outlook on this stubborn problem is rather brighter than hitherto".

The British business man is too often insufficiently aware of these public services; and the potential rewards of successful forecasting offer abundant temptation to incautious consultants. There are those who, to all appearance, gamble on sunspots; those who believe it has been given to them to discover periodicities of various sorts; those who think in terms of singularities, and perhaps some on the outskirts who appear to be best described as 'hunch-drunk', to use the delightful phrase coined by an eminent professional meteorologist. But how many of our would-be 'independent consultants' have the temerity to disregard the world synoptic charts, so efficiently assembled by the Meteorological Office working with other nations in an unostentatious but exhilarating daily display of international collaboration?

GORDON MANLEY

* Annual Report on the Meteorological Office for the year April 1, 1956, to March 31, 1957. Pp. 51+4 plates. (M.O. 633.) (London: H.M. Stationery Office, 1957.) 3s. net.

RÉAUMUR

BESIDES his thermometer, René-Antoine Ferchault, lord of the manor of Réaumur in the Vendée, and of Des Angles and La Bermondière, made many contributions to scientific knowledge. In 1708, at the age of twenty-five, he presented a memoir to the Academy of Sciences, and in 1709 two others concerned with general solutions of certain geometrical problems. Having justified his election as *élève* in geometry, he then turned his attention to natural history, and in some highly original observations demonstrated that the shells of molluscs grow by successive external additions of new parts rather than by the alternative process of intussusception. On the death of the geometer Louis Carré in 1711, he was promoted to *pensionnaire mécanicien* and put in charge of the work on trades, arts and crafts; he compiled volumes on the manufacture of anchors, of pins and of cast iron.

In the next few years Réaumur discovered an insect living as an internal parasite on the snail; he studied the movements of shell-fish, sea-anemones and starfish, and the great variety of organs of locomotion in shell-fish and their means of attachment to different solid bodies; he found a hitherto unknown fish that gave a purple colouring matter like the famous Tyrian purple of the ancient world; he demonstrated the correctness of the popular belief that crayfish, crabs and lobsters, having lost a claw, could grow another in its place; he studied the torpedo fish, or electric ray, known for its property of benumbing the hand or limb that touched it, and, while the usual explanation was that this was due to the emission of 'torporific corpuscles', he argued that it was produced by the speed and rapidity of the blow that the ray could inflict by means of its admirably constructed muscular system; he examined the native turquoises of Languedoc, showed that they were in no way inferior to those imported from Persia, supposed at that time to be the only source of these gems, and demonstrated by experiments that they were petrified fossil-bones coloured by a metallic ingredient dissolved in them by firing; he studied pearls and their production and falsification, considering the former as due to disease and showing that the colouring matter of false pearls was obtained from the scales of a fish known as the ablette (in English, the bleak); he examined the great bank of *falun*, or fossil shell-marl, in Touraine; he was interested in the nature and formation of flint, in the plant called *Nostoc* or star-jelly, in the luminescence of certain shell-fish, in the ease of magnetization of iron and steel by percussion, and in the recovery of gold from the sands of various French rivers; he had also already begun to reveal his active interest in the practical arts and their relation to the sciences, reporting to the Academy descriptions of the preparation of slate, and of the gilding of leather, of mining for iron-ore, of the manufacture of mirrors, of the drawing of gold-wire and the properties of paper and other bodies in preventing the passage of air and water.

Later, Réaumur published a paper describing the procedure for the conversion of wrought iron into steel: this is a landmark in the history of the iron and steel industry and effectively marked the introduction of the manufacture of steel into France.

Réaumur also rendered a similar service to the tinplate industry; he showed that vinegar was the cheapest and most effective solvent for the removal of the scale from the surface of the iron before tinning.

All this, as well as Réaumur's outstanding achievements with thermometers and in entomology, is described in a fascinating article by Prof. D. McKie published in *Science Progress* (45, No. 180; 1957). Besides this study of Réaumur, the journal contains an article by Prof. W. B. R. King on water supply and geology and one by Dr. G. H. A. Cole on the Earth and its magnetic field.

ORIGIN OF COMETS

"THE Distribution of the Directions of Perihelia of Long-Period Comets" is the title of a paper by J. G. Tyror in *Mon. Not. Roy. Astro. Soc.* (**117**, 4; 1957), in which he deals specially with Lyttleton's theory of the origin of comets (see *ibid.*, **103**, 465; 1948; and "The Comets and their Origin", Cambridge, 1953). This theory envisaged a process of accretion of dust particles by the Sun as it passed through interstellar dust clouds, and while it explained some of the observed features of comets and of their orbits, like many other theories it presented certain difficulties. If the theory is accepted, then comets must originally have come from preferred positions in the sky, and although the diffusion of the perihelion points of such a family would probably occur, it is considered that some traces of perihelion groupings, at least for families born during recent cloud passages, could be detected.

Mr. Tyror examines the distribution of perihelion points of long-period comets with the object of determining whether there is any evidence of such grouping. Previous investigations by W. H. Pickering and others suggested that there was some evidence of the grouping of aphelion points, but it has been considered advisable to revise these results in the light of additional information which has appeared since the completion of their work. The present survey does not include short-period comets and periodic comets because planetary perturbations would have eradicated reliable evidence of any original grouping; while it is true that all orbits would have been affected to some extent, the investigation has been carried out only for comets suffering slight perturbations. The whole subject is beset with difficulties because it is inevitable that available data must suffer to some extent from observational selection. A detailed description of the contents of the paper is quite impossible in a short note, and it will suffice to deal with the data utilized and the conclusions that have been reached.

Investigations of the positions of 448 comets with periods greater than 200 years were made, and of these 67 had calculated eccentricities greater than 1, 263 equal to 1, and 118 less than 1. There is evidence that the perihelion points of long-period comets tend to be distributed non-randomly, and it is pointed out that this tendency may be due to observational selection or to a real grouping phenomenon, or even to a combination of both. The first of these has undoubtedly played a prominent part in the discovery of comets, and other vitiating factors in the analysis are mentioned. The conclusions are summarized at the end of the paper and are briefly as follows.

The departure from randomness in the observed distribution of perihelion points of the comets considered is strongly suggested, and there is evidence indicating a preference for the perihelion points to lie near a particular great plane. In addition, the centre of the observed distribution appears to be significantly displaced towards a point on the celestial sphere. The identification of the plane with the plane of the Galaxy and of the point as that lying in a direction opposed to that of the Sun's motion cannot be considered unreasonable. These suggestions may be interpreted in the light of Lyttleton's accretion hypothesis, according to which the perihelion positions of comets should show a tendency to lie near the apex of the Sun's motion relative to the local interstellar cloud, and further, the distribution of perihelion points would have a preference for lying near the galactic plane.

QUALITY IN MEAT

NOW that the supply of meat is approaching the level of demand, quality is again assuming economic importance. Definitions and tests of quality have been examined by D. M. Joubert of the Department of Animal Husbandry, University of Pretoria, who has also examined the economic consequences which follow from changed attitudes towards quality (*Colonial Plant and Animal Products*, 6, No. 2; 1956).

Only a few decades ago quality in beef meant well-marbled meat covered by a thick layer of fat. Not only did the average consumer during those times demand more fat owing to the bodily needs imposed by hard manual labour, but also excess fat was used for other purposes, chiefly cooking. At present, cooking fats can be obtained from cheaper sources, the consumers perform less manual labour and are better protected in their homes against cold conditions, and consequently demand the minimum of fat with their beef. Since butchers are concentrating on carcasses of young animals, it is not unlikely that the optimum carcass weight will become even lower in future.

When considering quality in the case of mutton and lamb, the size factor is of primary importance. With the size of the average family decreasing all over the world and with cooking facilities less spacious than they used to be, the general demand is for small joints. Preference is given to a whole joint of small size over half a large one since the latter, because of its cut surface, does not retain its succulence so well and leads to greater wastage through exudation. As in beef, a minimum of fat is preferred. With the rapid development of the dairy industry in recent years and with progress in the manufacture of margarine, the excess fat is no longer widely used as a substitute for butter and goes to waste.

Definition of quality in mutton is particularly complicated because of the differences in the taste of individuals in respect of flavour. Mutton produced from early-maturing sheep (as, for example, Southdown, Suffolk) raised and fattened in stalls may appear extremely attractive and, therefore, be labelled as of high quality. On the other hand, mutton produced from late-maturing sheep breeds (such as Scotch Blackface, and even possibly Merino) off extensive pastures may, by comparison, appear unattractive and may be labelled as being of low quality.

The quality of pork is determined primarily by the amount and nature of the subcutaneous back fat. The amount of fat preferred with pork by consumers in Britain at present is considerably less than a few decades ago, while in South Africa, for example, a large amount of fat has never been tolerated except where it was required for purposes other than eating. It was not realized that lean pork can be produced provided the right type of animal is used and that correct feeding is practised, and the consumption of pork in South Africa remained extremely low until quite recently. On the contrary, in certain Continental countries the general taste demands rather more fat with pork, and a certain amount of excess fat is required by butchers for the production of a great many varieties of sausage and salami. Consequently the type of pig raised in the central European States (such as Germany and Hungary) differs markedly in its conformation from that which is considered as the ideal type in Great Britain and South Africa.

The final factors determining the quality of a piece of meat, and one which often nullifies all factors considered prior to its cooking, centre around the purely human element, namely, the ability of the cook—either to spoil the good qualities of meat through inefficiency, or to improve to such an extent the quality of a poor sample of meat through skill and knowledge of cooking, *per se*, that its pre-cooked quality remains unquestioned.

ASSAY OF VITAMIN A OILS

By Prof. E. BRUNIUS

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IN 1954 a Vitamin Assay Commission was set up by the Food Division of the Applied Chemistry Section of the International Union of Pure and Applied Chemistry.

The official members of the Vitamin Assay Commission are: Prof. E. Brunius (Sweden, chairman), Dr. W. F. J. Cuthbertson (Great Britain), Dr. M. Kofler (Switzerland), Dr. B. L. Oser (United States) and Prof. H. Simonnet (France). The Commission has held four Conferences: in London 1954, Zurich 1955, Amsterdam 1956, and Paris 1957. In all the Conferences, besides members of the commission, the following participated: Dr. D. W. Kent-Jones (Great Britain, honorary secretary of the Food Division), Prof. R. Nicolaysen (Norway, member of the Food Division), Mr. E. Hayes (Great Britain), and Mr. R. J. Taylor (Great Britain). In addition the following were present at the Amsterdam conference: Dr. J. Straub (The Netherlands, member of the Food Division), and Dr. C. Engel (The Netherlands); and at the Paris Conference: Dr. K. Dürrenmatt (Switzerland, chairman of the Food Division), Prof. J. Brüggemann (Germany), Dr. C. Engel (The Netherlands), Dr. A. François (France), and Dr. J. Tiews (Germany).

One of the Commission's tasks was to develop a standardized method for the assay of vitamin A oils which would be acceptable in international trade.

Current vitamin A assay methods are based on the recommendations made by the Subcommittee on Fat-Soluble Vitamins of the World Health Organization. In its report[1] the International Unit of vitamin A potency is defined in terms of the activity of crystalline all-*trans* vitamin A acetate, and the conditions for the spectrophotometric assay of the vitamin are broadly set down. The elaboration of methods in different countries, however, has led to divergences in the assessment of vitamin A potency, and this has given rise to difficulties in the international trade in vitamin A oils. It was therefore considered an urgent task for the Commission to attempt to develop a standardized method of assay.

Vitamin A oils vary widely in quality and potency. At the outset the Commission decided, on the evidence available, to consider them in two categories according as their spectrophotometric characteristics approached those of pure vitamin A or not. For oils in the first category (comprising most fish-liver oils and vitamin A concentrates) a correction procedure based on the Morton–Stubbs principle[2] was considered sufficient. For oils in the second category (comprising whale-liver oils and other oils having a high proportion of irrelevantly light-absorbing materials) a chromatographic step should precede the determination of extinction and the application of correction. All measurements should be made on the unsaponifiable matter of the oils. It was suggested that this should be isolated by the method described in the United States Pharmacopeia.

The Commission organized three collaborative experiments, in which laboratories in Europe, Japan and the United States co-operated. Thirty-seven laboratories participated in the first experiment, thirty-four in the second and nine in the third.

The main purposes of the experiments were: (1) to ascertain the loss of vitamin A in isolating unsaponifiable matter of oils according to the method of the United States Pharmacopeia; (2) to investigate whether *iso*propanol and absolute ethanol could be used as alternative solvents in measuring extinction; (3) to determine the constants for a correction formula based on the Morton–Stubbs principle[2]; (4) to ascertain the loss of vitamin A in a chromatographic method suggested for samples in the second category; (5) to investigate the selectivity of this method; (6) to compare two techniques for following the movement of vitamin A through the chromatographic column; and (7) to estimate the experimental errors in the vitamin A potencies of oils in both categories as assayed by the procedure suggested.

A vitamin A reference standard containing all-*trans* vitamin A acetate in vegetable oil (nominal potency 100,000 I.U. per gm.) and samples of oils belonging in the second category were used as test materials.

In the chromatography, the unsaponifiable matter of the sample was passed through a column of weakened alumina and the vitamin was eluted with mixtures of light petroleum and ether. The movement of the vitamin was followed by testing aliquots of the eluate with antimony trichloride solution and, in the third experiment, alternatively by observing the column in weak ultra-violet light. Two different samples of alumina were used by most participants.

A statistical screening procedure, based on Chauvenet's criterion[3], was applied to the results.

The main outcome of the experiments can be summarized as follows. The average loss of vitamin A in isolating the unsaponifiable matter of the vitamin A reference standard was found to be 1·2 per cent in

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the first experiment and 1·2–1·5 per cent in the second. *Iso*propanol and absolute ethanol could not be recommended as alternative solvents, because the respective E_{310}/E_{325} and E_{334}/E_{325} ratios differed significantly in the two solvents, which gave rise to systematic errors when correction was applied. The correction formula derived for *iso*propanol from the results of the first and second experiments was:

$$E_{325}\text{ corr.} = 6{\cdot}815\,E_{325} - 2{\cdot}555\,E_{310} - 4{\cdot}260\,E_{334}$$

The average loss of vitamin A in chromatographing the unsaponifiable matter of the vitamin A reference standard amounted to 2·4 per cent irrespective of the kind of alumina used. The average total loss of vitamin A, that is, the losses in isolating and chromatographing the unsaponifiable matter, was 3·5–4 per cent. After chromatography the samples of oils belonging in the second category readily met the specifications laid down for oils in the first category. The two procedures for following the movement of vitamin A through the column were equally efficient and could thus be recommended as alternative techniques. The inter-laboratory error (s) at $P = 0{\cdot}95$ for a duplicate assay of vitamin A potency was estimated at 6–8 per cent for an oil in the first category and at 10–14 per cent for an oil in the second category. The error of the mean of assays performed at n different laboratories—each of them making a duplicate assay—will accordingly be $s/\sqrt{n}$.

For vitamin A oils showing negligible amounts of irrelevant light absorption, the corrected E value should theoretically be identical with the uncorrected E value but, because of the experimental error due to the correction procedure, positive corrections must sometimes be encountered. About half the assays on the vitamin A reference standard in the first and second experiments showed positive corrections. In the first experiment 14 out of 15 positive corrections did not exceed 2·5 per cent and in the second 29 out of 30 positive corrections did not exceed 3·5 per cent.

The Commission now makes the following recommendations for the assay of vitamin A oils:

1. All oils shall be saponified, and the assay made on the unsaponifiable matter.

2. The unsaponifiable matter shall be isolated by the method of the United States Pharmacopeia XV [4].

3. All spectrophotometric measurements shall be made in *iso*propanol as solvent.

4. Oils shall be considered in two categories:

Category 1: those oils the unsaponifiable matter of which has an absorption maximum lying within the region 323–327 mμ and an extinction ratio E_{300}/E_{325} not exceeding 0·73.

Category 2: those oils the unsaponifiable matter of which has an absorption maximum lying outside the region 323–327 mμ or an extinction ratio E_{300}/E_{325} exceeding 0·73.

5. For oils in category 1, the E_{310}, E_{325} and E_{334} values of the unsaponifiable matter shall be measured and a correction applied according to the formula:

$$E_{325}\text{ corr.} = 6{\cdot}815\,E_{325} - 2{\cdot}555\,E_{310} - 4{\cdot}260\,E_{334}$$

6. For oils in category 2, the unsaponifiable matter shall be chromatographed according to a prescribed procedure. Provided the chromatographed unsaponifiable matter satisfies the criteria for category 1 oils, its E_{310}, E_{325} and E_{334} values shall be measured and a correction applied as directed under 5.

7. Corrected E_{325} value shall be used for calculating vitamin A potency, except in the cases mentioned under 8.

8. A corrected E_{325} value which lies within ± 3·0 per cent of the uncorrected value shall be regarded as equal to the uncorrected value for the purpose of evaluation, and the uncorrected value shall be used for calculating vitamin A potency. A corrected E_{325} value which is greater than 1·030 times the uncorrected value shall be re-determined and, if confirmed, treated as a special case between buyer and seller.

9. The E_{325} value is converted into $E^{1\%}_{1\text{cm.}}$ 325 mμ. The vitamin A potency of the sample, expressed in I.U. per gm., is obtained by multiplying the $E^{1\%}_{1\text{cm.}}$ 325 mμ value by 1830 [5], that is, the factor of the reference quoted, taken to three significant figures.

Detailed reports of the Commission's collaborative work and of the recommended procedure for assay will be published elsewhere.

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[1] Report of the Subcommittee on Fat-Soluble Vitamins, WHO/BS/65 Rev. 1 (1949); World Health Org. Tech. Rep. Ser., No. 3 (1950).

[2] Morton, R. A., and Stubbs, A. L., *Analyst*, 71, 348 (1946).

[3] Chauvenet, "Theoretical and Practical Astronomy", 2. Quoted from Brunt, D., "The Combination of Observations", 130 (University Press, Cambridge, 1923).

[4] "The Pharmacopeia of the United States of America", Fifteenth revision, 941 (Mack Pub. Co., Easton, Pa., 1955).

[5] Boldingh, J., *et al.*, *Nature*, 168, 598 (1951).

CORRECTION FOR THE GAMMA-RAY SENSITIVITY OF THE BETA-COUNTER IN THE STANDARDIZATION OF COBALT-60 BY THE BETA–GAMMA COINCIDENCE METHOD

By B. OWEN and R. A. LLOYD

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THE standardization of radioactive isotopes by the beta–gamma coincidence method involves correcting the observations to obtain the true disintegration rate[1,2]. Some of these corrections, such as the natural backgrounds in the beta- and gamma-counters, can be determined without difficulty. The correction for the γ-ray sensitivity of the beta-counter, however, is usually made by screening the counter from the source by placing between them an absorber of such a thickness that it absorbs all the β-radiation. The objection to this method is that the absorber usually alters the γ-ray sensitivity of the beta-counter.

In an attempt to solve this problem for cobalt-60 we have incorporated a pulse-amplitude analyser following the β-ray detector of the beta–gamma coincidence-counting equipment. This equipment[3] consists essentially of two scintillation counters, one containing a thin anthracene crystal as the beta-counter and the other a thick crystal of activated sodium iodide as the gamma-counter.

Pulses lying within a voltage-range V to $(V + \Delta V)$ are passed by the analyser to the coincidence unit, and finally counted in the β-scalers. As V is varied, the β-counting rate will alter in a manner similar to the energy distribution of the original β-particles.

The beta-counter will also detect secondary electrons caused by the interaction of the cobalt-60 γ-rays with the crystal and surrounding material. It is the detection of these secondary electrons which gives rise to the 'γ-ray sensitivity of the beta-counter'. For cobalt-60 the energies of these electrons range from zero to 1·33 MeV., which is the energy of the higher of the two γ-rays. The β-particles range in energy from zero to 0·3 MeV. An absorber thick enough to absorb electrons up to 0·3 MeV. will cut off the β-radiation, but the residual counting rate with the absorber will not necessarily be the same as the γ-counting rate without the absorber.

We have measured the pulse-output distribution from the beta-counter, both with and without an absorbing screen in front of the anthracene crystal. Fig. 1 shows the result obtained. Without an absorber, a curve resembling the usual β-spectrum is obtained; with an absorber, the distribution appears flat. Measurements above the end-point energy of the β-spectrum shows that the γ-efficiency is increased by the interposition of an aluminium absorber 0·5 mm. thick between the source and the counter. This would also probably be the case when the analyser channel is set to record β-particles. That is, the standardization of cobalt-60 with this equipment, using a conventional absorber, will be erroneous because the γ-ray sensitivity of the counter is increased by the use of an absorber.

It is reasonable to assume that because the pulse distribution appears flat with an absorber, it will also be flat without an absorber (although not the same in magnitude). If this were so, then a variation of the analyser channel position would vary the β-efficiency of the beta-counter, but its γ-efficiency would remain constant (channel width ΔV and amplifier gain constant). This can be shown to be one of the conditions for the β-counting rate to be a linear function of the coincidence-counting rate.

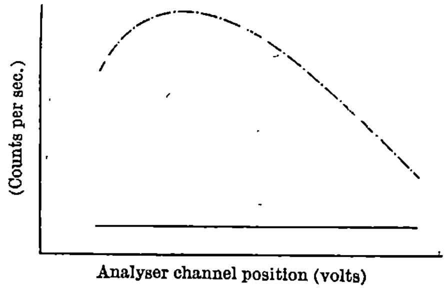

Fig. 1. Output of the anthracene β-detector with (full line) and without (pecked line) an absorbing screen

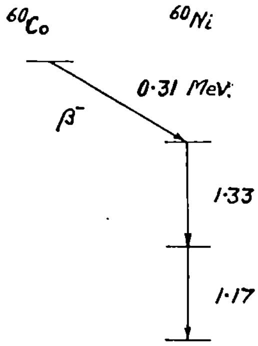

Fig. 2. Cobalt-60 decay scheme used for equation 5 (neglecting the weak β-branch)

For, considering the decay scheme shown in Fig. 2, if $(N_\beta + N_{\gamma\,\text{in}\,\beta})$ is the β-counting rate for any particular setting of the analyser channel, e_β the efficiency of the beta-counter for the β-rays, and $(e_1 + e_2)$ the efficiency of the beta-counter for the two γ-rays from cobalt-60, then

$$(N_\beta + N_{\gamma\,\text{in}\,\beta}) = N_0' e_\beta + N_0 (e_1 + e_2) \qquad (1)$$

where N_0 is the true disintegration rate.

Similarly,

$$N_\gamma = N_0 (E_1 + E_2) \qquad (2)$$

where N_γ is the counting rate from the gamma-counter, the efficiency of which is $(E_1 + E_2)$ for the two γ-rays from cobalt-60. In the experiment, $(E_1 + E_2)$ is kept as constant as possible, that is to say:

$$N_\gamma = N_0 (E_1 + E_2) = \text{const.} \qquad (3)$$

If $(N_{\beta\gamma} + N_{\gamma\gamma})$ is the counting rate from the coincidence circuit,

$$(N_{\beta\gamma} + N_{\gamma\gamma}) = N_0 e_\beta (E_1 + E_2) + N_0 (E_1 e_2 + E_2 e_1) \qquad (4)$$

A re-arrangement of equations (1), (2) and (3) gives

$$(N_{\beta\gamma} + N_{\gamma\gamma}) = (N_\beta + N_{\gamma\,\text{in}\,\beta})(E_1 + E_2) - N_0 (E_1 e_1 + E_2 e_2) \qquad (5)$$

Equation (5) expresses the relation between the β-counting rate $(N_\beta + N_{\gamma\,\text{in}\,\beta})$ and the coincidence counting rate $(N_{\beta\gamma} + N_{\gamma\gamma})$. It is assumed that the usual corrections for backgrounds, accidental coincidences and dead-time losses have already been made to the observations.

Equation (5), expressed in the form $y = mx + C$, will be linear when the terms corresponding to m and C are constant. It is arranged experimentally that $m = (E_1 + E_2)$ is constant; but in the case of $C = N_0 (E_1 e_1 + E_2 e_2)$, N_0 is a constant, allowing for radioactive decay during the measurement, therefore the required condition is that $(E_1 e_1 + E_2 e_2)$ must be constant. If $(E_1 e_1 + E_2 e_2) = \text{const.}$, all terms are finite and E_1 and E_2 are constant, then either $\Delta e_1 / \Delta e_2 = - E_2 / E_1$ or $(e_1 + e_2) = \text{const.}$ If, therefore, the γ-spectrum of the beta-counter is indeed flat, then one of the conditions for $(N_\beta + N_{\gamma\,\text{in}\,\beta})$ to be a linear function of $(N_{\beta\gamma} + N_{\gamma\gamma})$ is realized. Furthermore, the slope $(E_1 + E_2)$, in conjunction with the γ-counting rate, will give N_0 without any necessity for using an absorbing screen. Fig. 3 shows a hypothetical plot of this linear function. The straight-line plot extends from $e_\beta = 0$ to an upper limit determined by the apparatus.

Measurements on cobalt-60 so far have shown that this line has a slight curvature, the slope varying by about 3 per cent over the range of measurement. A

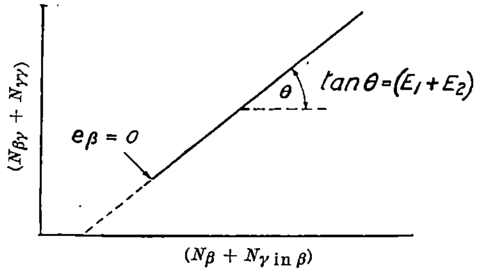
$(N_{\beta\gamma} + N_{\gamma\gamma})$
θ
$\tan\theta = (E_1 + E_2)$
$e_\beta = 0$
$(N_\beta + N_{\gamma\,\text{in}\,\beta})$

Fig. 3. Illustrating equation 5 when $(N_{\beta\gamma} + N_{\gamma\gamma})$ is a linear function of $(N_\beta + N_{\gamma\,\text{in}\,\beta})$

least-squares analysis of the points on the line gives a standard deviation of ± 0·5 per cent for the slope, but in view of the curvature, the disintegration rate cannot as yet be determined to better than ± 1·5 per cent. The curvature appears to be influenced by several experimental variables which are at present being investigated.

Equation (5) can be investigated by other methods for varying e_β. For example, it is possible to vary e_β by placing absorbers of various thicknesses in front of the beta-counter, and it can now be seen that a measurement with an absorber which cuts off all the β-radiation represents only one point on this line; a measurement without an absorber constitutes another point, and the usual method of evaluating N_0 from these two measurements is really a determination of the slope of this line. The apparent disintegration rate is less or greater than the true one according to whether the absorber increases or decreases the γ-efficiency of the beta-counter. This can be shown in a similar way to the argument involving equations (1) to (5), except that now the γ-efficiency of the beta-counter $(e_1 + e_2)$ is changed by the absorber to $(e_1' + e_2')$.

Another way of varying e_β is to alter the distance between the source and the beta-counter, when e_β will vary approximately as the solid angle between the source and the counter. But a plot of $(N_{\beta\gamma} + N_{\gamma\gamma})$ against $(N_\beta + N_{\gamma\,\text{in}\,\beta})$ will not then give a straight line, because the γ-efficiency of the beta-counter will also vary with the solid angle. This may account for the variation in disintegration rate which has been observed in this laboratory using the conventional absorber method with varying geometrical arrangements. Lastly, it may be noted that measurements on sources of different strengths should not affect the slope of the line, provided that the γ-efficiency of the gamma-counter remains constant.

It is hoped to pursue this work on the standardization of cobalt-60, to investigate the method more fully, and to apply the method to other suitable isotopes.

This work has been carried out as part of the research programme of the National Physical Laboratory, and is published by permission of the Director of the Laboratory.

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EVIDENCE FOR A PROTEIN COMPONENT IN THE MIDDLE LAMELLA OF PLANT TISSUE: A POSSIBLE SITE FOR INDOLYLACETIC ACID ACTION

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WHILE looking for a method for separating root tips into single cells, I attempted to use calcium-binders, following Northcraft[1]. Similar methods have been used for separating animal tissue[2-4]. Northcraft used ammonium oxalate. The actions of ammonium oxalate, citrate and ethylene diaminetetraacetic acid were compared on the assumption that calcium stabilizes the intercellular cement, as cited by Bonner[5]; calcium pectate is found in the middle lamella. The stabilizing action of calcium might also be due to its decreasing the zeta-potential of the colloidal pectins. Zwilling[4] obtained separation in animal tissue within 20–30 min., using ethylene diaminetetraacetic acid. Chelating compounds having high affinity for calcium should, therefore, readily and quickly also separate plant tissue.

The following method was used. The 1-mm. root tips of Alaska pea seedlings grown for 45–50 hr. were used. The root tips were immersed in 1 ml. of the test solution in small vials, and at the appropriate times they were put on slides in a drop of distilled water. By tapping gently on the cover glass separation of root tips occurs. Under the microscope the percentage of separation may be estimated.

Some typical results of the first sets of experiments are shown in Figs. 1, 2 and 3. The following emerges:

(1) The degree of separation is dependent upon concentration up to 0·1 *M* ethylene diaminetetraacetic acid. At 0·01 *M* no separation was obtained, even at high temperatures. Above 0·1 *M* the extent of separation again decreases. This decrease is being

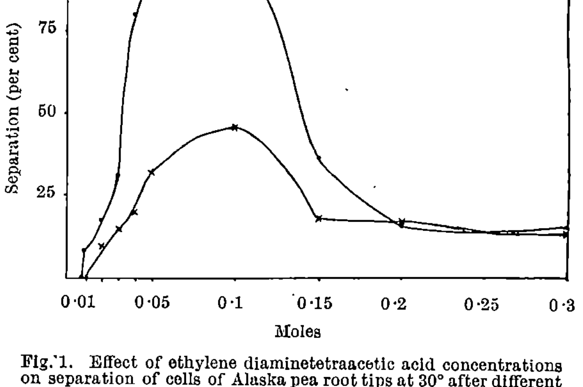

Fig. 1. Effect of ethylene diaminetetraacetic acid concentrations on separation of cells of Alaska pea root tips at 30° after different times. Solution *p*H 8·0. ×, 9-hr. treatment; ●, 16-hr. treatment

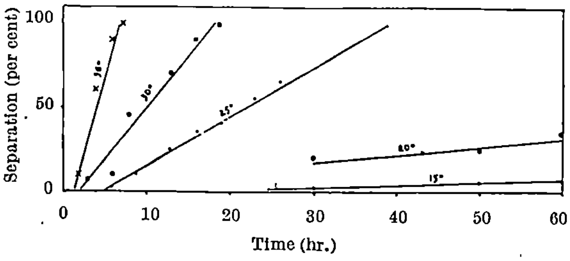

Fig. 2. Effect of temperature and time on the separation of cells of Alaska pea root tips. Ethylene diaminetetraacetic acid concentration 0·1 *M*. *p*H 8·0

investigated further. The active concentrations are very high as compared with those normally used in biological experiments and also as compared with those used for estimating calcium. (2) The rate of reaction is rather slow, compared with other known chelating reactions *in vitro* and *in vivo*. (3) The Q_{10} of the separation is very high, indicating a high 'energy of activation' which was calculated to be of the order of 35–40,000 cal. (4) Dependence on *p*H up to 11·0 is similar to, but not identical with, the calcium-chelating power of ethylene diaminetetraacetic acid as a function[6] of *p*H. This seems to indicate that an additional factor, apart from calcium chelating, is involved in the reaction.

These results cannot be interpreted as the mere removal of exchangeable calcium from the intercellular cement.

A working hypothesis was assumed as follows. The calcium ion is hidden by some structure and is therefore not accessible to ethylene diaminetetraacetic acid chelating action. This stabilized structure is part of the intercellular cement. Now, it seemed reasonable to assume that such a structure is part of a macromolecule existing in the middle lamella. It might be a pectic substance or other macromolecule that has not yet been identified in the middle lamella of plants, such as a protein or protein-containing complex. If such a macromolecule is involved, the use of the known agents breaking intramolecular links should modify the effect of ethylene diaminetetraacetic acid. Three substances were therefore selected. Urea, for breaking hydrogen bonds; thioglycolate, for breaking S—S bonds; and butanol, for breaking the hydrophobic linkages (Tables 1, 2 and 3).

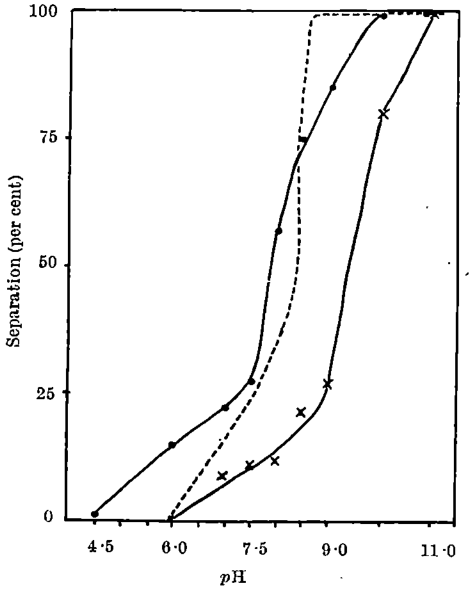

Fig. 3. Separation of cells of Alaska pea root tips at different *p*H values. Ethylene diaminetetraacetic acid concentration 0·1 *M*. Temperature 25° C. ×, 9-hr. treatment; ●, 26-hr. treatment; - - -, chelating action of ethylene diaminetetraacetic acid for calcium at various *p*H (after Martell and Calvin, ref. 6)

Table 1. SEPARATION OF CELLS IN ALASKA PEA ROOT TIPS AFTER TREATMENT WITH ETHYLENE DIAMINETETRAACETIC ACID AND UREA FOR 8 AND 26 HR. SOLUTION *p*H 8·0

Ethylene diaminetetraacetic acid concentration (mol.)		Per cent of cells separated		
		0	0·1	0·01
− Urea	After 8 hr.	—	10	—
+ Urea 0·125 *M*		0·0	80	—
− Urea	After 26 hr.	—	—	7
+ Urea 0·125 *M*		0·0	—	90

Table 2. SEPARATION OF CELLS IN ALASKA PEA ROOT TIPS AFTER TREATMENT WITH ETHYLENE DIAMINETETRAACETIC ACID AND THIOGLYCOLATE. SOLUTION *p*H 8·0

Concentration of ethylene diaminetetraacetic acid (mol.)	Per cent of cells separated after 10·5 hr.	
	No thioglycolate	Thioglycolate 1 per cent added
0·1	15	32
0·01	1	40
0·001	0	50
0·0001	0	4
0	0	0

Table 3. SEPARATION OF CELLS IN ALASKA PEA ROOT TIPS AFTER TREATMENT WITH ETHYLENE DIAMINETETRAACETIC ACID AND *n*-BUTANOL FOR 19 HR. SOLUTION *p*H 8·0. TEMPERATURE 25° C. The results are given as per cent of cells separated

Ethylene diaminetetraacetic acid 0·1 *M*	Ethylene diaminetetraacetic acid 0·1 *M* + 5 per cent butanol	Butanol 5 per cent
40	100	0

The results of these experiments are in accord with the view that there is a protein component in the intercellular cement, as all the denaturing agents favoured the destruction of the intercellular cement. Particularly the action of thioglycolic acid supports this, if its action is indeed only on S—S bonds, which are known to occur in proteins.

Further evidence for this view was obtained from the action of proteolytic enzymes. Pepsin gave good separation of the cells, cathepsin *C* gave slight separation. Other enzymes, such as papain, trypsin and chymotrypsin, digest the whole tissue; no separation could be determined.

If the action of ethylene diaminetetraacetic acid is a chelating one, then other chelating compounds should also be effective in the presence of modifying agents such as thioglycolic acid (Table 4).

Table 4. EFFECT OF THIOGLYCOLATE ON THE EFFECTIVENESS OF VARIOUS CHELATING AGENTS IN SEPARATION OF CELLS IN ALASKA PEA ROOT TIPS. PER CENT SEPARATION DETERMINED AFTER 3 DAYS. TEMPERATURE 25°
The results are given as per cent of cells separated

	Sodium diethylthiocarbamate *p*H 8·0	Phenanthroline *p*H 6·7	8-Hydroxyquinoline *p*H 6·0
No thioglycolate	0	15	0
Thioglycolate 1 per cent added	15	30	22·5

Table 5. EFFECT OF 1 PER CENT THIOGLYCOLATE ON SEPARATION OF CELLS IN ALASKA PEA ROOT TIPS BY INDOLYLACETIC ACID 10^{-3} *M*. SOLUTION *p*H 11·0

The results are given as per cent of cells separated

24 hr.		7 days	
Without thioglycolate	With thioglycolate	Without thioglycolate	With thioglycolate
4	13	22	50

It will be seen that different compounds having different structures and having only chelating action in common work on the system in much the same way.

From the work of Heath and Clark[7,8], Weinstein *et al.*[9] and Bennet-Clark[10], it has been suggested that ethylene diaminetetraacetic acid and other chelating compounds have a growth-stimulating activity, and that the action of indolylacetic acid itself could be similarly interpreted as being due to chelating action. Indolylacetic acid, therefore, should also effect the separation of cells in the presence of a suitable protein-denaturing agent (Table 5).

If, to accept the old idea of Heyn, which has recently been recalled by Bennet-Clark[10] and by Bonner *et al.*[11], the effect of indolylacetic acid is to plasticize the cell wall or, in other words, to decrease the wall pressure of the cell, the following might be suggested. The 'wall pressure' can be seen as having two components—the pressure of the rest of the tissue and the tensile properties of the cell wall, that is, the wall pressure proper. Now the indolylacetic acid might act on the intercellular cement, and by partially loosening it, decrease the effect resulting from the pressure of the neighbouring cells. Alternatively, we may look upon the cement as part of the wall and the change of structure caused by chelating of the metal, thus affecting the tensile strength of the wall.

It may therefore be concluded that a metal ion is in some way bound in the middle lamella, possibly by a protein or protein complex. This might explain the function of the proteins which occur in the middle lamella. In addition, under the extreme conditions used, indolylacetic acid could be shown to have a clear chelating action in the presence of suitable modifiers. These two facts together suggest that indolylacetic acid may indeed act as a chelating agent. These facts would also be in agreement with the views of Burström[12], that ethylene diaminetetraacetic acid may act by competitive chelating action.

This paper is part of a Ph.D. thesis to be submitted to the Hebrew University, Jerusalem. I am indebted to Prof. M. Evenari, Dr. A. M. Mayer and Dr. A. Poljakoff-Mayber for their guidance, interest and encouragement during the time that this research was carried out.

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RESPONSES OF A FERN APEX TO GIBBERELLIC ACID, KINETIN AND α-NAPHTHALENEACETIC ACID

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THE reactivity of the shoot apex of *Dryopteris austriaca* (*D. aristata*) to the direct external applications of physiologically active substances[1,2] has been further investigated during treatments with gibberellic acid, kinetin and α-naphthaleneacetic acid. These substances have recently been shown to produce remarkable physiological and morphological changes when applied externally to leaves, etc., and in tissue culture[3-14].

Large, bare apices of *Dryopteris austriaca* were treated, as already described[1,2], for periods of about three weeks with aqueous solutions of gibberellic acid (100 mgm./l., 10 mgm./l.), kinetin (100 mgm./l., 10 mgm./l., 1 mgm./l., 0·1 mgm./l.), and α-naphthaleneacetic acid (1,000 mgm./l., 100 mgm./l., 10 mgm./l., 1 mgm./l.) and closely examined at frequent intervals. Control apices were similarly treated but with water throughout. The experiments with gibberellic acid and kinetin were undertaken in May and July, and those with α-naphthaleneacetic acid in January, February, May and July. (During the winter months the apical meristem of *Dryopteris* is inactive; in May it is becoming active, and in July it is more or less at the height of its activity.)

Gibberellic acid. In May, 10 mgm./l. gibberellic acid stimulated the growth and morphogenetic activity of the apex, an average of eight primordia being formed as compared with three in the control during the same period; but with 100 mgm./l. only three new primordia were formed. In July, 10 mgm./l. applications had a smaller stimulatory effect (an average of six primordia as compared with four in the control), whereas an average of eight primordia was obtained with 100 mgm./l. The number of primordia formed both during and after the gibberellic acid treatment was always greater than that in the controls. The older primordia in treated apices showed an increase in size but no marked elongation of the rhizomatous stem was observed. The normal course of tissue differentiation was not modified.

Kinetin. At 100 mgm./l. kinetin completely inhibited the growth of apices and eventually killed them. With 10 mgm./l. and 1 mgm./l. of kinetin, no new primordia were formed during a period of four

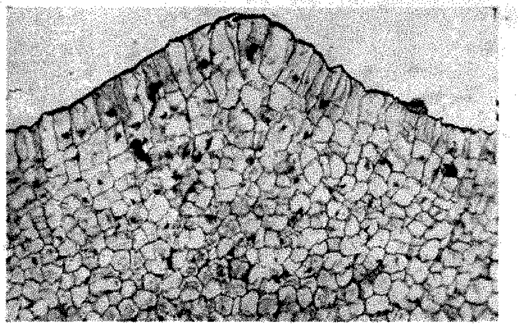

Fig. 1

weeks after the cessation of the treatment in either the May or July collections of apices. The apices underwent a considerable general increase in size, with formation of new scales around the base of the meristem and a conspicuous growth of the bases of the older scales which had been removed. At both concentrations, primordia 1 and 2 disappeared during the period of treatment and no organ re-formed in these sites when the treatment was discontinued. Later in the experiment, when the treatment had been discontinued, the growth of primordia 3 and 4 did not continue, and they were gradually transformed into flattish mounds. Primordia 5, 6, 7 and 8 likewise did not increase in size and were overtaken by the rapid growth of the surrounding tissues and old scale bases. Treatment with 0·1 mgm./l. kinetin slightly stimulated the formation of leaves, an average of six primordia being obtained as compared with four in the control. In microtome sections of treated apices it was seen that the normal histological organization had been profoundly affected and that tissue differentiation, for example, of the prevascular tissue had not occurred (Fig. 1). The general effect could be described as one in which cell division had been followed by a more or less uniform formation of parenchyma throughout the apical cone.

α-Naphthaleneacetic acid. Applications of 1,000 mgm./l. killed both winter and summer apices. In the winter experiments, treatments with 100 mgm./l. and 10 mgm./l. induced a very marked enlargement and saucer-shaped upgrowth of the subapical region (Fig. 2), indicating that in the so-called 'dormant' winter apex some growth potential still persists in this region. When treatment was discontinued, this subapical growth gradually became obscured by growth at the base of the apical cone. The latter, which includes the apical meristem, did not increase in size, but gradually became scaly right to the summit in some cases. In a February experiment, with controlled temperature (22–24° C.) and lighting (150-ft.-candles for 16 hr. per day), one or two new primordia were formed in some of the apices after the cessation of the treatments. A similar formation of primordia was observed in the controls.

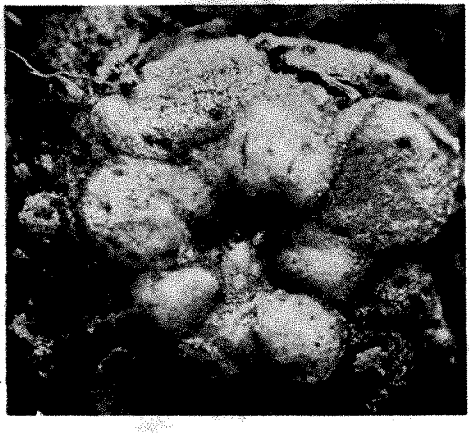

Fig. 2

In the summer experiments with 100 mgm./l., no new primordia were formed during the period of treatment, and the subapical region did not form the characteristic upgrowth already described. The apical meristem appears to have retained its characteristic property of self-maintenance in the embryonic state and, when the treatment was discontinued, formed an average of three new primordia in three weeks. 10 mgm./l. did not seem to affect the growth of the meristem either during or after the treatment. Applications of 500 mgm./l. inhibited the growth of the meristem in some specimens while in others it stimulated growth in the subapical region, but did not induce the saucer-shaped upgrowth. Treatment with 1 mgm./l. was slightly stimulatory to the formation of leaves by the apex.

The results obtained with gibberellic acid are in general accord with previous findings with other plants, except that there was no notable elongation either of young primordia or of the stem. Apices collected in May and July responded differently to the two concentrations; such seasonal differences in apical reactivity have frequently been noted in this laboratory. In the experiments under consideration they are especially interesting in respect of the responses of winter and summer apices to different concentrations of α-naphthaleneacetic acid. The reactivity of different regions of the apex to α-naphthaleneacetic acid was also a notable feature and one which needs fuller investigation.

Kinetin is known to have both inhibitory effects[9,15] and stimulatory effects on cell division[5,6] and enlargement[7]. In *Dryopteris*, kinetin stimulates cell division and parenchymatous enlargement throughout the whole apical region. As a result, the apical organization is so modified that it no longer gives rise to the characteristic pattern of tissue differentiation that normally attends the inception and formation of organs.

These observations will be considered in greater detail elsewhere.

We are indebted to Mr. E. Ashby and Mr. G. Barker for the photographs.

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College of Sc

LETTERS TO THE EDITORS

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Irreversible Processes in Physical Theory

PROF. K. R. POPPER[1], in several communications on the nature of irreversible processes, has formulated the idea that the irreversibility of a simple physical process arises from the causal impossibility of arranging for coherence between the independent oscillators required for the operation which is the inverse of that process.

Prof. E. L. Hill and A. Grünbaum[2] believe that the point raised is sufficiently important to deserve formulation as a general principle in physics. They suggest that the distinction between physically reversible and irreversible processes is parallel to that between closed and open systems. A closed system is quasi-periodic and causally reversible. An open system is aperiodic and irreversible. In particular this distinction requires that the process of radiant heat transfer in an infinite universe be just as irreversible on the quantum theory as on classical mechanics. The difficulty of this point has already been stressed by Einstein.

Popper casts doubt on the generality of the principle of Hill and Grünbaum. He claims, for example, that the system of the Sun and a comet moving on a hyperbolic orbit, while undoubtedly an open system, is definitely one we should like to regard as reversible. He then cites two further examples to elaborate his point with regard to the relation between reversibility and coherence. A spheroidal reflector with an oscillator at each conjugate focus constitutes a reversible system. A similar system but with a scattering instead of a reflecting surface, even if perfectly externally insulated, does not. This, says Popper, arises from the impossibility of arranging for coherence between the oscillators on the scattering surface by means of any centrally directed mechanism, thereby claiming that his principle of coherence is of more general validity than that of Hill and Grünbaum.

There is, however, an alternative way of describing the distinction between causally reversible and causally irreversible processes and one which I claim is of higher generality than that advanced by Popper.

In the description of a mechanical system by classical mechanics the parameters used, namely, the co-ordinates and momentum, give a complete description of the path of every particle of the system, and the reversibility of these paths is ensured by the ordinary laws of motion which are invariant with respect to change from $+t$ to $-t$. When, however, we come to describe a system by means of parameters which have only a statistical significance, a complete description of the path of every particle concerned is no longer obtained. The inverse process is then not necessarily a microscopic copy on a reversed time-scale of the direct process. The inverse process no longer completely undoes the action of the direct and the change is essentially irreversible. Thus, as I have pointed out elsewhere[3], a pure radiative process, with the optical paths of all rays concerned completely determined, is reversible. A conductive process is described by such statistical terms as mean free paths or mean collision frequencies and is accordingly irreversible.

The distinction between statistical and precise descriptions of the process gives a natural interpretation of the examples raised by the other authors. Thus, Popper's second example is irreversible because the properties of the oscillators on the absorbing screen can only be described by statistical qualities. His first example is reversible because it is possible to define the precise path of every quantum from one oscillator to the other. The addition of any scattering material, for example, smoke, within the reflecting body would diffuse the optical paths which would then only have statistical significance and the whole process of energy exchange would become irreversible. Again, the distinction between the description of divergent radiation on the wave and quantum theories disappears in this new view. Both processes are thermodynamically equivalent; one because the intensity of the radiation is progressively decreased and the other because the probability of finding a quantum in unit volume of space decreases at the same rate.

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PROF. R. C. L. BOSWORTH's view, if I understand him properly, is that held by most physicists since the time of Boltzmann. It has become famous through Eddington's metaphor of the arrow of time. It consists of the following two theses: (1) Every non-statistical or 'classical' mechanical process is reversible; this, to quote Prof. Bosworth, "is ensured by the ordinary laws of motion which are invariant with respect to change from $+t$ to $-t$"; (2) irreversibility enters into physics "by means of parameters which have only a statistical significance"; or in Eddington's way of putting it, the increase of entropy (or of statistical disorder) determines the "arrow of time".

It was precisely this position, so ably restated in Prof. Bosworth's communication, which I briefly sketched at the beginning of my communication "The Arrow of Time"[1], which started this correspondence, and which I tried to criticize in that letter by giving a counter example to thesis (1). I did not discuss my reasons for disbelieving thesis (2).

Prof. Bosworth questions my counter example in its optical form in which it appears in my reply to the communication by Profs. Hill and Grünbaum[2], by asserting that "the properties of the oscillators on the absorbing screen can only be described by statistical qualities". But there is surely some confusion here. We may assume—and this becomes clear if we revert to my original example of a water wave—that all the elementary processes are purely mechanical and *prima facie* deterministic (admittedly an over-simplification): only then does it become quite clear that the process in which we are interested is theoretically fully reversible, since we may in fact construct a large number of oscillators, operating coherently, which actually reverse it. But if we look more closely at the way in which these oscillators are controlled so as to make them cohere, we find that they must, essentially, be controlled from one centre from which some signal—for example, a light signal—must run to the places where the oscillators are situated.

Thus although the elementary classical physical processes involved in an expanding wave are reversible, we find that in order to obtain the reversion, that is, the contracting wave, we always need a wave that spreads from a centre, or something equivalent to it. If not steered by an expanding wave, the contracting wave, though not in itself physically impossible, would nevertheless have the character of a physical miracle: it would be like a conspiracy, undertaken by many people, each carefully acting so as to support all the others, but without any previous arrangement, or anything like a prepared plan.

This explains why, although theoretically possible, spontaneous contracting waves do not in fact occur: they are theoretically possible, but causally, and therefore physically, impossible.

Prof. Bosworth's analyses of my examples are inadequate: in the reversible case of the ellipsoid mirror (called by Prof. Bosworth my first example) contracting waves never occur unless they are excited by an expanding wave; and the example was designed to show, among other things, that even perfect reversibility is not yet causal reversibility.

Of course all these experiments are idealizations, and, in reality, there would be in all these cases an increase of entropy. So much is common ground. Also, in explaining any concrete mass phenomena, we have of course to use statistical methods.

Although my whole analysis was only intended to throw light on (1) by showing that even elementary classical processes may be in an important sense physically irreversible, I may perhaps say, very briefly, why I distrust (2). The suggestion has been made (first by Boltzmann himself) that the arrow of time is, either by its very nature, or by definition, connected with the increase in entropy; so that entropy cannot decrease in time because a decrease would mean a reversal of its arrow, and therefore an increase relative to the reversed arrow. Much as I admire the boldness of this idea, I think that it is absurd, especially in view of the undeniable fact that thermodynamic fluctuations do exist. One would have to assert that, within the spatial region of the fluctuation, all clocks run backwards if seen from outside that region. But this assertion would destroy that very system of dynamics on which the statistical theory is founded. (Moreover, most clocks are non-entropic systems, in the sense that their heat production, far from being essential to their function, is inimical to it.)

I do not believe that Boltzmann would have made his suggestion after 1905, when fluctuations, previously considered no more than mathematically calculable near-impossibilities, suddenly became the strongest evidence in favour of the physical reality of molecules[3]. (I am alluding to Einstein's theory of Brownian motion[4].) As it is, a statistical theory of the arrow of time seems to me unacceptable. The purpose of my first communication was to propose an example of a non-statistical process such that no physicist who finds a film strip of this particular process would need to doubt where the film begins and where it ends: he could determine its arrow of time.

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Life-time of an Artificial Earth Satellite

Fejer[1] and Scott[2] have given simple methods for estimating the remaining life-time of an artificial Earth satellite. Their methods do not apply when the eccentricity is small, and it is not immediately clear why the estimates are so good (cf. particularly Scott's data for the descent of the rocket of 1957 Alpha Satellite). Nevertheless, it has been found possible to show that their formulæ are accurate so long as the eccentricity is not too large.

A strict application of first-order perturbation theory to the motion of a satellite subjected to a purely axial force with constant drag coefficient shows that the rate of descent of apogee per revolution is given by

$$\frac{\mathrm{d}H_a}{\mathrm{d}n} = - \delta . H^{a2} \int_{-\pi}^{\pi} (1 + \cos\theta) \frac{\sqrt{1 + 2e\cos\theta + e^2}}{(1 + e\cos\theta)^2} \rho(\theta)\, \mathrm{d}\theta \quad (1)$$

where H_a is the height of apogee above the centre of the Earth, $\delta = SC_D/m$ in the usual notation, θ is the anomaly, e the eccentricity, n the number of revolutions, and ρ the density. The rate of descent of perigee $\mathrm{d}H_p/\mathrm{d}n$ is given by a very similar formula. If e is small enough and if a simple exponential atmosphere is an adequate model, the integral (1) may be evaluated exactly (as was noted by Scott) to give

$$\frac{\mathrm{d}H_a}{\mathrm{d}n} = - 2\pi\delta H_a{}^2\rho_o \exp\{\beta(H_o - H) - \beta h_o\} [I_0(\beta h) + I_1(\beta h)] \quad (2)$$

where $H = \frac{1}{2}(H_a + H_p)$, $h = \frac{1}{2}(H_a - H_p)$, ρ_o is the density at height H_{po}, β the lapse-rate of the atmosphere, and a suffix o denotes an initial value. I_0 and I_1 are Bessel functions of the first kind and imaginary argument. The formulæ given by Fejer and Scott are the asymptotic forms of this equation for large βh. Thus the Scott–Fejer analysis seems to require that e should be both large and small.

Equation 2 and the very similar formula for $\mathrm{d}H_p/\mathrm{d}n$ may be regarded as equations of motion for H_a and H_p (or H and h) as functions of n. Since βH_{po} is large, they may be integrated when e is small, to give

$$\exp\{\beta(H_o - H)\} = \frac{h_o I_1(\beta h_o)}{h I_1(\beta h)} \quad (3)$$

and

$$h_o{}^2 - h^2 = 4\pi\delta H_o{}^2\rho_o \,.\, h_o \exp(-\beta h_o) \,.\, I_1(\beta h_o) \,.\, n \quad (4)$$

From equation 4 it follows that:

$$e_o{}^2 - e^2 = 4\pi\delta\rho_o \,.\, h_o \exp(-\beta h_o) \,.\, I_1(\beta h_o) \,.\, n \quad (5)$$

The linear variation of e^2 with n also follows from the analysis of Fejer and Scott. The fundamental reason for the success of their work is that the relation is in fact valid down to $e = 0$. From it, we may deduce that the remaining life-time of the satellite is

$$t_o = \tfrac{3}{4} e_o \frac{T_o}{(-\mathrm{d}T/\mathrm{d}t)_o} \quad (6)$$

T_o being the initial period, and $(-\mathrm{d}T/\mathrm{d}t)_o$ the initial rate of decrease of the period; if this decrease is measured in seconds per day, t_0 is immediately expressed in days, which is convenient. Scott's equation 1 agrees with my equation 6 to order e_0, while Fejer's equation 7 is a direct consequence of my equation 4.

The relative error in equation 6 is believed to be of order e_0. A correction of this form would be of some significance for Satellite 1957 Beta, with its long life and high initial eccentricity, and an attempt is therefore being made to evaluate it.

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Jan. 16.

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Remanent Magnetization of Ancient Bricks

It has recently been suggested that, in the values of remanent magnetization of clay bricks fired in ancient times, there exists evidence of a secular decrease in the strength of the Earth's magnetic field[1,2]. It has been further suggested that the effect of such a change in magnetic field on the intensity of cosmic radiation incident upon the Earth would tend to falsify radiocarbon dating procedures based on an assumed constant intensity of cosmic radiation[3].

The conclusions based on the magnetization of ancient bricks have presupposed that this magnetization is proportional to the intensity of the Earth's magnetic field at the time the bricks received their original firing, provided that no high-temperature firings have intervened. In the procedure of E. Thellier[1,2,4], the magnetization, M, of the brick, as found, is measured at a standard temperature (60° C.). The brick is then fired at successively higher temperatures to 670° C., apparently in an inert atmosphere[2], and then allowed to cool from 670° to 60° in the present Earth's field, H'. The resulting magnetization of the brick, M', is then measured. The value of the Earth's field, H, at the time of the original firing, is assumed to be related to the above values by the equation:

$$H = H' M/M'$$

However, it has been shown in an earlier paper of E. Thellier[5] that the specific magnetization, σ, acquired by a given baked clay, when fired at 670° in a constant magnetic field of 13 gauss, can increase by a factor of 200 when the firing atmosphere is changed from nitrogen to illuminating gas. (Cf. Table 1, taken from ref. 5. T is the maximum firing temperature.)

It is proposed, therefore, that the apparently high value of remanent magnetization of ancient bricks can have been the result of the use of fuel-heated kilns during their original firing. The presence of incompletely burned products of combustion in such kilns could provide a reducing atmosphere comparable in effect to illuminating gas. This would tend to cause a higher value of magnetization to exist in the brick after cooling than would result from firing in an inert atmosphere.

Table 1. Specific Magnetization of Fired Clay ($\sigma \times 10^4$)

Temperature (° C.)	400°	580°	670°	870°
Oxygen	2·0	3·6	4·8	6·5
Nitrogen	2·6	4·5	10·0	570·0
Illuminating gas	520·0	4,750·0	2,000·0	36·0

If the possibility of the occurrence of such an effect has not been taken into account in the measurements of 'fossil' magnetization of ancient clays, the results may well lead to the deduction of an excessively high value of the magnetic field of the Earth at the time of the original firing.

We are indebted to Dr. L. S. Cressman and Mr. Thomas Newman of the University of Oregon for directing our attention to the measurements for dating by clay brick magnetization.

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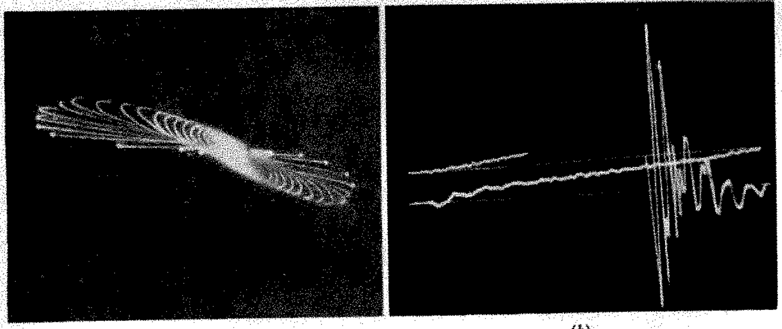
Abnormal Polarization of the Atmospheric Pulses reflected successively from the Ionosphere

While engaged in the determination of the direction of arrival of atmospherics by the conventional cathode-ray tube direction-finder, it was observed that, on occasions, for atmospherics of comparatively distant origin, there were elliptic patterns of gradually decreasing eccentricity and tilt-angle along with one or more linear responses, although when tested with the audio-frequency oscillations from a signal generator fed into the aerial system of the cathode-ray tube direction-finder, the fluorescent screen exhibited only the usual linear responses. It appears certain that these elliptic patterns are evidences of abnormal polarization of the atmospheric pulses reflected successively from the ionosphere, the linear responses being due to the direct (or ground-wave) atmospheric pulses. More than forty oscillograms showing the elliptic patterns and lines were recorded during the monsoon months of 1955. Usually the tilt-angle of the ellipses was found to decrease with the increasing order of ionospheric reflexion. A reversal in the direction of precession was noticed in few cases.

A typical record of the precessing ellipses with five or six straight lines bunched within a small angle along with the record of the wave-form of the atmospheric pulses simultaneously taken with the automatic atmospheric recorder[1] is shown in Fig. 1. The wave-form record reveals quasi-periodic pulses followed by a series of successive ionospheric reflexions. The distance of the lightning discharge yielding these records, as calculated from the observed time-interval between the successive reflexions, is about 500 km. The tilt-angle of the elliptic patterns was found to decrease from about 176° to about 167° and the phase-difference between the normal and abnormal components, as calculated from the observed ellipses, was found to increase steadily from about 40° to about 67° after six successive reflexions from the ionosphere.

It is suggested that the several straight lines, bunched within a small angle, were due to the



(*a*) (*b*)

Fig. 1. Oscillograms of (*a*) the elliptical patterns with gradually varying eccentricity and tilt-angle and (*b*) the corresponding wave-form recorded simultaneously with the automatic atmospherics recorder. Date, October 10, 1955. Time, evening

radiation which originated at the branching points of a long horizontal or slightly inclined lightning discharge from one cloud to another and reached the direction-finder directly. The quasi-periodic pulses observed in the wave-form pattern were due to the current variations at the branching points, and they were followed by the different orders of ionospheric reflexion. The horizontal length of the lightning channel responsible for the oscillograms, shown in Fig. 1, has been calculated and found to be about 7 km. This seems to be consistent with the observations of Shipley[2], who reported long horizontal channels along the lower edge of the cloud.

The possibility that abnormal polarization might be shown by the atmospheric pulses due to the zig-zag path of the lightning discharge was first pointed out by Adcock and Clarke[3]. The observed regular pattern of the precessing ellipses with continuously changing eccentricity and tilt-angle, however, strongly suggests that the effect of the random zig-zag path of the lightning discharge cannot be appreciable.

The experimental work was carried by Dr. B. A. P. Tantry and Mr. R. S. Srivastava under my guidance, as a part of the programme of a research project sponsored by the Council of Scientific and Industrial Research, New Delhi, to whom our thanks are due. A detailed paper will be published elsewhere.

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Temperature Coefficient of Ultrasonic Absorption in Organic Liquids

FROM the data heretofore available in regard to the observed ultrasonic absorption and its ratio to the coefficient calculated on the basis of Stokes's and Kirchhoff's theories, the various organic liquids have been broadly classified[1,2] into four groups. Confining our attention to temperature variation alone, we find that, according to this classification, members of group *A*, consisting of non-associated polyatomic liquids, are expected to show a positive temperature coefficient of absorption, whereas the liquids in the other groups are expected to show a negative temperature coefficient. It may be remarked, however, that the grouping and also the temperature coefficient assigned to each group are on an empirical basis.

In the course of an exhaustive investigation carried out in this laboratory on the temperature variation of absorption coefficient in a large number of liquids, including several homologous series, it has been noticed that some liquids which fall in group *A* show a negative temperature coefficient of absorption instead of positive as expected. Aniline, hexadecane, 1-dodecene and amyl acetate are some of the liquids showing this behaviour. Further, in some of the homologous series such as the saturated hydrocarbons and 1-olefines it is seen that the temperature coefficient is positive for the lower members but becomes negative for the higher members, passing through a stage where the absorption coefficient is practically independent of temperature over the range of observation (15–60° C.), as, for example, for *n*-decane in the case of the saturated hydrocarbons and for 1-nonene in the case of 1-olefines. Some of the measurements are given in Table 1.

Liquid / Temp. (° C.)	$\alpha/\nu^2 \times 10^{17}$ (at 21 Mc./s.)					
	20°	25°	30°	35°	40°	45°
Aniline	66·7	60·0	54·5	51·5	49·0	48·2
Amyl acetate	86·0	84·3	82·9	81·5	79·8	79·2
n-Hexane	56·9	60·6	63·6	66·3	68·9	71·4
n-Decane	56·7	56·7	56·7	56·7	56·7	56·7
n-Hexadecane	97·8	95·4	91·9	88·9	86·2	83·8
1-Octene	57·6	57·4	57·4	57·5	57·9	58·6
1-Decene	51·4	49·5	47·8	46·3	44·5	44·2
1-Dodecene	72·6	68·0	65·5	62·3	59·5	57·1

The object of this communication is to report on the anomalies between our observations and the classification and to direct attention to the inadequacy of the present theories to explain them. The observation regarding negative temperature coefficient of absorption in some of the above-mentioned liquids, and also the reversal of temperature coefficient from the lower to the higher members of the homologous series, is not consistent with the present classification of liquids according to their sound absorption, nor is it accounted for by the Stokes's and Kirchhoff's theory of classical absorption.

By comparing the above observed values of sound absorption with those calculated according to the classical theory it is seen that in every case the measured value is larger. As is well known no theory is able uniquely to explain the excess absorption in all the liquids. The various theories[3,4] advanced so far are based on thermal relaxation, structural relaxation and bulk viscosity. A formula[5] lately given correlates the observed absorption to the classical absorption in terms of a function of γ, the ratio of specific heats, as

$$\frac{\alpha_{\text{obs.}}}{\nu^2} = \left(\frac{2/3}{5/3 - \gamma}\right)^4 \left\{ \frac{8\pi^2}{3v^3\rho} \left(\eta + \frac{3}{4} \frac{\gamma - 1}{c_p} K \right) \right\}$$

It may be remarked here that the existing classification of liquids into various groups is of an *ad hoc* nature and has to be examined closely.

The observation that some of the measured liquids do not fit into the present classification and that in a homologous series the temperature coefficient of absorption which is positive for the lower members changes to negative for higher members is being examined in terms of the available theories.

Detailed discussion of the topic will be published elsewhere.

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Influence of Moisture upon the Dielectric Properties of Solid Powders dispersed in Liquid Paraffin

IT is known that various colloidally or coarsely dispersed systems show anomalous dielectric behaviour. Fricke[1] reported that an aqueous dispersion of solid particles or macromolecules showed a striking dielectric dispersion in the audio- and radio-frequency ranges, and he ascribed these effects to the polarization of oriented water molecules bound loosely at or near the surface of the dispersed phase. But the exact nature of the effect has not been established.

We have measured the dielectric constant and loss, ε' and ε'', of various suspensions or pastes consisting of inorganic or organic powders dispersed in liquid paraffin, over a frequency-range of 0·5–3,000 kc./s. by means of a conductance-capacitance bridge. As is shown in Fig. 1, pronounced dispersion was found with suspensions of titanium oxide in both its crystalline forms, anatase and rutile. The titanium oxide powders had been air-dried and contained about 0·7 per cent moisture by weight; the content of the powder was about 13 per cent by volume, and the dispersed systems remained sufficiently stable during measurements.

The effect was more pronounced with anatase than with rutile. For a suspension of rutile, the dependence upon frequency of ε' and ε'' is expressed precisely by the following relations, which have been given for insulating materials by Schweidler[2]:

$$\varepsilon' - \varepsilon \;\; = A \cot(\pi m/2)\omega^{-m} \qquad (1)$$

$$\varepsilon'' = A\omega^{-m} \qquad (2)$$

$$\varepsilon''/(\varepsilon' - \varepsilon_{\infty}) = \tan(\pi m/2) \qquad (3)$$

where ε_{∞} is the limiting value of ε' at high frequencies, A and m the empirical constants characteristic of the dispersed systems, and ω the angular frequency. Fig. 2 shows the linear relation between ε' and ε'' which can be expected from relation 3. In the case of anatase, the experimental results showed some deviation from these relations. Similar dielectric behaviour was observed also for a suspension of calcium carbonate powder.

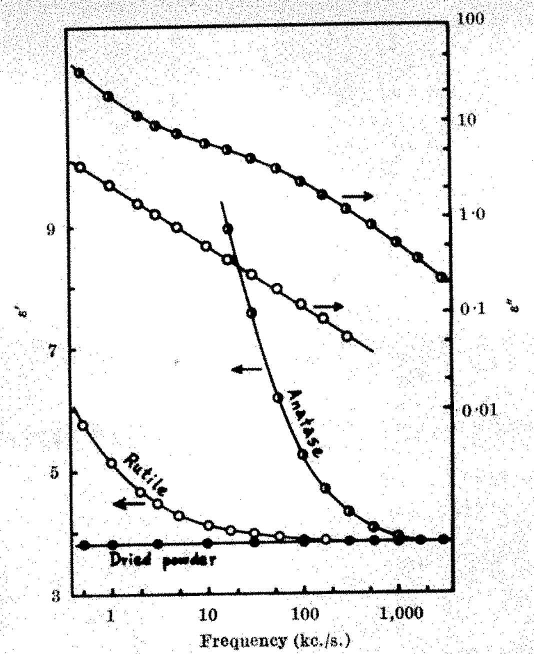

Fig. 1. Dependence upon frequency of ε' and ε'' for dispersed systems of titanium oxide (○ rutile, ◑ anatase and ● dried specimens) in liquid paraffin at 20° C. Particle size, moisture content and volume concentration of powders are about 0·4 micron, 0·7 per cent and 13 per cent respectively for both types of titanium oxide

However, this dependence upon frequency disappeared completely when the powder was dried at 150° C. for 3 hr., and the dielectric constant ε' remained constant over the range of frequency used, giving the value of ε_{∞} defined above, whereas ε'' was too small to be observed. Thus it is evident that the dielectric dispersion of the suspension mentioned above arises from the moisture adsorbed by the powder. This interfacial effect may be essentially the same as that pointed out for aqueous dispersions by Fricke.

In the cases of more hygroscopic powders, for example, starch and bentonite, the dependence upon frequency of ε' and ε'' was more complicated. It seems that, in these cases, anomalous dispersions of the type mentioned above and of the Debye type due to the polar groups overlap. The values of ε' for the powders of copper, aluminium and sulphur have been shown to be independent of the frequency even for air-dried specimens which contained

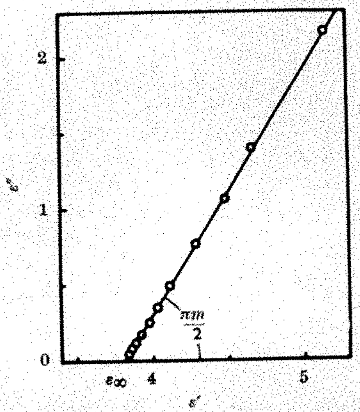

Fig. 2. Plots of ε'' versus ε' for the rutile suspension ; $m = 0·644$

appreciable moisture of more than 0·1 per cent by weight.

A more complete account of this work will be published elsewhere. We thank Prof. E. Suito and Prof. S. Ono for gifts of samples.

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Electron Micrographs of a Crystalline Lattice Structure in Yolk Platelets of the Amphibian Embryo

YOLK platelets are one of the cytoplasmic inclusions characteristic of embryonic cells, and constitute the most important reserve material for these cells. A weak birefringence has been reported from fresh or fixed yolk platelets of various amphibian embryos[1]. However, no further information is available concerning the physical organization of these inclusions. In the course of our electron microscopic studies of embryonic cells, regular fringe systems have been found over the whole area of yolk platelets, indicating a crystalline structure of the yolk matrix.

Small pieces of the ectoderm were isolated from embryos of the newt, *Triturus pyrrhogaster*, at various stages[2] from the gastrula (stage 11) to the tail bud (stage 26). 1 per cent osmium tetroxide in Holtfreter solution buffered with veronal acetate at *p*H 7·8 was used as the fixative. After fixation at 4° C. for 2 hr. and subsequent washing in Holtfreter solution for a few minutes, the fixed material was dehydrated in a series of graded ethanols, and embedded in a mixture of methacrylates. Sections were made on an ultramicrotome at a thickness less than 50 mμ, picked up on a collodion-coated grid and examined with the Hitachi electron microscope *HU*–10 at 75 kV.

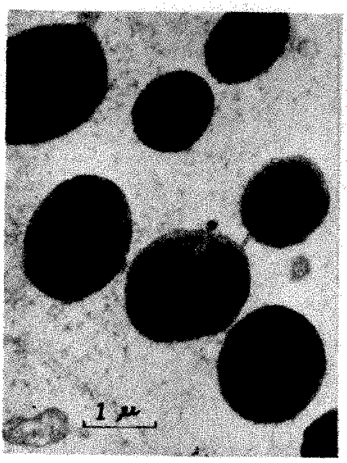

Fig. 1. Electron micrograph showing a group of yolk platelets scattered in the cytoplasm of an ectoderm cell of a late gastrula. One mitochondrion and the cell boundary are visible (below, left). × 10,000

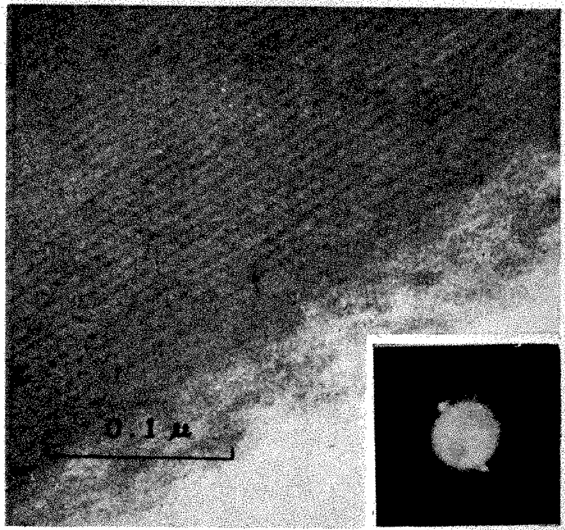

Fig. 2. High-power electron micrograph and selected area diffraction diagram (inset) of a yolk platelet. The granular layer attached to the surface of the yolk platelet is visible below in the main picture. Note the fringe system in the yolk platelet proper. × 250,000

In the embryonic ectoderm cells, the cytoplasm is moderately laden with yolk platelets. Under the electron microscope, the platelets appear as sharply outlined dark ovals varying from 0·3 to 6μ in diameter. The platelets are surrounded by a dense layer of fine granules of about 100 A. (Fig. 1). This layer disappears during the tail-bud stage, when significant changes take place on the surface of the yolk platelets[3].

Fig. 2 shows a high-magnification electron micrograph of the yolk platelets at the neurula stage, in which a system of fringes with spacing of 70 A. is evident. Careful observation reveals another system of weak fringes which is oblique to the main system. Similar fringe systems were observed in yolk platelets from the gastrula to the tail-bud stage. It should be noted that these fringes are always straight, and no dislocation has so far been observed in them. The regular arrangement of fringe systems proves that the matrix of yolk platelets is crystalline.

In the electron diffraction pattern of the yolk platelet, two pairs of spots can be observed (inset, Fig. 2). One pair is fairly strong and the other very weak. The presence of two pairs of spots would be expected from the existence of two systems of fringes intersecting each other in the electron micrograph. The distance between these spots corresponds to a fringe-spacing of 72 A. in both pairs. This spacing is in good agreement with that measured directly in the electron micrograph.

During the period of yolk resorption, the yolk platelets were found to split into parallel disks and rodlets[4]. A similar phenomenon of lamellar cleavage was observed also *in vitro* when the yolk platelets were exposed to weak acid or alkaline solutions[5]. These observations support the view that the crystalline structure seen in the fixed sections is not caused by the fixative but exists in the living cells.

We thank Profs. T. Yamada, R. Uyeda and Y. Sakaki for valuable suggestions, and the staff of the Hitachi Central Research Laboratory for generous assistance. The investigation was partly supported by grants from the Rockefeller Foundation to Prof. T. Yamada and the research funds of the Ministry of Education of Japan.

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An Instrument for measuring Evaporation from Natural Surfaces

THE need has long existed for a direct method of measuring evaporation from natural surfaces for application in a wide range of problems connected with agricultural science, hydrological engineering and the like. The only method hitherto generally available has been that of isolating and weighing a portion of the evaporating body—a procedure which is cumbersome and often seriously interferes with the process it purports to measure. Reliance has therefore often been placed on formulæ, usually of doubtful validity, relating evaporation with other meteorological variables.

We have constructed prototype equipment which permits the automatic, direct determination of natural evaporation by equating it to the vertical turbulent flux of water vapour in the layers of air near the ground. The validity of this equation demands that there be no vertical transport of water vapour by mean vertical motion nor accumulation of water vapour between the ground, and the level of the instrument, and that a measurement of turbulent flux made at a point be representative of an area. Practically, this means that the area must be one of good horizontal uniformity and that the measurement must be made within a few metres of the ground. Providing that these conditions are fulfilled, there is no restriction on the nature of the surface. Measurements can then be made over, say, a growing crop or a free water surface with equal facility, and the method is directly applicable to problems such as those indicated above.

The turbulent flux of water vapour is given by the covariance between (1) the product of air density (ρ) and the vertical velocity component (w) and (2) the specific humidity (q). The principle involved was first used by Swinbank[1], who recorded fluctuations of ρw and of q and afterwards calculated the required covariance, $\overline{(\rho w)'q'}$ (where the primes indicate deviations from means and the bar an averaging with respect to time), at first by hand methods and later on a differential analyser. This method, though establishing the usefulness of the principle, is much too laborious for routine use.

The instrument which we have developed provides continuous electrical signals proportional to ρw and q, and performs the necessary mathematical operations of multiplication and integration automatically. Since the mean values of ρw and q cannot be known in advance, it is necessary to evaluate the required covariance in the form

$$\overline{(\rho w)'q'} = \overline{(\rho w - a)(q - b)} - \overline{(\rho w - a)}.\overline{(q - b)}$$

where a and b are arbitrary zeros from which ρw and q are measured. A block diagram of the instrumental arrangement is shown in Fig. 1.

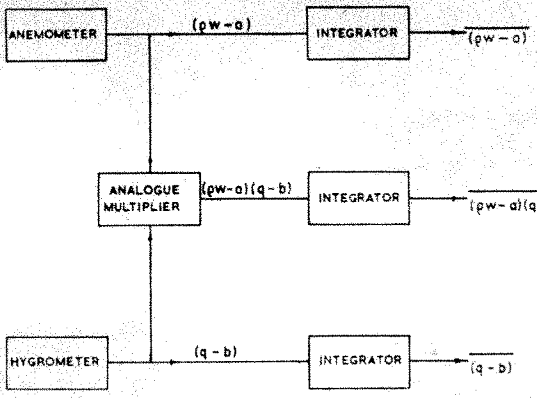

Fig. 1. Block diagram of evaporimeter

A height of 1·5 m. above the ground has been found suitable for mounting the sensing devices, and, at this height, response times of about 0·3 sec. are needed in the anemometer, hygrometer and multiplier in order to take account of the contribution to the flux made by the smallest eddies (1–2 sec. period) which are important at that height. A minimum period of observation of 5 min. is needed to accommodate the largest contributing eddies.

The anemometer, which is of an entirely new design[2], is linear and has a sufficiently rapid response. It depends in its operation on measuring the temperature in the wake of a heated wire by resistance-bridge thermometry and, by means of an amplifier feedback circuit controlling the input voltage to the bridge, this voltage can be made linearly dependent upon the product of ρ and the velocity component perpendicular to the instrument. Two such anemometers are arranged at equal and opposite angles to the horizontal, and the difference of their outputs is obtained as a measure of ρw.

The hygrometer is based on fine wire wet- and dry-bulb resistance thermometers of a design due to McIlroy[3]. These are constructed of fine nickel wire (0·0005 in. diam.) in order to obtain a sufficiently small response time, and are adjusted to a standard calibration of 900 ohms at 0° C. and 1,020 ohms at 30° C. A separate bridge network is used for each thermometer, the wet-bulb bridge being included in an electronic feedback circuit which simulates the saturated vapour pressure/temperature relationship of water[4]. The outputs of the two bridges are then combined in accordance with the psychrometric equation and an output signal linear with respect to $(q - b)$ is obtained.

Analogue multiplication is achieved by the quarter-square technique[5] making use of the identity $mn = \frac{1}{4}\{(m + n)^2 - (m - n)^2\}$. The squaring circuits each consist of a chain of ten diodes acting as function generators, four such chains being required for four-quadrant multiplication. Additions and subtractions are performed according to standard computing techniques using operational amplifiers.

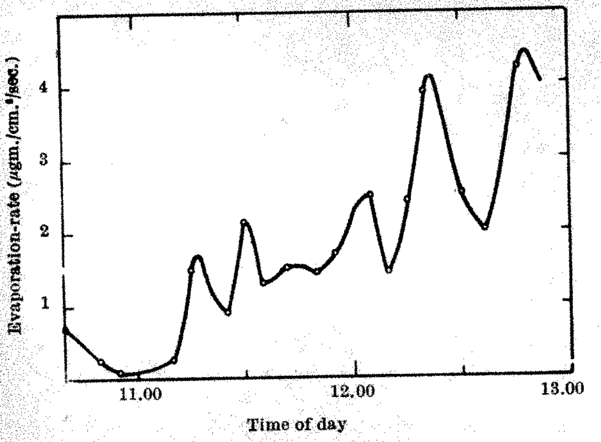

Fig. 2. Observed values of evaporation-rate, September 24, 1957

The integrators are of the electromagnetic type suggested by Gilbert[6], but with considerable modification of the original design to obtain greater accuracy and ruggedness. Special circuit arrangements have also been developed so that the integrator can accept currents of either sign. An important feature of this type of integrator in the present application is that it has no zero drift. A full description will be published by one of us (A. J. D.) elsewhere. The final results of the integrations appear on counters from which the total evaporation over the observation period is easily computed.

The complete equipment has been tested in the field, and some checks against Swinbank's method have been carried out with satisfactory results. A typical series of measurements is shown in Fig. 2, in which are plotted the results of a number of five minute runs. The increase in evaporation during the morning is evident, and the results demonstrate the inherent variability of the evaporation as a result of chance fluctuations in wind-speed, incoming radiation and other such factors.

Further field trials are now in progress, and development work is proceeding. Full instrumental details and the results of further observations will be published elsewhere.

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Lamellar Compound of Sodium with Graphite

It is well known that graphite forms lamellar compounds with potassium, rubidium and cæsium[1,2], but hitherto it has seemed likely, both on experimental[1-3] and theoretical[4] grounds, that sodium does not behave in this way. Recent work at Harwell reported here has, however, provided evidence for the existence of a lamellar compound of sodium with graphite.

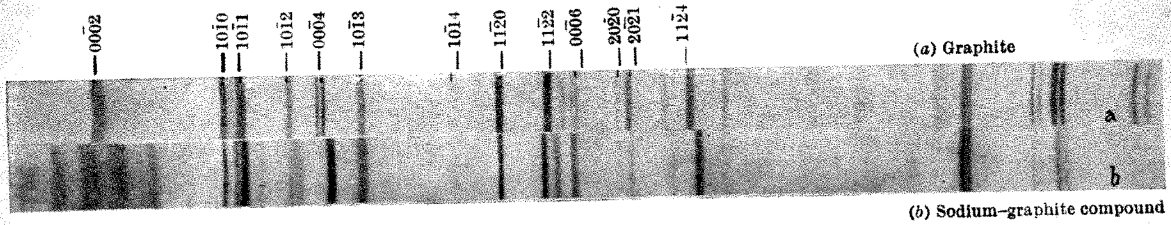
The compound was prepared very simply in a helium atmosphere (less than 20 p.p.m. oxygen) in a 'glove-box'. Powdered graphite was heated with about 3 per cent sodium (commercial purity, filtered through sintered glass at about 150° C.) at about 400° C. for 1 hr. with continuous stirring. The conditions are not at all critical, since the compound has been formed with heating times between ½ hr. and 6 hr. and at temperatures between 120° and 500° C. (although mixing is bad below about 200° C.). The product, virtually pure sodium-graphite compound, is very similar in appearance to the parent graphite but has a deep violet tinge. The analogous potassium, rubidium and cæsium compounds have similar strong colours; for example, C_8K is copper-coloured.

The main evidence for the formation of a compound is obtained from X-ray diffraction (compare the typical photographs in Fig. 1,*a* and *b*). We have found that the product made from a highly crystalline graphite, such as purified natural graphite, gives the most sharply defined X-ray diffraction pattern, but that the same product is formed from less-crystalline materials, for example, reactor-grade graphite; the definition is also improved by prolonged heating at about 400° C.

The formation of a compound is indicated in two ways. First, several diffraction lines which are strongly characteristic of graphite (for example, the $00\bar{0}2$ and $00\bar{0}4$ lines) are absent from the diffraction photograph of the product; as little as 5 per cent free graphite should be detectable in this way. Secondly, the product has a definite composition. Thus if excess of either sodium or graphite was used in the preparation, the excess was revealed roughly quantitatively in the photograph as unreacted material. The composition was found by this method to be between $C_{60}Na$ and $C_{68}Na$—probably $C_{64}Na$.

The change in structure thus indicated cannot be attributed to the formation of the potassium-graphite compounds since the potassium content of the sodium was certainly less than 0·1 per cent.

These diffraction results seem to fit best a structure in which sodium atoms lie in interstitial planes separated by eight carbon layers (that is, a lamellar compound) as indicated in Fig. 2,*a*. At every eighth layer, therefore, the spacing is increased in this way from 3·35 A. to about 4·6 A., which is consistent with



(*a*) Graphite

(*b*) Sodium–graphite compound

Fig. 1

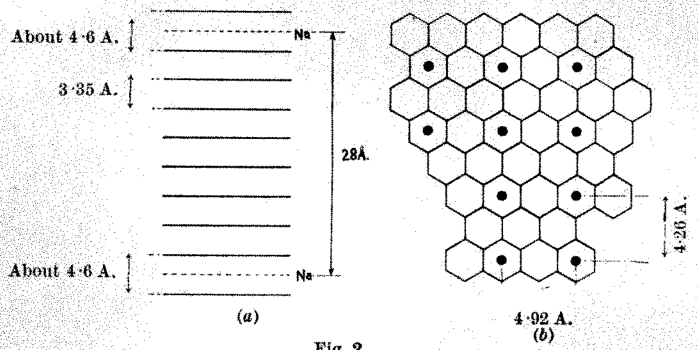


Fig. 2

the atomic diameters of sodium and carbon. The unit-cell dimension in the c direction then becomes 28 A. (or a simple multiple of this) and the average layer spacing is now 3·50 A., that is, 5 per cent greater than in the parent graphite. Graphite artefacts swell when immersed in liquid sodium, but only by about 0·5–1·0 per cent. The smaller magnitude of this swelling compared with the increase in the c spacing is due mainly to the fact that the crystallites in an artefact are anisotropically oriented. Since it is possible to estimate the degree of this anisotropy from the thermal expansion, we have been able to relate, at least approximately, the swelling to the change in the c spacing.

The detailed analysis of the X-ray photographs is not yet complete. At present, therefore, it is possible to make only a tentative suggestion for the arrangement of the sodium atoms within the interlayer gaps. That indicated in Fig. 2,b would account for the formula $C_{64}Na$.

The compound with the suggested formula $C_{64}Na$ is the only sodium-graphite compound which has been detected in our work in spite of the range of experimental conditions used. Thus sodium apparently differs from the heavier alkali metals; potassium, for example, is reported[2] to form a range of compounds between C_8K and $C_{60}K$.

Fuller reports, including the results of the more detailed structural analysis and also measurements of the physical effects of sodium on graphite, will be published elsewhere.

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Ferric Perchlorate Complex Ion

Sutton[1], and later Sykes[2], have reported association constants for the formation of ferric perchlorate complex ion, $FeClO_4^{++}$, although other investigators have been unable to find evidence for the existence of this species[3,4]. Inasmuch as perchloric acid and perchlorate salts are commonly used for maintaining constant ionic strength in physical-chemical measurements on the assumption that perchlorate ion does not complex appreciably with cations in aqueous solution, the question of the existence and extent of perchlorate complexing is a matter of some importance.

Both Sutton[1] and Myers[5] have suggested that perchlorate complexing might play a part in the kinetics of the iron(II)–iron(III) electron-exchange reaction. For reaction paths involving hydrated but otherwise uncomplexed ferrous ion and ferric species the rate of this exchange reaction, generalizing the results of Silverman and Dodson[6], may be represented by

$$R = \sum_{X} \sum_{n=0}^{n=6} k_n\, (\mathrm{Fe}X_n^{3-mn})\, (\mathrm{Fe}^{++}) \qquad (1)$$

where R is the rate of exchange, X is any complexing ligand (including hydroxide ion) of charge m, and k_n is the specific reaction-rate constant for the exchange process in which Fe^{++} and $\mathrm{Fe}X_n^{3-mn}$ are reactants. Silverman and Dodson[6] and Hudis and Wahl[7] have assumed that k_0, the specific reaction-rate constant for the exchange process involving uncomplexed ferric ion, has a value other than zero, that is to say, that exchange occurs between ferrous and uncomplexed ferric ion. Experiments which substitute heavy water for water as solvent[8], however, indicate that the situation is more complicated than initially supposed.

Alternatively, if k_0 is nearly zero, and if $FeClO_4^{++}$ is the only ferric perchlorate complex formed, assuming a value for k_1, the specific reaction-rate constant for the exchange process involving $FeClO_4^{++}$ on the basis of the values for other monovalent complexing anions, the value of the formation constant, K_1, for the ferric monoperchlorate complex ion can be estimated from available kinetic data on the exchange reaction since,

$$(\mathrm{Fe}X_n^{3-mn}) = K_n\, (\mathrm{Fe}^{+++})\, (X)^n \qquad (2)$$

and the rate contributions of hydrolysed ferric species are known. According to the data of Silverman and Dodson[6], at 21·6° C. and an ionic strength of 0·55:

$$k_1 K_1 = k/(\mathrm{ClO}_4^-) = 3\cdot3/0\cdot55 = 6\cdot0 \text{ sec.}^{-1}\text{ f.}^{-2} \qquad (3)$$

where k is a specific reaction-rate constant determined by Silverman and Dodson and equated by them to k_0. Except for $FeOH^{++}$, the reactions of ferrous ion with dipositive ferric complexes have specific rate constants of comparable magnitude and apparently related to the size of the complexing anion. If the value of k_1 is estimated to be between 1 and 10 sec.$^{-1}$ f.$^{-1}$ by analogy with the values of 14, 20, 29 and 40 sec.$^{-1}$ f.$^{-1}$ for bromide[9], thiocyanate[9], chloride[6] and fluoride[7] ions respectively, then the resulting formation constant for the ferric monoperchlorate complex ion is between 6 and 0·6 f.$^{-1}$. The values reported by Sykes[2] on the basis of his own studies and calculated by him from data of others and from Bjerrum's theory, corrected to an ionic strength of 0·55 using the semi-empirical equation[3] and ignoring small temperature differences, namely, 2·8, 2·0 and 4·4 f.$^{-1}$ respectively, all lie well within these limits.

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Differential Thermal Method for determining Reactivity of Calcium Oxide

It has been reported[1] that the extent to which the reaction

$$CaO + MgCO_3 \rightarrow CaCO_3 + MgO$$

proceeds is influenced by the reactivity of the calcium oxide. The possibility that both this and the analogous reaction

$$CaO + Mg(OH)_2 \rightarrow Ca(OH)_2 + MgO$$

might be used for determining the reactivity of calcium oxide was systematically investigated, using differential thermal analysis. A hydration calorimetric technique and determinations of specific surface area by nitrogen adsorption were used for comparative purposes.

On the basis of the established fact that the reactivity of calcium oxide decreases as the temperature of calcination increases[2], samples of calcium oxide of widely differing reactivity were prepared by heating reagent quality calcium hydroxide at 100 deg. C. temperature intervals over the range 500–1,400° C. and precipitated calcium carbonate over the range 900–1,400° C. Thermograms for mixes of equimolecular quantities of such calcium oxides and magnesite are presented in Fig. 1 as curves (*a*) to (*e*) inclusive. Only one curve, (*e*), is given for the oxide from the carbonate because the curves were virtually identical for all such oxides prepared. The thermograms for the mixtures containing calcium oxide derived from calcium hydroxide at temperatures up to 1,100° C. show an exothermic peak at about 380° C., due to the net exothermal effect of the reaction. The subsequent endotherms represent respectively the decomposition of the remaining magnesite and the calcium carbonate formed as a result of the interchange reaction. The fact that, for the comparatively inactive forms of oxide where no interchange exotherm was found, considerable amounts of calcium carbonate were nevertheless formed, shows that its formation also proceeds as a result of reaction between the calcium oxide and the carbon dioxide formed during the magnesite decomposition over the range 600–700° C.

Three trends can be seen from these results. First, as the reactivity of the calcium oxide decreases, so the extent of the exothermal interchange reaction decreases until, for the oxide obtained from calcium hydroxide at 1,200° C. or higher, and for all oxide obtained from calcium carbonate, it is absent. Secondly, the area of the magnesite peak increases as the reactivity of the oxide decreases, and thirdly, the calcium carbonate peak area shows a corresponding decrease. The relationship between the oxide reactivity as reflected by the ratio of thermoactive reaction product and reactant peak areas and its temperature of preparation is presented in Fig. 2 in curves (*a*) and (a_1) respectively for the oxide obtained from the hydroxide and the carbonate.

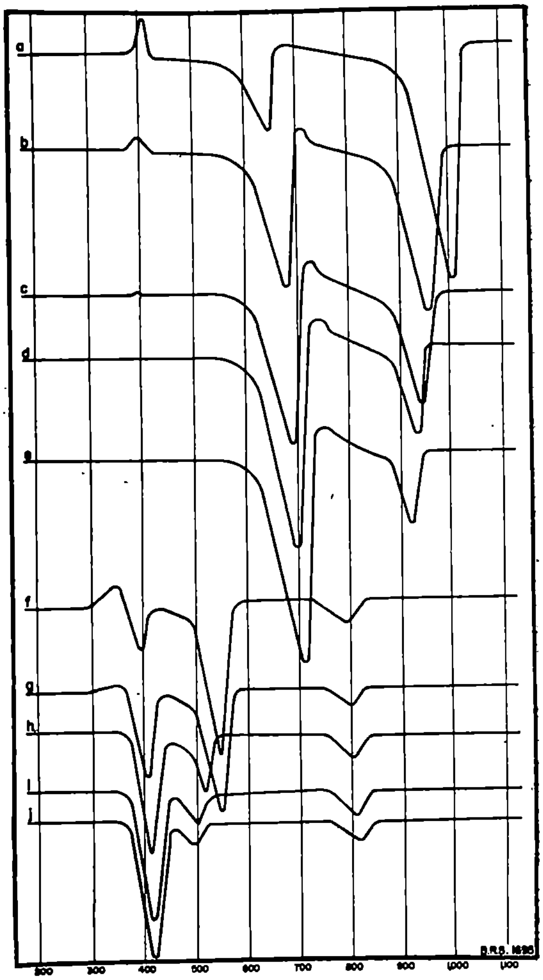
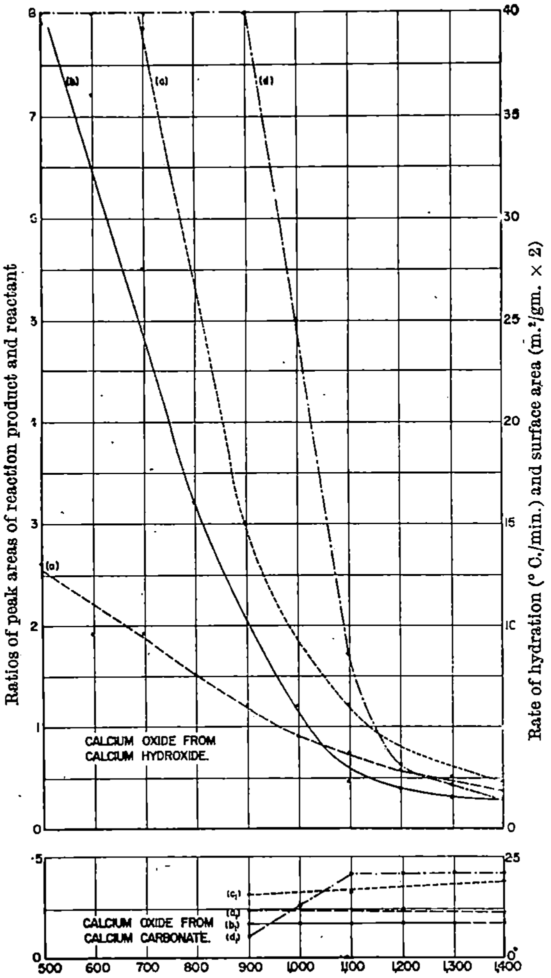


Fig. 1. Thermograms for equimolecular mixtures of magnesite or magnesium hydroxide and calcium oxide of origin indicated: (*a*)–(*d*), Magnesite and CaO derived from Ca(OH$_2$) at (*a*) 500° C., (*b*) 900° C., (*c*) 1,100° C., (*d*) 1,400° C.; (*e*), magnesite + CaO derived from $CaCO_3$ at 900° C.; (*f*)–(*i*), magnesium hydroxide + CaO derived from Ca(OH$_2$) at (*f*) 500° C., (*g*) 900° C., (*h*) 1,100° C., (*i*) 1,400° C.; (*j*), magnesium hydroxide + CaO derived from $CaCO_3$ at 900° C.

Thermograms for the magnesium hydroxide–calcium oxide mixes are shown in Fig. 1 as curves (*f*)–(*j*) inclusive. For the most reactive oxides the exothermal peak above 300° C. is evident; as the oxide reactivity and the extent of reaction decreases, the subsequent magnesium hydroxide peak increases and the calcium hydroxide reaction product peak decreases. From the peak area ratios illustrated in Fig. 2, curves (*a*), (a_1), (*b*) and (b_1) the parallel trends of the results for the two reactions investigated are evident; the results of the specific surface area determinations (curves (*c*) and (c_1)) and the hydration



Temperature of preparation of calcium oxide (° C.)

Fig. 2. Effect of origin and temperature of preparation of calcium oxide on ratio of peak areas of reaction product and reactant for magnesite–calcium oxide reaction (— — —), and magnesium hydroxide–calcium oxide reaction (———); on surface area (------) and on rate of hydration (—·—·—·—) of the calcium oxide

calorimetric data (curves (*d*) and (d_1)) demonstrate that these latter-established techniques yielded somewhat similar results. The decrease in the reactivity of the oxide obtained from calcium hydroxide with increasing calcination temperature and the virtual independence of reactivity on calcination temperature for that prepared from precipitated calcium carbonate emerge clearly. However, by these techniques of differential thermal analysis, the reactivity of calcium oxide prepared from calcite was found to decrease with increasing calcination temperature, as reported by Murray, Fischer and Sabean[3] and others.

While the hydration calorimetric technique shows marked differences in the reactivity of the oxide from calcium hydroxide calcined over the range 900–1,400° C., it does not, under the experimental conditions used, discriminate between oxides of widely differing reactivity prepared over the range 500–900° C.; differential thermal analysis, for both reactions, shows marked differences of reactivity for oxide prepared in the range 700–1,100° C. for the exothermic reactions and over the wider range 500–1,400° C. for the reaction product–reactant peak area ratio.

Slight hydration of the calcium oxide, corresponding to an ignition loss of about 5 per cent, profoundly reduced its reactivity as evaluated by the hydration calorimetric technique. In contrast, with the technique of differential thermal analysis, hydration of calcium oxide does not reduce the measured reactivity.

A detailed account of this work will be published elsewhere. This communication is published by permission of the South African Council for Scientific and Industrial Research.

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Action of Periodate on some Polysaccharides containing Aldoheptose Sugars

Information about the molecular localities of the heptose residues in certain polysaccharides[1] may be obtained by application, in sequence, of periodate oxidation, reduction with sodium borohydride and acidic hydrolysis.

The following experimental procedure was adopted: aqueous solutions of polysaccharide (1 vol., 1 per cent w/v) and sodium metaperiodate (0·5 vol., 2 per cent w/v) were mixed at room temperature (*c.* 20°). At suitable time-intervals, aliquots (2 ml.) were withdrawn and treated immediately with ethylene glycol (0·5 ml.). After standing for 15 min. a fresh aqueous solution of sodium borohydride (2 ml., 1 per cent w/v) was added. After a further 15-min. period glacial acetic acid (1 ml.) was added to each aliquot, which was diluted to 8 ml., dialysed overnight against running tap-water and freeze dried. Samples of these products were used for aldoheptose and hexose determination by the Dische methods[2], further samples of 3–10 mgm. were hydrolysed in ampoules with 2 *N* hydrochloric acid (0·5 ml.) at 100° for 3 hr., the hydrolysates diluted to 5 ml. and neutralized by di-*n*-octylmethylamine[3]. The hydrolysates were freed from amino-sugars by 'Amberlite *IR*-120' (H+), neutralized[3], concentrated and analysed by zone electrophoresis (enclosed strip method[4], borate buffer *p*H 10) and paper chromatography[5]. The results are summarized in Fig. 1 and Table 1.

The heptose content of the *Chromobacterium violaceum* polysaccharides was rapidly reduced by 90 per cent or more whereas about 30 per cent of that of *Pasteurella pestis* polysaccharide remained intact (Fig. 1) and could be detected by paper chromatographic and zone electrophoretic analysis (Table 1). There was a corresponding increase in the hexose content in the initial stage of the reaction.

Thus in the polysaccharides studied it appears that there may be at least two modes of linkage of the heptose units, in one of which the heptose is very rapidly attacked by periodate.

Table 1. CHANGE IN NITROGEN-FREE SUGAR CONTENT OF SOME BACTERIAL POLYSACCHARIDES ON PERIODATE OXIDATION FOLLOWED BY REDUCTION

Polysaccharide source	Time of periodate oxidation (min.)	Glucose	Galactose	Mannose	Rhamnose	D-Glycero-D-galactoheptose	D-Glycero D-mannoheptose	L-Glycero-D-mannoheptose
*Pasteurella pestis** (ref. 6)	0	++		−				+++
	1–2	++		++				++
	4–8	++		++				++
Chromobacterium violaceum N.C.T.C. 7917 (ref. 7)†	0	+	+++	−			++	
	2	+	+++	++			+	
	4–8	+	+++	++			−	
C. violaceum (BN)* (ref. 8)	0		−		++	+++		
	8		+++		++	−		

+++, Major component; ++, moderate amount; +, trace; −, not detected.
* Also contains *N*-acetyl-D-glucosamine.
† Also contains *N*-acetyl-D-fucosamine.

In the reaction sequence adopted the heptose was converted to a hexose which, in each instance, was different from that originally present in the polysaccharide (Table 1) and, moreover, was that anticipated from the structures allocated (only tentatively for *P. pestis* and *C. violaceum* 7917) to the parent heptoses.

A possible structural arrangement which would account for the above observations would involve the presence of heptopyranose units with unsubstituted $C_{(6)}$- and $C_{(7)}$-hydroxyl groups, as terminal or internal units in the polysaccharide chains.

Conversion of the heptose units in the polysaccharides to hexose units may offer a means of simplifying structural determination of the polymers.

An attempt to relate the structural changes induced to loss of serological specificity could only be attempted with the *C. violaceum* (7917) polysaccharide. Serological activity was tested by inhibition of hæmagglutination using red cells sensitized with the parent lipopolysaccharide[9]. In this instance all serological activity appeared to have been lost after exposure to periodate for 30 sec.; reduction with sodium borohydride alone, however, caused no detectable loss of serological activity. This agrees with the widely held view that the reducing end residue does not contribute significantly to the serological specificity.

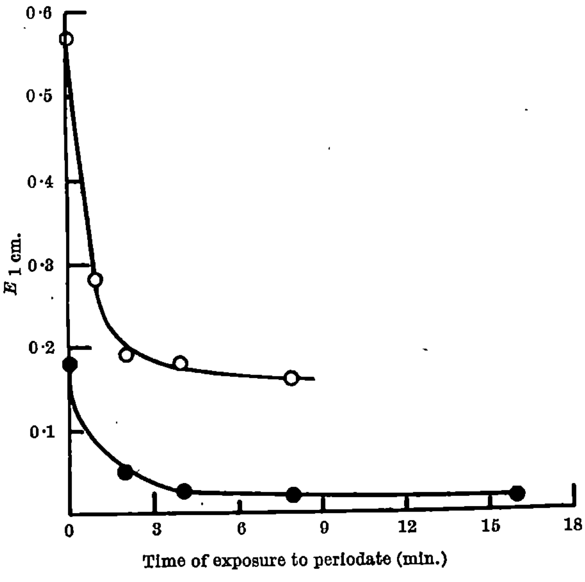

Fig. 1. Loss of aldoheptose sugars from bacterial polysaccharides on periodate oxidation. Heptose estimated colorimetrically (ref. 2) and expressed as extinction 505–540 mμ. ○, *P. pestis* polysaccharide; ●, *C. violaceum* (7917) polysaccharide; the identity of the heptose sugars has not been rigorously established, but they are believed to be L-glycero-D-mannoheptose and D-glycero-D-mannoheptose respectively

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Formation of >C=O Bonds in the Radiation-induced Oxidation of Protein in Aqueous Systems

A SERIES of observations recently made indicate that formation of the >C=O bond is a principal chemical effect of the attack of hydroxyl radicals on protein in oxygenated solution. Irradiations were made in a neutron flux produced by bombardment of beryllium with 24-MeV. deuterons in the Crocker Laboratory 60-in. cyclotron. Solutions were exposed under one atmosphere of oxygen in sealed 'Pyrex' cells mounted in a motor-driven reel situated 15 cm. from the beryllium target. One of the cells in each exposure contained a formic acid–oxygen dosimeter[1]. (We employed the formic acid–oxygen dosimeter to obtain an estimate of the relative number of water molecules decomposed via (1) $H_2O = H + OH$ and (2) $H_2O = \frac{1}{2}H_2 + \frac{1}{2}H_2O_2$. Absolute yield values could then be calculated in terms of G(molecules/100 eV.), since in dilute solutions at pH values above 2·5, the sum $G(1) + G(2) = G(H_2O)$ is to a first approximation independent of the quality of the absorbed radiation[1]. With our standard geometry for neutron exposures, we obtained $G(1) = 2{\cdot}68$, $G(2) = 0{\cdot}97$ on the basis of $G(H_2O) = 3{\cdot}65$[2].)

The following procedures were found applicable to the study of carbonyl formation in aqueous pepsin (twice crystallized, Lot No. 9477 Nutritional Biochemicals Corporation, Cleveland, Ohio) solutions (6·0 mgm./ml., 0·5 M in sodium sulphate, 10^{-3} M in sulphuric acid)[3]. Immediately after irradiation, platinum black was added to destroy hydrogen peroxide, and the solution was heated to obtain the two fractions, precipitate (I) and supernatant (II). Each was treated with 2,4-dinitrophenylhydrazine–hydrochloric acid solution[4] and dialysed to remove excess reagent and any products of low molecular weight. An appropriate aliquot of the dialysed protein was then added to methanol–potassium hydroxide solution for spectrophotometric analysis after the method of Lappin and Clark[5]. These authors have shown for monocarbonyl 2,4-dinitrophenylhydrazones that the position of the absorption maximum, as well as the value $E_{\text{max.}}$, is nearly independent of the structure of the carbonyl compound. We found that the absorption spectrum of fraction I ($E_{\text{max.}} = 480$ mμ) corresponded to the spectrum of authentic monocarbonyl hydrazones and, by using the formaldehyde derivative as a standard, obtained the value[3] $G = 1{\cdot}2$ for monocarbonyl production at a dose equivalent to $2{\cdot}5 \times 10^{18}$ eV./ml. Fraction II showed a blue colour and absorption spectrum ($E_{\text{max.}} = 550$ mμ) which can be attributed to 1,2-dicarbonylhydrazones. Using an authentic glyoxal derivative as a standard, we obtained $G = 0{\cdot}02$ for dicarbonyl production. The pepsin in unirradiated control solutions showed no retention of 2,4-dinitrophenylhydrazine. The position of carbonyl formation in the radiation-induced oxidation of pepsin is now under investigation; the relative importance of the various main and/or side-chain bonds is being determined.

Independent evidence for formation of carbonyl groups through processes induced by attack of hydroxyl radicals at the peptide linkage has been obtained in a parallel study of the oxidation of gelatin (purified pigskin, Lot No. 60–6657, Eastman Organic Chemicals solution) (40 mgm./ml. in air-saturated solution) by Fenton's reagent in which case hydroxyl radicals are formed by the reaction[6] $Fe^{2+} + H_2O_2 = Fe^{3+} + OH^- + OH$. We have found in this system (*a*) that the dialysed protein contains approximately one carbonyl group for every two hydroxyl radicals formed and (*b*) that glyoxylic, pyruvic, and α-ketoglutaric acids are among the carbonyl compounds liberated on hydrolysis of the dialysed fraction with 2 *N* hydrochloric acid solution under oxygen-free conditions. Identification of the keto-acids is based on the observation that the 2,4-dinitrophenylhydrazone derivatives could not be distinguished chromatographically[7] from the corresponding authentic material. (Formation of these keto acids is consistent with a previously suggested mechanism for the radiation-induced rupture of the peptide linkage[8]; $R\text{CONHC}R_2 \rightarrow R\text{CON}{=\!=}\text{C}R_2 \xrightarrow{H_2O} R\text{CONH}_2 + R_2\text{CO}$. We have recently found that irradiated solid pepsin on dissolution in water also yields high-molecular-weight products containing carbonyl groups and suggest that imino intermediates are also involved in direct action: $R\text{CONHC}R_2 \rightarrow R\text{CON}{=\!=}\text{C}R_2 + H_2$.)

The possible biological importance of carbonyl formation is indicated by the observation that the addition of 2,4-dinitrophenylhydrazine to irradiated (4×10^{17} eV./ml.) rat liver homogenate[9] (50 mgm./ml. in water) gave a non-dialysable hydrazone fraction that exhibited an intense magenta colour on mixing with methanol–potassium hydroxide. (We estimate that this technique, with slight modification, could be used for measuring an X-ray dose of a few hundred roentgens.) Control tests with unirradiated homogenate showed a negligible background colour. The literature[10] indicates that radiation-induced oxidation of a number of different types of chemical linkages may contribute to carbonyl production in a biological system.

A detailed report of this work will appear in a forthcoming paper.

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Acetylation of Trypsin in Organic Solvents

PREVIOUS work in this laboratory has shown that treatment of trypsin with various anhydrides results in the formation of the corresponding acyltrypsin derivatives, each possessing some interesting properties of its own, while all retained their original proteolytic activity[1]. From the derivatives so far prepared, acetyltrypsin is the best-characterized chemically modified enzyme[2], while succinyltrypsin is the most stable of the derivatives so far obtained[3]. The use of water as a solvent in investigating enzyme modification sets some definite limitations as to type of reagent usable and as to reactions possible. It was with these experiences in mind that the study of acetylation of trypsin was pursued in two organic solvents, formamide and dimethylsulphoxide, Rees and Singer[4] having indicated the compatibility of these systems.

The dissolution of trypsin in the two solvents results in an immediate loss of about 50 per cent of the enzymic activity, when it is assayed in the conventional way, that is, in aqueous solutions, using either urea-denatured hæmoglobin or benzoylarginine ethyl ester as substrates. On prolonged incubation in the two solvents, no further decrease in activity is observed. The loss in activity is not diminished by distilling formamide twice over calcium or barium oxide, at a pressure of 1 mm. Effective purification can be, however, obtained by treatment of the solvent with a cation exchange resin ('Amberlite *IR*–120'). By this manipulation, more than 85 per cent of the tryptic activity is retained. The addition to the solvent of minute amounts of acetic or citric acids, acetyltryptophan and hydrochloride of benzoylarginine ethyl ester also results in the stabilization of the enzyme. The addition of alkali destroys proportionately tryptic activity, while the temperature at which the experiments are carried out is without noticeable effect. The dissolution of trypsin in organic solvent–water mixtures with increasing water content does not stabilize the enzyme. On the contrary, there is a relatively narrow region containing about 55–65 per

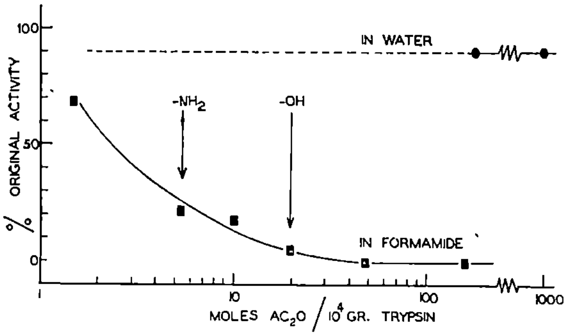

Fig. 1. Inactivation of trypsin by acetic anhydride in formamide. Trypsin concentration: 5 mgm./ml. of formamide; acetylation for 1 hr. at 22° C. Two stoichiometric points are indicated, corresponding to the total number of amino- and hydroxyl-groups present in trypsin

cent of organic solvent, in which the enzyme loses up to 80 per cent of its activity on dissolution in 'Amberlite'-untreated formamide. In treated formamide, or dimethylsulphoxide, this is not observed.

The acetylation of trypsin in the two solvents is accompanied by a loss of enzymic activity in proportion to the amount of anhydride employed. While in buffered aqueous solutions huge excesses of the anhydride are without detrimental effect, a total loss of activity is observed in formamide, at 22° C., when about 50 equivalents of anhydride are employed per mole of trypsin. This amount corresponds approximately to the total number of hydroxyl groups in trypsin. The correlation of activity and amount of anhydride is recorded in Fig. 1.

The extent of substitution of amino- and hydroxyl-groups in trypsin, acetylated with an amount of anhydride corresponding to the total hydroxyl groups of the enzyme, was found to be 95 per cent and 7·5 per cent respectively. This proportion is essentially identical with that observed in the course of acetylation of the enzyme in aqueous solutions[2]. Therefore, the degree of substitution by itself does not explain the loss in activity. At higher proportions of anhydride, a complete acetylation of the hydroxyl groups occurs in formamide, but not in water. It would therefore appear that the difference in specificity of the reaction is responsible for the inactivation of the enzyme. The inactivation is irreversible, and activity cannot be regained by mild hydrolytic treatment.

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Carotenoid-sensitized Fluorescence of Chlorophyll *in vitro*

It is well established that light absorbed by carotenoids can contribute to photosynthesis, phototaxis and the red fluorescence shown by chlorophyll *A* in the intact chloroplast. In *Chlorella*, independent measurements of both fluorescence[1] and photosynthesis[2] indicate a 40–50 per cent efficiency of energy transfer from β-carotene and lutein to chlorophyll *A*. In brown algae[3,4] almost complete transfer of energy from fucoxanthol to chlorophyll *A* is reported.

Table 1

Carotenoid		Porphin	Approximate transfer efficiency (per cent)
β-Carotene	transfer to	Chlorophyll *A*	10
,,	,, ,,	Phæophytin *A*	0
Lutein	,, ,,	Chlorophyll *A*	60
,,	,, ,,	Chlorophyll *B*	10
,,	,, ,,	Phæophytin *A*	0
Fucoxanthol	,, ,,	Chlorophyll *A*	100
,,	,, ,,	Chlorophyll *B*	20
,,	,, ,,	Phæophytin	0

This transfer has now been observed in artificial systems, in which the concentration of pigments approaches that found in chloroplasts. Pure plant pigments, freshly prepared by chromatography, were dispersed in detergent micelles[5] to give local concentrations of about 0·1 *M*. In this way, equimolecular mixtures of carotenoid and chlorophyll or phæophytin were prepared. Electronic energy transfer was measured by comparing the fluorescence excitation spectra of chlorophyll or phæophytin in the presence and absence of carotenoid. The exciting wave-lengths ranged between 380 and 670 mμ. Two of the resulting spectra are shown in Fig. 1, together with the difference spectra representing the contribution of fucoxanthol and lutein respectively to chlorophyll *A* fluorescence. Table 1 shows approximate transfer efficiencies for several pairs of pigments all at roughly 0·1 *M* concentration.

These results show that for lutein and fucoxanthol, transfer to chlorophyll *A* in micelles is similar in

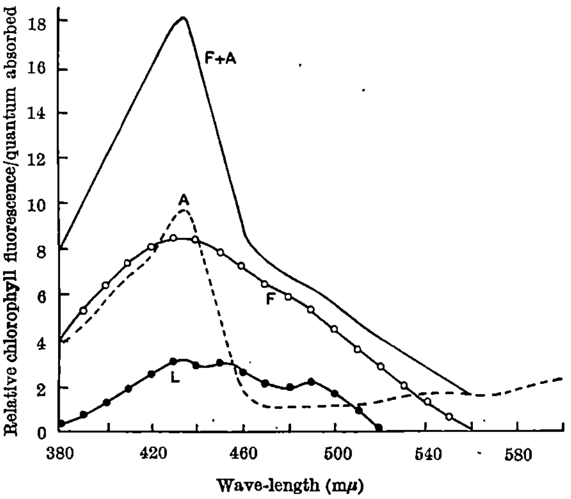

Fig. 1. Electronic energy transfer from carotenoids to chlorophyll *A* in detergent micelles. *A* and *F* + *A*, Fluorescence excitation spectra of chlorophyll *A* alone, and an equimolecular mixture of *F*, fucoxanthol and chlorophyll *A*; *F* and *L*, difference spectra measuring electronic energy transfer from fucoxanthol and lutein respectively to chlorophyll *A*. Ordinate: Relative numbers of quanta absorbed which appear as chlorophyll *A* fluorescence; abscissa, wave-length of exciting light in mμ

magnitude to that reported for chloroplasts. The value for β-carotene may be too low, as difficulty was encountered in dispersing this material in micelles.

The low value for carotenoid–chlorophyll *B* transfer, and zero transfer to phæophytin *A* are surprising, if only the intermolecular distance and estimated overlap of absorption and emission spectra are considered. These are similar for both the chlorophylls and phæophytin *A*. It is evident[6], however, that proximity and overlap are not the only factors necessary for transfer. The ratio of the fluorescence polarization measured with radiation absorbed mainly by fucoxanthol, to that excited by radiation absorbed only by the red band of chlorophyll *A*, was determined. In chlorophyll *A* alone this ratio is 23 per cent, while in the fucoxanthol–chlorophyll *A* system this value is increased to 70 per cent. This increase in positive polarization illustrates the preferred coupling of fluorescence and absorption oscillators which the transfer involves. High positive polarizations are only found in chlorophyll *A* beyond 600 mμ.[7], so that the fluorescence spectrum of fucoxanthol presumably extends into this region.

It is tempting, in view of the high efficiency of transfer to chlorophyll *A* compared with chlorophyll *B* and phæophytin *A*, to assume a specific complex to exist.

However, an approximate calculation indicates that the observed transfer values could exist in a random array of pigment molecules. By an absolute method[8], the carotenoids can be shown to have quantum yields not greater than 10^{-4}. If this value is taken as a maximum value, the fluorescence lifetime must be of the order of 10^{-12} sec. For a normal lifetime of 10^{-8} sec. we can assume a half-transfer radius of about 40 A., taking into account the overlap integral and the transfer radii reported for xanthydrol dye molecules[9]. Assuming transfer by the mechanism of coupled oscillators, *d* the half-transfer radius for a fluorescence lifetime of 10^{-12} sec. is given by

$$\left[\frac{40}{d}\right]^6 = \frac{10^{-8}}{10^{-12}} \text{ or } d = 8{\cdot}6 \text{ A.}$$

In an equimolar mixture of pigments at 0·1 *M* concentration the average intermolecular spacing *d* is 10 A., while many intermolecular distances will be smaller. The higher efficiency of fucoxanthol compared with lutein could be due to higher absolute quantum yield, or a more efficient overlap of its fluorescence spectrum with chlorophyll *A* absorption.

Complex formation usually produces changes in position of absorption maxima. No such changes, however, were observed in the systems showing transfer. Carotenoids, on the other hand, show very marked flattening and broadening of the absorption bands. Fucoxanthol and lutein, which in dilute solutions do not absorb beyond about 500 mμ, show absorption up to 560 mμ and 520 mμ respectively. Similar broadening can be seen in concentrated solutions of the pure carotenoids. The extension of fucoxanthol absorption to about 560 mμ is observed in brown algae and is responsible for their characteristic colour. When the grana are disintegrated by heating, the algae become green, as the absorption limit of fucoxanthol returns to about 500 mμ.

In brown algae, fucoxanthol is an efficient substitute for chlorophyll *B*, filling in the region 460–540 mμ where chlorophyll *A* is relatively transparent, and in these plants the fucoxanthol–chlorophyll *A* ratio approaches unity. In green plants however, where the fractional absorption of carotenoids is small, it is probable the energy transfer is only a manifestation of the proximity of these pigment molecules, the full significance of which remains to be determined.

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Effects of Orotic Acid on Coenzyme A and Pantothenic Acid of Liver in Vitamin B_{12} Deficiency

OROTIC ACID was found to reduce the vitamin B_{12} requirement for growth and for the betaine–homocysteine transmethylase activity of liver in rats fed corn/soybean meal ration deficient in vitamin B_{12}[1]. These results suggested a metabolic relationship between orotic acid and vitamin B_{12}. To ascertain whether this metabolic relationship was limited or more extended, we have directed our research towards other biochemical modifications reported in vitamin B_{12} deficiency.

Since an increase in concentration of liver pantothenic acid[2] and coenzyme A[3] was observed in animals deficient in vitamin B_{12}, we have extended our investigation to the effect of orotic acid on content of total pantothenic acid and coenzyme A of liver in rats deficient in vitamin B_{12}.

To this end, fifteen weanling male rats of the Sprague–Dawley strain, weighing 40–45 gm., were employed. The animals were divided into three groups, all of which were fed the basal corn/soybean meal ration deficient in vitamin B_{12} as proposed by Register *et al.*[4]. Iodinated casein or desiccated thyroid was omitted. Group 1 served as control and received only the basal ration. Group 2 was fed the basal ration supplemented with vitamin B_{12} (2γ/100 gm. of diet). Group 3 received the basal ration supplemented with orotic acid (1,000γ/100 gm. of diet). The animals were maintained on their respective ration for 8 weeks and weighed weekly. Feed and water were supplied *ad libitum*. At the end of the experiment the animals were killed by decapitation and bled. Total pantothenic acid and coenzyme A were evaluated in the liver of each animal. To liberate pantothenic acid from liver tissues, a weighed portion of each liver was homogenized in a Potter glass-homogenizer with four volumes of water. 2 ml. of this homogenate were placed in a 125 ml. Erlenmeyer flask with 40 ml. of water and 1 ml. of toluene. The materials were incubated for 16 hr. at 37° C. After incubation the samples were boiled, cooled, adjusted to 100 ml. and filtered. Total pantothenic acid was assayed, according to the method of Skeggs and Wright[5], in aliquots of the filtrate, utilizing *L. arabinosus* 17/5 *ATCC* 8014 as a test organism. For evaluating coenzyme A, a weighed portion of the same liver used for studies on pantothenic acid content, was homogenized with ten volumes of ice-

Table 1

Group No.*	Supplement to 100 gm. basal ration	Pantothenic acid (γ/gm. liver fresh weight)	Coenzyme A (units/gm. liver fresh weight)
1	None	377 ± 27·6†	207 ± 12·7
2	2γ vitamin B_{12}	86 ± 8·1	81 ± 3·3
3	1,000γ orotic acid	234 ± 16·2	148 ± 8·8

* Five animals per group.
† Standard error of the mean.

cold water. The homogenate was boiled in a water bath, then cooled and centrifuged. In the aliquots of the supernatant, coenzyme A was determined by the usual procedure of Kaplan and Lipmann[6].

The results for liver pantothenic acid and coenzyme A are presented in Table 1. A striking increase in content of pantothenic acid and of coenzyme A concentration in the liver of rats kept on the vitamin B_{12}-deficient diet (group 1) for 8 weeks, is evident. These values appear much lower in rats of group 2 fed vitamin B_{12}. These results confirm the results previously reported in the chick and in the rat[2,3]. Orotic acid fed to vitamin B_{12}-deficient rats (group 3) exerts a vitamin B_{12}-like action in lowering the content of pantothenic acid and coenzyme A in the liver of male rats. Nevertheless, the effects of orotic acid are less, under our experimental conditions, than those shown by vitamin B_{12} itself. Therefore, orotic acid is not to be considered only as a factor in promoting growth and stimulating liver betaine–homocysteine transmethylase activity in rats deficient in vitamin B_{12} [1], since it also participates in the regulation of pantothenic acid and coenzyme A in the liver of male rats. These findings may point to a more extended metabolic relationship between vitamin B_{12} and orotic acid.

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Enzymatic Formation of Aminomalonic Acid from Ketomalonic Acid

Recent work in this laboratory demonstrated the occurrence of a new enzyme, aminomalonic acid decarboxylase, in the posterior silk-gland of silkworm and in rat liver[1]. The fact that this enzyme was first observed in silkworm, which has a remarkably high activity of glycine synthesis[2], seems to suggest a physiological significance of the enzyme in the biosynthesis of glycine, although natural occurrence of this amino-acid has hitherto not been reported.

In the present communication, we report the formation of aminomalonic acid by an alanine-ketomalonate (mesoxalate) transaminase from silkworm and animal tissues. The first observation of this enzyme activity was reported by Braunstein in 1939 with pigeon-breast muscle; however, no attempt was made to identify the reaction product, aminomalonic acid, nor to characterize the enzyme further[3]. Later, Green *et al.* found that the purified glutamate–aspartate transaminase of pig heart showed a slight activity toward ketomalonate in place of oxalacetate[4].

The enzyme solution was prepared by homogenizing the posterior silk-glands of silkworms at the fifth instar stage with 3 vol. of 0·15 *M* potassium chloride solution (*p*H 7·8) and centrifuging off the undissolved material. The incubation mixture contained 1·0 ml. of the enzyme solution (approximately 1·0 mgm. N), 30 μmol. of disodium ketomalonate, 60 μmol. of DL-alanine, and 200 μmol. of borate buffer (*p*H 9·0) in a total volume of 3·0 ml. The mixture was incubated for 40 min. at 37° and deproteinized with sulphuric acid and sodium tungstate.

For the determination of the aminomalonate formed a simple method was devised: an aliquot taken from the supernatant solution was diluted with hydrochloric acid to give a final concentration of 0·1 *N* and heated for 30 min. in a boiling water-bath. This treatment proved to be sufficient for converting aminomalonic acid to glycine quantitatively. The glycine thus formed was determined by the method of Krueger[5]. Aminomalonic acid was also identified by paper chromatography and paper ionophoresis. The keto-acids were identified as their 2,4-dinitrophenylhydrazones by the method of Cavallini[6].

The activity of this enzyme solution (on the seventh day of the fifth instar stage), expressed as μmol. of the aminomalonate formed under the above condition, was about 9·2.

The *p*H optimum for the transamination of alanine–ketomalonate was found to be at 9·0–9·2. This is markedly different from those for the reactions of alanine–glutamate or alanine–aspartate, which have been reported to be 7·5 or 7·4, respectively[7]. This fact is interesting and may suggest that there might be a separate transaminase for this reaction from the alanine–glutamate or the alanine–aspartate enzymes. Transaminases with alkaline *p*H optima have been recently reported, namely, alanine–glyoxylate enzyme in silkworm (*p*H 9·0–9·5)[3], in *Pseudomonas* (*p*H 8·0–9·0)[8], and ornithine-α-ketoglutarate enzyme (*p*H 8·2–9·0)[9].

Of 17 different amino-acids studied in the presence of ketomalonate, alanine was the most active in forming aminomalonate. Glutamate, α-aminobutyrate, and aspartate also could act as amino-donors in decreasing order of reactivity. In the case of 13 other amino-acids there was no appreciable formation of aminomalonate from ketomalonate.

The activity of this enzyme preparation was 99 per cent inhibited by *p*-chloromercuribenzoate (10^{-3} *M*), 84 per cent by benzoquinone (10^{-3} *M*), 58 per cent by hydroxylamine (2×10^{-3} *M*), and 38 per cent by potassium cyanide (10^{-3} *M*).

Of all tissue homogenates tested for this enzymatic activity, the posterior silk-gland of silkworm showed the highest activity. Besides, it was observed that the activity of this tissue increased with time in the fifth instar stage. It may be noted that this tissue also exhibited the highest activity of aminomalonic acid decarboxylase; thus the distributions of these two enzymes in this tissue seem to be associated with each other. These facts may suggest a possible role of this transaminase in the biosynthesis of glycine, participating in the following metabolic pathways :

$$(\text{tartronate} \xrightarrow{10}) \text{ ketomalonate} \xrightarrow{\textit{transaminase}} \text{aminomalonate} \xrightarrow{\textit{decarboxylase}} \text{glycine}$$

The transaminase activity was also demonstrated in the homogenates of rat liver, rabbit liver and rabbit heart. The highest activity was observed with the rat-liver enzyme.

The enzyme was partially purified from the rat liver homogenate by fractionating with ammonium sulphate. The preparation was about 18 times as active as the starting material, but pyridoxal phosphate had no effect on the activity at this stage of purification.

Full details of this work will be reported in a future publication. Our thanks are due to Miss Aiko Kikuchi for her skilful technical assistance in this work.

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Insulin - Cortisone Relationship in Experimental Teratogenesis

It is well known that the administration of large amounts of cortisone to experimental animals is associated with the production of hyperglycæmia[1]. There is also evidence from clinical cases that in diabetes the therapeutic use of cortisone increases considerably the daily amount of insulin required to maintain the blood-sugar within normal limits[2]. The nature of this contra-insulin effect of cortisone is uncertain, but it has been suggested that it may be due to excessive destruction of insulin since there is no definite evidence that contra-insulin factors are responsible for a marked increase in the peripheral requirements for insulin[3].

In a series of experiments reported recently we used the teratogenic effects of hypervitaminosis A as a base line for the study of the action of cortisone during pregnancy[4,5]. In these experiments one group of pregnant female rats of the Wistar strain received 60,000 I.U. vitamin A acetate daily by gastric intubation from the eighth to thirteenth days of pregnancy. Another group received the same treatment with, in addition, 20 mgm. of cortisone acetate daily by subcutaneous injection from the ninth to twelfth days. A third group received only the cortisone treatment. It was found that in the young obtained from these rats on the twentieth day of gestation there was an incidence of deformities of the brain and calvaria of 7·8 per cent when the rats had received vitamin A alone during pregnancy, and of 36·6 per cent when they had received both vitamin A and cortisone. There were no deformities in the young from those mothers which received cortisone alone (Table 1). These results were interpreted as suggesting that the cortisone potentiated the teratogenic effects of the hypervitaminosis A, and it appeared that this potentiating action might in some way be related to a disturbance of carbohydrate metabolism.

Table 1

Treatment	No. of dams	Total No. of young	No. of young with brain deformities	Percentage of young with brain deformities
Vitamin A	12	77	6	7·8
Vitamin A, cortisone	12	41	15	36·6
Cortisone	12	73	0	0

We decided therefore, in view of the known contra-insulin effects of cortisone, to carry out further experiments in order to examine the possibility that insulin might exert a contra-cortisone effect in relation to the production of malformations. In these experiments one group of pregnant female rats was given vitamin A for the same period and in the same doses as in the earlier experiments. In addition, they received 1·5 units of protamine zinc insulin by subcutaneous injection, daily from the ninth to twelfth days of pregnancy. Another group received both vitamin A and cortisone in the same quantities as previously administered, but were also given 1·5 units of protamine zinc insulin daily by subcutaneous injection from the ninth to twelfth days. The results of these experiments are shown in Table 2. It will be seen that the incidence of deformities in the young fell from 36·6 to 1·2 per cent when insulin was given in addition to vitamin A and cortisone; and that while there was an incidence of 7·8 per cent in the young of dams which received vitamin A alone, no young with brain deformities were obtained from the dams which received insulin in addition to vitamin A.

Table 2

Treatment	No. of dams	Total No. of young	No. of young with brain deformities	Percentag young with brain deformities
Vitamin A, insulin	12	47	0	0
Vitamin A, cortisone, insulin	12	79	1	1·2

These findings indicate that the potentiating action of cortisone in relation to the production of malformations by hypervitaminosis A is wholly prevented by the administration of insulin. Further, it appears possible that insulin may have some effect in protecting the young against the teratogenic effects of hypervitaminosis A.

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Reversibility of the Inactivation of Rous Sarcoma Extracts by Detergents

The infectivity of an aqueous extract from a Rous sarcoma is lost if cetyl trimethyl ammonium bromide ('Cetavlon'), a cationic detergent, is added to the active extract[1]. By further addition of an acid colloid substance, like ribonucleic acid[2] or heparin, to the non-infective system infectivity is restored.

From the results obtained by Pirie and co-workers[3-6] on some plant viruses, including the tobacco mosaic virus, treated with anionic detergents, and by Pfankuch and Kausche[7] on tobacco mosaic virus with cationic detergents, the mechanisms of the actions of the two types of detergents on tobacco mosaic virus appear to be different. We have explored the possibility of an analogous behaviour of Rous sarcoma extract towards the two types of detergent, with particular reference to the reversibility of inactivation. The results are given in Tables 1 and 2.

The extract was prepared with a Miller and Golder's buffer[8] 0·14 *M*, *p*H 7·0. The initial concentration of extract was 5 per cent. After centrifuging at 1,500 *g* for 60 min., hyaluronidase, 5 U.V./ml. (Ialovis Vister) was added as solubilizer, and after 30 min. the extract was centrifuged at 15,000 *g*. All operations were carried out at 3° C.

In the experiments with 'Cetavlon' the proportion detergent/infective extract, was 2 mgm./ml., and the amount of acid colloid (heparin) needed to restore infectivity was equal by weight to the amount of 'Cetavlon'. In the experiments with the anionic detergent (sodium lauryl sulphate), the proportions were 0·4 mgm./ml., and the amount of basic colloid (protamine) added was equal to the weight of anionic detergent. Inoculations (standard amount, 2 ml.) were made in the breast muscles of 8-week-old chickens, all from the same breed. They were killed between the thirteenth and fifteenth day of the experiment, at which time the first control animals were beginning to die.

It appears from the results obtained that, whereas the cationic detergent has a reversible action, as is shown by the restoration of infectivity in the inactivated system (extract + 'Cetavlon'), such a reversibility does not occur with the anionic detergent, even after addition of a basic colloid, like protamine.

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Table 1. Inactivation and Reactivation of Extracts from Rous Sarcoma treated with Cationic Detergent ('Cetavlon')

Extract + heparin				Extract + 'Cetavlon'				Extract + 'Cetavlon' + heparin			
Inoculations in chickens	Developed tumours	Positive inoculations (per cent)	Mean weight developed tumours (gm.)	Inoculations in chickens	Developed tumours	Positive inoculations (per cent)	Mean weight developed tumours (gm.)	Inoculations in chickens	Developed tumours	Positive inoculations (per cent)	Mean weight developed tumours (gm.)
28	25	89	28	57	20	35	5	30	26	86	16

In the control chickens the ratio, developed tumours/inoculations was 70/76, with a positive inoculation of 92 per cent.

Table 2. Inactivation and Reactivation of Extracts from Rous Sarcoma treated with Anionic Detergent (Sodium Lauryl Sulphate)

Extract + heparin				Extract + sodium lauryl sulphate				Extract + sodium lauryl sulphate + protamine			
Inoculations in chickens	Developed tumours	Positive inoculations (per cent)	Mean weight developed tumours (gm.)	Inoculations in chickens	Developed tumours	Positive inoculations (per cent)	Mean weight developed tumours (gm.)	Inoculations in chickens	Developed tumours	Positive inoculations (per cent)	Mean weight developed tumours (gm.)
14	12	85	24	28	7	25	2	25	3	12	0·500

In the control chickens the ratio, developed tumours/inoculations was 70/76, with a positive inoculation of 92 per cent.

Effect of Creatine Phosphate Administration on the Cardiac Adenosine Triphosphate of Thyroxinized Rats

The amounts of adenosine triphosphate, creatine phosphate and inorganic phosphorus in the heart of hyperthyroid animals are below normal. These amounts are restored to about the normal level by administration of adenosine triphosphate, whereas with cocarboxylase and organic phosphates restoration is incomplete[1]. Moreover, thyroxin intoxication reduces the creatine content of the skeletal muscle and the rate of creatine synthesis by liver[2].

We have sought to establish if creatine phosphate, which is essential in oxidative phosphorylation, affects the reduction of this process in the heart, induced *in vivo* by thyroxin in doses of 0·01 mgm. per animal.

0·01 mgm. D,L-thyroxin was daily injected intramuscularly into each of twenty-four rats, which were then divided into four lots. Lot *B* received no further treatment; lot *C* daily received 0·1 mgm. of buffered creatine phosphate per animal injected intramuscularly; lot *D* received daily 5 mgm. of buffered creatine per animal, injected intramuscularly; the rats in lot *E* each received a single injection of both creatine phosphate and creatine at the same doses as above. A fifth lot (*A*) of normal animals was used as control. After fifteen days the animals

Table 1. Adenosine Triphosphate, Creatine Phosphate, Inorganic Phosphorus Creatine and Glycogen Content of Rat Heart Tissue after Daily Administration of Thyroxin and other Substances

Lot	Adenosine triphosphate	Creatine phosphate	Inorganic phosphorus	Creatine	Glycogen
	(μgm./gm. fresh tissue)			(mgm./100 gm. fresh tissue)	
A (6)	331 ± 27	308 ± 23	521 ± 46	408 ± 16	183 ± 11
B (6)	126 ± 11	< 10	316 ± 34	293 ± 33	149 ± 18
C (6)	224 ± 30	167 ± 19	409 ± 43	307 ± 26	166 ± 22
D (6)	121 ± 16	< 10	325 ± 29	367 ± 38	151 ± 17
E (6)	230 ± 28	165 ± 21	418 ± 46	376 ± 41	164 ± 14

Values ± standard error

were killed by bleeding and determinations of adenosine triphosphate, creatine phosphate, inorganic phosphorus[3], creatine[4] and glycogen[5] were carried out.

As shown in Table 1, administration of creatine phosphate partially prevents the fall of adenosine triphosphate and creatine phosphate content of the heart in animals given thyroxin at high dosage. Creatine alone cannot do this, and not only the adenosine triphosphate content but also creatine phosphate content remain low.

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Phospholipids, Proteins and Platelet-Lipoid

The time taken for Russell viper venom to accelerate the clotting of fasting human plasma poor in platelets—the Stypven time—is relatively long. The addition of very small quantities of some active phospholipids[1,2] to this system produces a shortening of the Stypven time, and the shortening is proportional to the quantity added. It may be concluded that there is very little available active phospholipid in fasting platelet-poor plasma. A simple phospholipid extraction of fasting platelet-poor plasma yields a material that greatly accelerates the Stypven time of platelet-poor plasma. It is concluded that there are molecules of active phospholipids in plasma, but that they are 'unavailable' for this test and presumably are bound in the plasma proteins.

If a critical strength of an isolated phospholipid, active in the Stypven system, is added to platelet-poor plasma at 37° C. or 10° C. it is found that this activity has decreased at the end of 2 hr. (To 0·5 ml. of fasting platelet-poor plasma is added 0·5 ml. of a predetermined concentration of an active phospholipid in distilled water. 0·1 ml. of this mixture is transferred to another 0·1 ml. sample of stock plasma and the Stypven time determined. This should be about 14 sec. if the plasma alone has a Stypven time of 20 sec. At the end of 2 hr. a further 0·1 ml. of the mixture is transferred to 0·1 ml. of stock plasma and the Stypven time recorded. Another 0·5 ml. of plasma and 0·5 ml. of phospholipid are then mixed and 0·1 ml. transferred to 0·1 ml. of stock plasma and clotted as before to check that the plasma, Stypven and original phospholipid activity have not altered.) It may be concluded that less phospholipid is available after 2 hr. Plasma rich in heparin-clearing factor gives the same results as normal plasma. It is unlikely that any enzyme system has altered the chemical composition of the phospholipid since this reaction proceeds equally well at 10° C. as at 37° C. A possible explanation is that the phospholipid has become associated with the plasma proteins and is no longer 'available' for this test.

Intact platelets are inactive in accelerating the Stypven clotting time of plasma. If they are mechanically fragmented, a potent accelerator becomes available. The properties of fragmented platelets in all coagulation tests (except clot retraction) are identical with various cephalins including phosphatidyl-ethanolamine, phosphatidyl serine and phosphatidyl inositide[3] and it has been suggested that the activity of platelet-lipoid is due to its content of any one or a mixture of these or similar 'active' phospholipids.

If platelet fragments are incubated in a critical strength with platelet-poor plasma the acceleration of the Stypven time caused by their addition does not decrease in two hours. A protein-free phospholipid extract of platelets behaves like an active phospholipid extracted from any other source.

If the two previous conclusions are correct, this last observation may suggest that if platelet-lipoid is active in blood coagulation by virtue of a phospholipid prosthetic group, then there is another part of the molecule which prevents the whole molecule from becoming associated with the plasma protein and thereby losing its activity. In a natural state, platelet-lipoid is almost certainly associated with protein. The activity of platelets may, therefore, depend on a preferred orientation in the platelet-protein molecule of a prosthetic phospholipid group which is 'available', while the phospholipids in plasma proteins are differently orientated and inactive or 'unavailable'.

Further work is in progress to expand and confirm these tentative conclusions.

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Adrenocorticotrophic Hormone in the Blood of Adrenalectomized Rats

It is well known that stress results in increased activity of the adrenal cortex which is caused by an increased secretion of adrenocorticotrophin by the pituitary gland. However, the exact mechanism which controls the secretion of this hormone is not fully understood. Sayers and Sayers[1] suggested that stress causes an increased utilization of adrenocortical steroids by the peripheral tissues and the resulting low blood level of corticoids acts as a stimulus to the pituitary gland to increase its secretion of adrenocorticotrophin. The Sayers hypothesis received convincing support from the results of the investigations of Taylor, Albert and Sprague[2], Gemzell, Van Dyke, Tobias and Evans[3] and Sydnor and Sayers[4], who found that animals with adrenocortical insufficiency exhibited a high blood level of adrenocorticotrophin. On the other hand, Barrett and Hodges[5] were unable to demonstrate any difference in plasma concentrations of adrenocorticotrophin between normal and adrenalectomized rats three, six and twelve days after the removal of the adrenal glands. The explanation of the discrepancy between these results was difficult to find. However, Barrett and Hodges[5] did not use the conventional technique of Sayers, Sayers and Woodbury[6] which employs hypophysectomized rats for the bioassay of adrenocorticotrophin, but a modification of the method described by Hodges[7] in which normal rats pretreated with deoxycorticosterone acetate were used. The possibility exists that the method was not sensitive enough to detect differences between the plasma-levels of adrenocorticotrophin in the normal and adrenalectomized animals or may even have been completely unsatisfactory for the assay of the hormone in blood. Therefore, it seemed essential to repeat and extend the work using hypophysectomized rats for determination of the adrenocorticotrophin.

Blood was collected from normal albino female Wistar rats and from similar adrenalectomized animals at various time-intervals after the removal of their adrenal glands. Plasma was separated and assayed for content of adrenocorticotrophin by the adrenal ascorbic acid depletion method described by Sayers *et al.*[6]. It was found that normal rats exhibited no detectable circulating level of the hormone, neither did animals five days after adrenalectomy. Adrenocorticotrophin was just detectable in the plasma of rats which had been adrenalectomized ten days previously, but its concentration was considerably less than 5 μgm./100ml. plasma. Twenty-three days after adrenalectomy the concentration of the hormone in the plasma had risen to 10·6 μgm./100 ml. (with limits of error ($P = 0 \cdot 05$) 7·4–15·2 μgm./100 ml.), and the same high circulating level was still present in rats adrenalectomized thirty-four days previously. From the results of this experiment it appears that no rapid and well-maintained increase in the concentration of adrenocorticotrophin in plasma follows adrenalectomy in the rat until three to five weeks after the operation, when there exists a remarkably high circulating concentration of the hormone.

There are no serious discrepancies between these results and those previously reported by Barrett and Hodges[5]. The findings also agree with those of Brodish and Long[8], who demonstrated by a cross-circulation technique that the adrenalectomized rat did not maintain a high circulating level of adrenocorticotrophin until two weeks or more after the removal of the adrenal glands. Furthermore, Barrett and Sayers (Barrett, personal communication) have recently demonstrated similar time-relations in the changes in the concentration of adrenocorticotrophin in the blood of adrenalectomized rats. These results do not contradict the evidence that the release of the hormone from the adenohypophysis may be controlled by the level of adrenal cortical hormones in the blood. However, it appears that in the rat there is an interval of at least two weeks before the pituitary gland adapts itself to secrete *and maintain* an enormously increased output of adrenocorticotrophin in response to the complete absence of circulating corticoids.

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Isomeric Chondroitin Sulphates

A RECENT communication[1] claims to "confirm Meyer's hypothesis that chondroitin sulphates *A* and *C* are only two fractions of the same polydisperse substance". Apparent lack of agreement in nomenclature[2–4] further emphasizes the need for clear differentiation of the isomeric chondroitin sulphates of connective tissue. These three substances, chondroitin sulphate *A*, chondroitin sulphate *B* and chondroitin sulphate *C*, respectively, in the nomenclature of Meyer *et al.*[2], have been found to be linear polyelectrolytes with similar chain configuration-charge relationships. Chondroitin sulphates *A* and *C* have been clearly distinguished as molecular individuals by comparison of molecular constants and physical properties.

Chondroitin sulphate *B* may be readily differentiated from *A* and *C* by enzymatic and chemical techniques[2]. The *A* and *C* sulphates, however, differ only slightly in optical rotation and in solubility, a property also dependent upon molecular weight. These two, however, may be easily differentiated by their infra-red spectra (Fig. 1) in the 700–1,000 cm.$^{-1}$ region where chondroitin sulphate *C* has unique bands at 1,000 cm.$^{-1}$, 820 cm.$^{-1}$ and 775 cm.$^{-1}$. Chondroitin sulphate *A* has bands at 928 cm.$^{-1}$, 852 cm.$^{-1}$ and 725 cm.$^{-1}$; *B* resembles *A*, with bands at 928 cm.$^{-1}$, 855 cm.$^{-1}$, 840 cm.$^{-1}$ and 712 cm.$^{-1}$.

Spectral measurements on fractionated preparations confirm a suggestion[2] that chrondroitin sulphate *C* is present in human umbilical cord. On the basis of published spectra (and optical rotations), the mucopolysaccharide from nuclei pulposi called "chondroitin sulphuric acid-*B*"[3], and the chondroitin sulphate from shark cartilage[7], may also be regarded as the *C* sulphate. In disagreement with a previous report[2], preparations from rabbit skin[8] have been found to consist of a mixture of *A* and *B* sulphates. Small amounts of the *A* sulphate have been detected in samples of β-heparin.

On the basis of previous assignments of bands[3], it appears that the sulphate group has an axial configuration in chondroitin sulphate *A* and *B* and an equatorial configuration in sulphate *C*. In agreement with recent reports[9] a possible interpretation places the sulphate group on the C-4 position in the hexos-

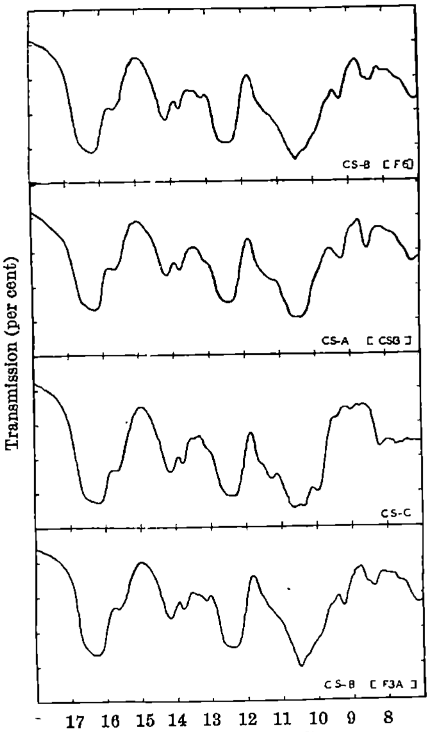

Fig. 1. Infra-red spectra for isomeric chondroitin sulphates obtained on a Perkin-Elmer spectrophotometer, model 21. with sodium chloride prism. 1·0 mgm. of the sodium salt of each polysaccharide was mixed with 150 mgm. potassium bromide, formed into a film of 0·45 mm. thickness (nominal) and compared with a potassium bromide blank. *A* was prepared from bovine nasal cartilage (ref. 5). Chondroitin sulphate *B* preparations were obtained by fractionation of a sample of β-heparin from bovine lung (ref. 6). One of these fractions, *F*-6, contained 20 per cent of the *A* sulphate. The *C* sulphate was a preparation from a human chordoma (ref. 2)

amine moiety of both the *A* and *B* sulphate, and on the C-6 position of the hexosamine moiety of the *C* sulphate.

This work, a fuller account of which is in preparation, was supported by a grant from the Chicago Heart Association and carried out during the tenure of an established investigatorship of the American Heart Association. I am indebted to Mr. Robert Hart for the spectral measurements, to Dr. A. Winterstein for the preparation of β-heparin, and to Dr. K. Meyer for the chondroitin sulphate *C* preparation.

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Effect of Hypophysectomy on the Ability of Rat Liver Microsomes in a Cell-free System to incorporate Radioactive Amino-Acids into their Proteins

THE incorporation of DL-leucine labelled with carbon-14 into the proteins of a cell-free system[1] prepared from rat liver has been compared with the incorporation obtained under the same conditions with a system prepared in exactly the same way from the livers of hypophysectomized rats. The system was prepared by homogenizing liver in a buffered-sucrose medium[1] and spinning at 14,000*g*. The unsedimented portion was incubated with the sodium salt of adenosine triphosphate, the sodium salt of creatine phosphate and DL-leucine-1-^{14}C. The incorporation obtained varied with the experimental conditions used, but in all cases less amino-acid was incorporated into the protein of hypophysectomized rats. The specific activity of the protein from hypophysectomized rats in ten experiments was between 20 and 70 per cent of that found in the normal control system. Treatment of the hypophysectomized rats with growth hormone restored almost to the normal level the ability of the cell-free system to incorporate amino-acids. This *in vitro* result is compatible with the *in vivo* observations that hypophysectomy results in a fall in liver weight and protein content and that treatment with growth hormone prevents this fall[2].

Incorporation into the proteins of the cell-free system takes place in at least two distinct steps. Hoagland, Zamecnik and Keller[3] have shown that the first step is the activation of the amino-acid by adenosine triphosphate and an enzyme present in the soluble fraction of the cell. Later the carboxyl-activated amino-acid is incorporated into protein on the ribonucleoprotein particles of the microsomes[4,5]. There may be intermediate steps between these two processes, and Hoagland, Zamecnik and Stevenson[6] have some evidence which implicates part of the ribonucleic acid of the soluble fraction of the cell in such a role.

The microsomes were separated from the activating enzymes and ribonucleic acid in the soluble fraction of the cell by centrifugation of the cell-free system at 105,000*g*. Neither the microsomes nor the soluble fraction when incubated separately in the presence of adenosine triphosphate, creatine phosphate and DL-leucine labelled with carbon-14 showed much incorporation, but incorporation into microsomal protein, to the extent found in the unseparated system, occurred when these two fractions were incubated together. A similar experiment (Table 1) with microsomes and soluble fraction from hypophysectomized rats showed the expected smaller incorporation into these microsomes. The microsomes from hypophysectomized rats were now incubated with the soluble fraction (supplemented with adenosine triphosphate and creatine phosphate) prepared from the normal animals and almost the same, smaller, incorporation was found. When normal microsomes were incubated with soluble fraction from hypophysectomized rats, almost normal amounts of radioactive amino-acid were incorporated into the microsomes. This shows that hypophysectomy was not causing changes in the activating enzymes, the energy generating system, or the possible ribonucleic acid intermediate[6] to any great extent, for the soluble fraction from hypophysectomized rats is capable of

Table 1. INCORPORATION OF DL-LEUCINE LABELLED WITH CARBON-14 INTO MICROSOMAL PROTEIN OF A CELL-FREE SYSTEM

	c.p.m./mgm. of microsomal protein
Normal microsomes + normal soluble fraction	146
Hypophysectomized microsomes + hypophysectomized soluble fraction	76
Hypophysectomized microsomes + normal soluble fraction	87
Normal microsomes + hypophysectomized soluble fraction	138

4 mgm. of microsome protein and 6 mgm. of soluble fraction protein were incubated at 37° in a buffered-sucrose medium (ref. 1) at *p*H 7·5 with adenosine triphosphate (6×10^{-3} *M*), creatine phosphate ($2 \cdot 3 \times 10^{-2}$ *M*) and DL-leucine-1-^{14}C ($1 \cdot 3 \times 10^{-4}$ *M* and about 40 μc./mgm.).

causing almost as great an incorporation as the soluble fraction from normal rats if it is incubated with normal microsomes. Most of the fall in incorporation resulting from hypophysectomy must be caused by some deficiency of the microsomes themselves. It is well known[7,8] that hypophysectomy in the rat is followed by a fall in the cytoplasmic ribonucleic acid content of the liver which can be prevented by administration of growth hormone. The observed changes in incorporating ability do not, however, depend on the total ribonucleic acid content of rat liver. Clark, Naismith and Munro[9] have shown that a large fall in the ribonucleic acid of rat liver occurs when rats are fasted, yet I have found incorporation of amino-acid into microsomes of cell-free systems from both normal and hypophysectomized rats fasted for 18 hr. to be the same as in fed animals. The ribonucleic acid which is broken down as a result of 18 hr. of fasting is not the same ribonucleic acid which is responsible for amino-acid incorporation into protein, nor is it the same as the ribonucleic acid which is lost as a result of hypophysectomy.

These experiments do not exclude the possibility that hypophysectomy also influences protein synthesis by inhibiting the entry of amino-acids into the cell or by decreasing the amount of energy available for these processes or by some other mechanism. It is, however, clear that hypophysectomy markedly reduces the ability of rat-liver microsomes to incorporate activated amino-acids into protein. The depression of protein synthesis after hypophysectomy[2] is probably secondary to this effect on the microsomes.

It is hoped to publish full details of these experiments in due course. I wish to express my thanks to Prof. F. G. Young for his interest and encouragement, to the Council of the Royal Society for a grant-in-aid, to Miss M. B. Thomas who performed the hypophysectomies and to Mr. D. C. Gardiner for highly skilled assistance.

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Adrenaline and Noradrenaline Content of the Adrenal Gland of the Rat following Depletion with Reserpine

It has been shown that reserpine causes a loss of catechol amines from cat[1] and rabbit[2] adrenal glands. In the experiments reported here a study has been made of the adrenaline and noradrenaline content of rat adrenal glands over a period of a month, reserpine being administered for the first 3 days. Thus information concerning the loss and replacement of amines was obtained.

Albino rats weighing 150–190 gm. were used, and in any one experiment all were of the same sex. In all instances groups of 5 rats were used, and every group had its own control, also of 5 rats. Each test animal was given reserpine (1 mgm./kgm.) subcutaneously, daily for three consecutive days. The control rats were given the reserpine solvent only. Groups of rats, with their respective controls, were killed at 3, 7, 14, 21 and 28 days following the first injection. In all, 170 rats were used. The adrenaline and noradrenaline contents of extracts of the glands were determined biologically, using the blood pressure of the hexamethonium-treated cat and the isolated uterus of the rat in dicestrus as test preparations. The results were calculated by the formula of Bülbring[3] and expressed in μgm./gland.

It was found that, at 3 days, reserpine caused a similar percentage loss of adrenaline and noradrenaline. This was despite the fact that normal rat adrenal glands contain only 10 per cent of noradrenaline. In all experiments the degree of depletion of both amines was of the order of 50 per cent. Following the depletion, the adrenaline content of the glands slowly returned to its initial, non-depleted value by 21 days and afterwards stayed at this level. In contrast, noradrenaline increased to several times its original value by seven days and then decreased to regain its original value by 21 days. Fig. 1 shows the typical percentage depletion of amines and their subsequent replacement. It may be noted that at the peak of the noradrenaline increase, the glands contained approximately 30 per cent of noradrenaline. All experiments gave similar results, there being no difference in this respect between male and female rats.

These results are further evidence that noradrenaline is a precursor of adrenaline in the rat, because otherwise it would be expected that the two amines

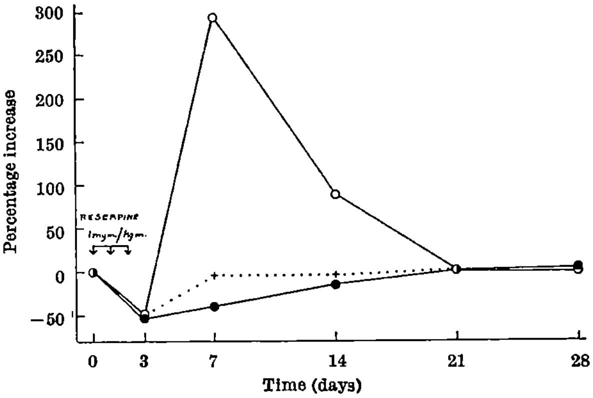

Fig. 1. A composite diagram to show the rate of replacement of adrenaline (●), of noradrenaline (○) and of total amine (+) in the adrenal gland of the rat, at various time intervals following depletion with reserpine. All results are expressed as percentages of the amine contents of the respective control glands

would return to their normal levels in a similar manner. The transient increase in the noradrenaline content, above the normal value, indicates that the rate of methylation of noradrenaline to adrenaline is slower than the rate of formation of noradrenaline. It is of interest that Butterworth and Mann[4] have obtained a similar depletion and replacement of catechol amines in cat adrenal glands, depleted with acetylcholine. Work is now in progress to determine whether this action of reserpine is central or peripheral.

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Nuclear Transplantation in *Xenopus laevis*

Briggs and King[1] have devised a technique with which they were able to transplant nuclei from cells of early embryos into unfertilized eggs of *Rana pipiens* from which the female pronucleus had been removed. In this way they could test the extent to which a nucleus from embryos up to neurula stages could produce normal development when transplanted into an enucleated egg[2].

We have modified this technique to start similar experiments on *Xenopus laevis*. We have not so far removed the female pronucleus because it does not usually participate in development. This useful fact was discovered through the use of a nuclear marker, visible in interphase nuclei (Fischberg, M., Smith, S., and Elsdale, T., unpublished).

A survey of the number of chromosome sets present in 70 normal and abnormal tadpoles gave the results shown in Table 1. The tetraploid embryos are usually due to the doubling of the diploid chromosome number of the injected nucleus, and not to the participation in development of the female pronucleus[1].

Table 1

	No.	Per cent
Diploids	55	79
Tetraploids	12	17
Mosaics, etc.	3	4
Total analysed	70	100

Table 2 consists of the combined results from six of our more successful experiments, and shows the number of embryos that appear normal at various stages of development up to the feeding tadpole. The donor nuclei came from embryos between late blastula and late gastrula stages, and between these limits the proportions of normal host embryos and the types of host abnormalities at different stages are similar; these appear not to be dependent upon the developmental stage of the donor nucleus and the germ layer from which it derives. Table 2 is heterogeneous, because it consists of the results from twelve different categories of donor nuclei (four temporal stages and three germ layers); we find that the numbers in the individual categories are too small to relate the abnormalities of transplanted embryos to the origin of the donor nucleus.

Table 2

	No.	Per cent
Total transfers	905	100
Uncleaved	387	43
Cleaved normal and abnormal	518	57
Normal gastrulæ	193	21
Normal at hatching	89	10
Normal feeding tadpoles	61	7

We have obtained normal tadpoles from eggs injected with ectoderm and endoderm nuclei from late gastrulæ. King and Briggs[2] obtained 10–12 mm. tadpoles from nuclei of ectoderm, chorda-mesoderm, and endoderm from late gastrulæ of *Rana pipiens*; but the majority of transplants from chorda-mesoderm and endoderm gave embryos developing syndromes of abnormalities specific for the origin of the donor nucleus.

We are continuing the work along two main lines: (*a*) to find the latest stages that provide donor nuclei which give normal development when transplanted into unfertilized eggs; (*b*) to see if embryos develop syndromes of abnormalities specific for the origin of the donor nucleus.

This work has been made possible by contributions from the British Empire Cancer Campaign (M. F. and T. E.) and the Medical Research Council (J. B. G.).

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Effects of Heat and Loss of Moisture on the Dormancy of Barley

In a paper on the effects of desiccation on delayed germination in barley it is suggested that ripening and germination are directly related to the moisture-content of the grain[1]. The observation is made that complete germination occurred when the moisture content naturally fell to 12·7 per cent or when artificial drying was used.

'Desiccation' was the word employed to describe drying at 40° C. It is the purpose of the present communication to direct attention to the fact that temperature can have an effect independent of the loss of moisture of harvested samples showing dormancy under seed testing conditions[2].

In an attempt to speed germination, treatments were given which included heat-sealing in polythene bags, some of which contained self-indicating silica gel, and oven-drying at 39° C. Room temperature, in late summer, varied between 16–24° C. Moisture-content was determined with a Marconi 933*A* meter, and checks made with a Carter/Simon oven. From each treatment 300 seeds were placed on damp sand.

Samples of Pioneer barley *A*27 (moisture content 16·3 per cent and germination 95 per cent), known to be dormant were sealed in polythene with silica gel. Overnight the moisture-content fell to 12·5 per cent when kept at 4° C. and to 10·7 per cent at room temperature. Germination after 6 days reached only 60 per cent and 57 per cent respectively; not significantly different from the control at 51 per cent.

At the same time samples of *A*27 were placed at 39° C. for 4 days. Germination after 6 days reached 95 per cent whether the sample was sealed (with a moisture loss of $\not>$ 1 per cent) or had dried down to 8·4 per cent moisture. The control, kept in a closed but not sealed polythene bag at room temperature for the 4 days, grew 75 per cent in 7 days.

Similar treatment was given to barley *A*29, moisture content 17·5 per cent, germination without treatment 60 per cent. After 2 days (or 4 days) at 39° C. germination reached 95 per cent or more with moisture-losses of either $\not>$ 1 or 7·5 per cent. Germination was adversely affected when grains on damp sand were sealed in polythene at 39° C. for 2 days.

It is suggested that, during natural desiccation, temperature, and probably time, may be more important factors than the precise moisture-content in affecting this type of delayed germination.

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A Mechanism of Resistance to Parathion in *Musca domestica* (L.)

THE ease with which the chlorinated hydrocarbons give rise to the development of resistance in *Musca* has led to the use of organo-phosphorus insecticides for controlling flies. However, development of resistance to some of these compounds appears possible also, although at present it seems to be less serious than in the case of the chlorinated compounds. An investigation into the mechanisms causing resistance to these substances has been undertaken.

Three strains, namely *S*, U_2 and *D*, with different parathion resistances were used in the present investigation. *S* is our susceptible laboratory strain which is also susceptible to parathion. Strain U_2, being highly resistant to γ-BHC and related compounds, shows some resistance to parathion, although it has never been in contact with organo-phosphorus insecticides. Strain *D* was collected by Keiding[1] on a farm (*J*79) in Denmark, where parathion had been used for a period of three years. It was submitted to further selection with parathion in the laboratory. Dr. Keiding kindly put this strain at our disposal.

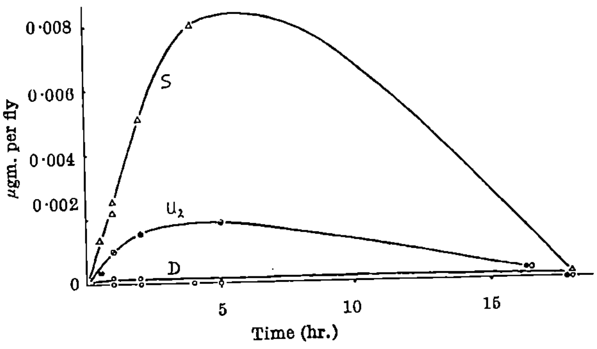

Fig. 2. Amount of paraoxon found in flies after injection of 0·01 µgm. of parathion in strains *S*, U_2 and *D*

It is assumed that parathion is oxidized in the flies to paraoxon, just as is the case in mammals[2] and in the roach (*Periplaneta americana*)[3], and that this compound exerts its action by inhibition of an enzyme, probably cholinesterase. As a first step, the susceptibilities of the strains to parathion and paraoxon were compared, using a contact method and injections (Fig. 1). In the contact experiments the flies were exposed in jars for twenty-four hours to a residue in a thin film of peanut oil. For the injections an emulsion of parathion dissolved in peanut oil was used, whereas paraoxon was injected as a solution in insect saline.

It was found that there is still a marked difference between the strains after injection of parathion. Therefore decreased penetration cannot be the cause of the resistance, or at least not the only cause. The differences found in the contact toxicity of paraoxon indicate that a resistance mechanism must be present that affects the susceptibility to parathion only through an influence on the toxic action of paraoxon. The difference after injection of paraoxon is discussed below.

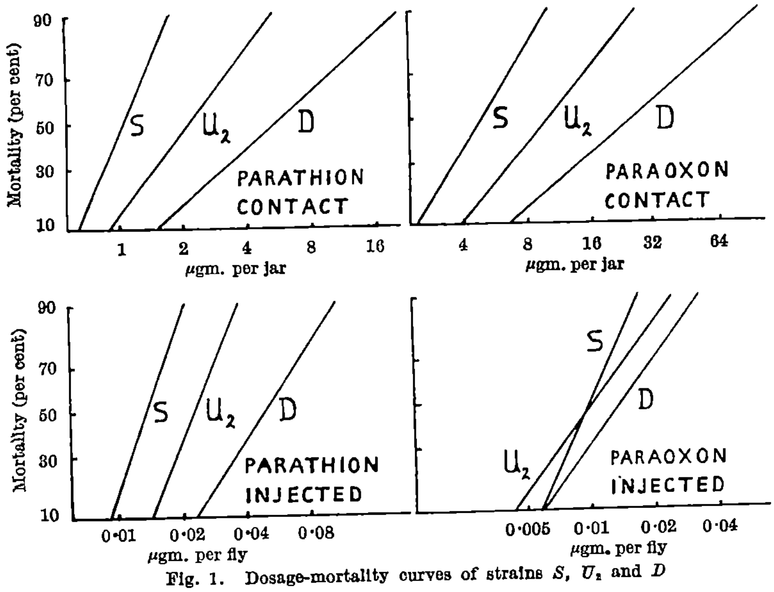

Fig. 1. Dosage-mortality curves of strains *S*, U_2 and *D*

The amount of paraoxon present after injection of parathion was estimated in the three strains. Upon injection the flies were kept at 25° C. for varying periods of time, after which they were homogenized and incubated for some time to bring the paraoxon in contact with the cholinesterase. The cholinesterase activity was estimated by the method of Hestrin[4]. The amount of paraoxon was determined by comparing the inhibition found with that caused by known quantities. Fig. 2 shows the results of injecting 0·01 µgm. of parathion per fly. A very large difference between the amounts of paraoxon in the three strains is apparent. The same was found after injections with larger doses. Injection of 0·02 μgm. resulted after a period of 5 hr. in about 0·017, 0·005 and 0·003 μgm. in strains *S*, U_2 and *D* respectively.

In another series of experiments 0·01 μgm. of paraoxon per fly was injected. After different periods of time a number of flies were homogenized, incubated and the inhibition of the cholinesterase was determined. Paraoxon was found to be eliminated more rapidly by the more resistant flies. Elimination of about 0·0085 μgm. of paraoxon was found after 6¾, 4 and 2¾ hr. in the strains *S*, U_2 and *D* respectively.

The fact that only small differences in susceptibility of the strains were found after injection of paraoxon may be explained by the very rapid action in this case. Apparently the elimination process can only protect the flies from the action of paraoxon if it appears in the body gradually.

The occurrence of only small differences in susceptibility after injection of paraoxon makes it less probable that an alteration of the affected enzyme is a cause of the resistance. As cholinesterase may possibly be this enzyme we estimated its activity in the strains and the amount of paraoxon required for its inhibition *in vitro*. Neither quantitative nor qualitative differences were found which could contribute to the resistance.

It is remarkable that strain U_2 —which was selected with γ-BHC —eliminates paraoxon much faster than strain *S*. This difference is not incidental, for it was found that strain *U*, a substrain of U_2 that has been bred for some years without selection and has lost its resistance to γ-BHC, has the same susceptibility to parathion as strain *S* and about the same capacity to eliminate paraoxon. There seems to be in this case some relation between the resistances to these quite different types of insecticides.

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Boron Deficiency in Tea

TEA must be the last commodity crop to show a need for boron. This is probably due to its low calcium requirement and to the fact that tea gardens are very rarely limed. The boron deficiency syndrome first appeared accidentally in a pot experiment testing five different soils for natural potassium uptake. All plants in two soils when they were about 30 cm. high died off at their growing points and developed corky excrescences on the undersides of petioles. These two soils were known from previous pot tests with tomatoes to be deficient in boron.

Half the plants in the experiment were then treated with a complete nutrient solution and half with the same solution without boron. Growth response to each treatment was rapid; but when the new shoots of the plants receiving no boron were about 25 cm. long, brown spots appeared, first in the petioles and then in the laminæ of the flush. As the young leaves developed, the brown spots enlarged in the laminæ and spread along most of the petioles and mid-ribs with considerable suberization. Normal growth was severely upset and affected leaves were strongly wrinkled and contorted. Cork was particularly thick on the underside of the petioles and often spread to the adjacent stems. Laminæ of affected petioles drooped to a near vertical position but remained quite turgid. Internodes were reduced to less than 1 cm. and finally growing-points died. Old leaves that had reached maturity before the boron deficiency became acute, exhibited suberized cracks on both sides of the upper surface of the main veins.

So far as can be ascertained the above has not yet been observed in field-grown tea bushes.

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Rate of Calcium Loss resulting from Ammonium Sulphate Treatment of a Tea Soil

FULL results of our investigation into the effect of treatment with ammonium sulphate on the calcium economy of a tea soil will be published elsewhere[1]; but certain preliminary observations can now be made. The soil under study, which is typical of the tea soils of north-east India, can be described as a highly acid loamy sand of alluvial origin, having *p*H about 4·5 and a low calcium content.

It is generally assumed[2] that the loss of bases resulting from application of 100 lb. of ammonium sulphate can be made good by applying about 110 lb. of calcium carbonate to the soil. The calculated rate of loss under our field conditions is, however, only about a third of the above figure. Our results appear to provide an indirect proof that tea growing in an acid soil and manured with ammonium sulphate absorbs nitrogen in the 'ammonia' form. It also follows from the results that, under our conditions, the tea plant takes up a considerable portion of its nitrogen requirement as 'free nitric acid'. The theoretical basis on which this latter deduction is made has already been explained by Pierre[3]. A chemical analysis of the tea plant growing in an acid soil supports the above deductions. As an illustration, the acidic and basic constituents in plucked tea shoots are given below (calculated by Truog's method[4]). The figures quoted do not refer to the whole plant and will not hold good in all cases, but they will serve to indicate the nature of the balance.

Total base-forming constituents, approximately 90 m.equiv./100 gm. dry weight.
Total acid-forming constituents excepting nitrogen, approximately 38 m.equiv./100 gm. dry weight.
Nitrogen content, approximately 375 m.equiv./100 gm. dry weight.

Our results also indicate that the rate of loss of calcium is higher in the case of shaded tea (that is, tea growing under a canopy of shade trees, in this instance, under *Albizzia chinensis* (Osbeck) Merr.) as compared with unshaded tea. Andrews and Cowart[5] have calculated the effects of fertilizers on the base supply of cotton soils from the unrecovered nitrogen percentage and chemical analysis of seed cotton. Although our case is complex, the same method can be used in the case of tea also. Under the plains conditions in north-east India, 1 lb. of nitrogen applied in the form of ammonium sulphate to unshaded tea is known to bring about an ultimate increase in yield of about 8 lb. of made tea. The corresponding increase in the case of shaded tea, on the other hand, is only about half that amount. From the nitrogen content of plucked shoots, an idea can be obtained about the percentage nitrogen unrecovered, although not all of it may necessarily be lost by leaching. It would appear that a higher percentage of nitrogen remains unrecovered in the case of shaded tea, and this, it is suggested, may serve as a qualitative explanation for the higher rate of calcium loss noted in the case of shaded tea.

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Occurrence of Sex Chromatin in the Basal Cells of the Epidermis and in Basal Cell Carcinomata

THE characteristic mass of sex chromatin, first observed by Barr and Bertram[1] in the nerve cells of the female cat, can be identified in the cells of several different tissues in the human female[2]. The method of 'nuclear sexing' is now a well-recognized technique of exceptional importance in the investigation of disorders of human sexual development. The technique has been applied to the study of human tumours and, provided that good histological preparations have been available, it has been found, in most cases, that sex chromatin was recognizable in the cells of tumours of female patients but not in those of males, that is, the tumour is of the same sex as the host[3-5]. The principal exception is in the case of teratomata, which are always of female nuclear sex if the host is female, but may be male or female if the host is male[3-6]. Two alternative hypotheses have been postulated in explanation of this anomaly: one presumes that the tumour arises by parthenogenesis of haploid germ cells followed by endomitosis to restore the diploid chromosome number; the other supposes that the tumour arises by conjugation of two haploid germ cells.

In addition to teratomata the basal cells of the epidermis and the basal-cell tumours of the skin have been found to be exceptional in this respect. Weinmann, Meyer and Marwah[7] found difficulty in diagnosing the nuclear sex of basal cell tumours of the skin. In a series of 11 such tumours from male patients a sex chromatin-like particle could be identified in many of the parenchymal neoplastic cells and also in many of the cells of the adjacent normal epidermis. It was not suggested that this particle indicated a sex reversal in these tumours, but rather that the chromatin structure of the cell was altered during oncogenesis. A similar explanation was invoked by Tavares[8]; he examined "undifferentiated cell carcinomata", a group of tumours regarded by him as separate from those showing evidence of differentiation, and found that of 18 tumours in males two appeared to be female; while of 35 tumours in females six appeared to be male and in 18 instances the result of sexing the tumour was equivocal. Sachs and Danon[9], on the other hand, reported that the basal cells of the epidermis were devoid of sex chromatin and suggested that this was due to the "high frequency of mitosis" in this site. In view of the discrepancies reported in these cells and in their tumours it was decided to investigate a fresh series of specimens.

The most critical method of determining the presence or absence of sex chromatin in tissue cells is to use these cells alone to determine the sex of the patient from whom the tissue was obtained. It is essential for this type of work that good histological preparations and suitable staining methods should be used. All the material used in this study was fixed in formalin, paraffin sections were cut at 5μ and were stained in hæmatoxylin and eosin, the staining being controlled by microscopical examination during differentiation.

A series of 37 sections of skin taken from the routine surgical material of the hospital was examined. The 'nuclear sex' was determined, first by examination of 100 basal cells and secondly by examination of 100 spinous cells of the overlying epidermis. Nineteen of the patients were female and eighteen male, in every case the 'sex' of the basal cells, the 'sex' of the spinous cells and the apparent morphological sex of the patient were congruous.

A consecutive series of 24 basal cell carcinomata were examined. The sections were first reviewed under the low power of the microscope to confirm the histological diagnosis and to select an area of tumour in which the cells were not too closely packed together by the surrounding tissues. The 'nuclear sex' was then determined by examination of 100 tumour cells followed by the examination of 100 cells in the adjacent epidermis. Nine of the patients were male and fifteen female, in every case the 'sex' of the tumour, of the skin and of the whole patient were identical.

Repeated examinations were made of many of the slides at different times; in no instance were anomalous results obtained.

These observations indicate that there is no peculiarity in the basal cells nor in their tumours, and that, given good histological preparations, sex chromatin can be identified in these structures as in all others. This point was made by Sohval and Gaines[10], who examined 134 tumours from female patients and found sex chromatin in only 33, and is of the utmost importance especially when cytological examination of cells and cell nuclei is used in the investigation of cases of sexual abnormality.

I am indebted to Miss C. D. M. McDougall and Mr. S. E. Wright, who were responsible for the excellent histological preparations which made this work possible.

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Effect of 2,4-Dichlorophenoxyacetic Acid on Pectin Methylesterase in Tobacco Pith Sections

The hypothesis by Bennet-Clark[1] that the degree of methyl esterification of the pectic substances of plant cell walls would have a marked effect on the plastic and elastic properties of such walls has directed attention to the role of the pectic substances in auxin-controlled extension growth. Ordin, Cleland and Bonner[2] have demonstrated that the methylation rate of pectins in the walls of coleoptiles is increased by auxin, and Tagawa and Bonner[3] have shown that the effect of various cations and of auxin on the physical properties of the walls are consistent with Bennet-Clark's hypothesis.

Recently, it has been shown[4,5] that the auxins, indoleacetic acid, 2,4-dichlorophenoxyacetic acid and α-naphthalene acetic acid may control the adsorption of pectin methylesterase to cell-wall fractions prepared from tobacco pith or Jerusalem artichoke tubers. The auxins, up to an optimal concentration of about 10^{-10} M, increased the amount of enzyme adsorbed. It was proposed that the extent of methyl esterification of the pectic substances of the walls in elongating cells could be controlled by auxin-induced adsorption of pectin methylesterase.

Evidence has now been obtained for an auxin-controlled mechanism of adsorption of pectin methylesterase in intact disks of tobacco pith. When pith from *Nicotiana tabacum* v. *glauca* was placed in a solution of 0·5 per cent pectin and 0·1 M sodium chloride, considerable pectin methylesterase activity could be measured. The rate of hydrolysis of ester bonds of the pectin (measured by the rate of acid production) gradually increased until a steady rate was reached. Vacuum infiltration of the disks with the pectin assay solution did not reduce the time for the attainment of the steady rate, indicating that the initial change of rate was not due to penetration of pectin into the disks.

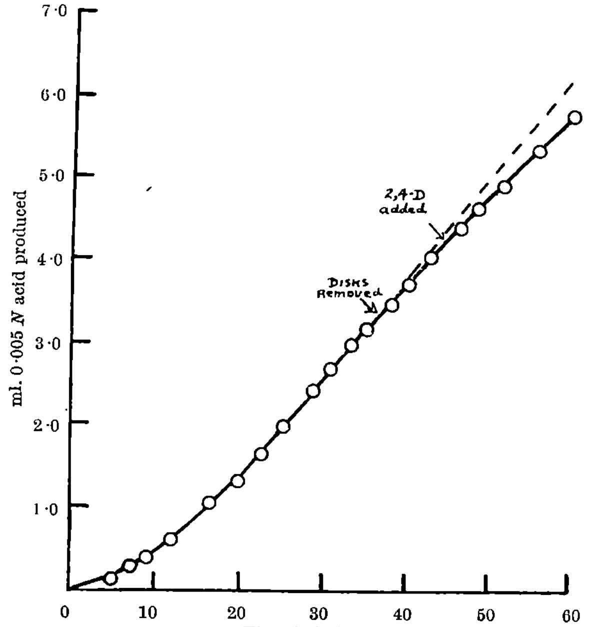

Fig. 1. Hydrolysis of pectin by pectin methylesterase extracted from tobacco pith disks by the assay solution. (0·5 per cent pectin; 0·1 M sodium chloride)

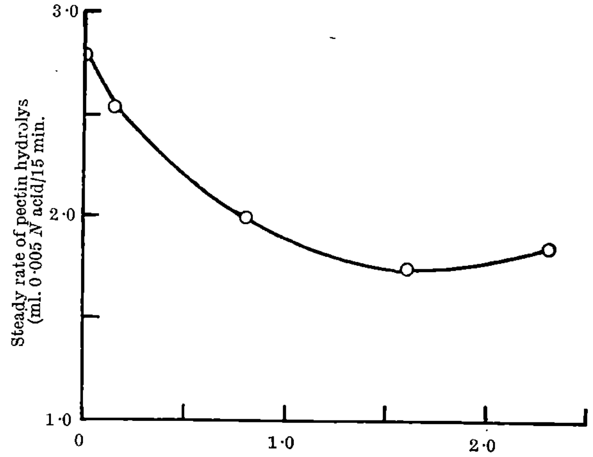

Fig. 2. Effect of 2,4-dichlorophenoxyacetic acid on the extraction of pectin methylesterase from tobacco pith disks. (0·5 per cent pectin; 0·1 M sodium chloride)

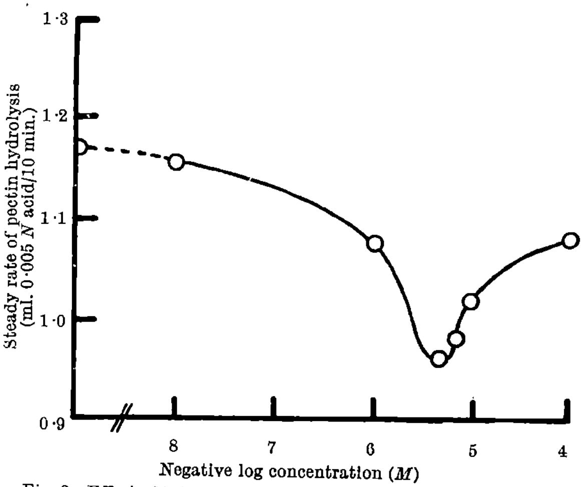

Fig. 3. Effect of 2,4-dichlorophenoxyacetic acid on the extraction of pectin methylesterase from tobacco pith disks. (0·5 per cent pectin; 0·2 M sodium chloride)

Removal of disks from assay solution after the steady rate had been reached showed that about 90 per cent of the measured pectin methylesterase activity remained in solution. When sodium chloride was omitted, no pectin methylesterase was extracted.

If disks which had been in pectin and sodium chloride until a steady rate of acid production was reached were transferred to a fresh assay solution, a second lot of pectin methylesterase was extracted. Again a steady rate was reached. The steady rate, therefore, represented an equilibrium position between enzyme in the assay solution and enzyme bound in the disks. The enzyme in the disks did not contribute substantially to the rate at which the pectin of the assay solution was de-esterified. This can be seen from Fig. 1, which also shows that 2,4-dichlorophenoxyacetic acid had no significant effect on the activity of pectin methylesterase when free in solution.

When 2,4-dichlorophenoxyacetic acid was included in the assay system, the steady rate of pectin hydrolysis by the disks was greatly affected. In Fig. 2 the steady rates are plotted against concentration of 2,4-dichlorophenoxyacetic acid. Fig. 3 shows results for a wide range of concentrations of 2,4-dichlorophenoxyacetic acid and 0·2 M sodium chloride as the extracting solution.

It is suggested that 2,4-dichlorophenoxyacetic acid shifts the equilibrium position for partitioning the enzyme between the disks and the external medium by controlling the binding of pectin methylesterase to sites in the cell wall.

These observations strengthen the hypothesis for the relation between auxin-controlled extension growth and auxin-controlled adsorption (inactivation) of pectin methylesterase[4,5]. Evidence for the heterogeneity of pectin methylesterase and adsorption sites in cell walls, a mathematical treatment of the adsorption process, and full details of experiments outlined here will be published elsewhere.

Acknowledgments are due to Dr. R. N. Robertson for helpful advice and criticism and to Miss Sue Ingles for technical assistance.

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Radicle Elongation of *Pseudotsuga menziesii* in Relation to Light and Gibberellic Acid

One of the characteristics of the 'bakanæ' disease of rice (which is caused by *Gibberella fujikurio*, the fungus which produces gibberellic acid) is its ability to stimulate adventitious root formation. Attempts to increase root development with artificially supplied gibberellic acid, however, have almost invariably failed; indeed, it has been claimed that root elongation is inhibited by the gibberellins[1,2]. With few exceptions, observations of root effects have been incidental to studies of shoot development and it is possible, therefore, that observed effects on roots are indirect and result from a re-distribution of material within the plant from root to shoot.

In view of the uncertainty relating to the influence of gibberellic acid on root elongation, it seemed of interest to test its effect directly, on material uncomplicated by the presence of an active shoot system. In the experiments reported here, elongation of the radicles emerging from germinating Douglas fir seed before the onset of cotyledon growth was used to measure the effect of the chemical. At the same time, a possible interaction between gibberellic acid and light was investigated.

Preliminary tests employed a light treatment (continuous light at 4,000 lux and continuous darkness) and five gibberellic acid treatments (0, 3, 10, 30 and 100 p.p.m. applied in de-ionized water to filter paper and used as a growth medium). Root elongation over a 24-hr. period was markedly inhibited by exposure to light, but in both light and darkness there was a stimulation by low concentrations (about 3 p.p.m.) of gibberellic acid. To investigate these effects more precisely, seeds were germinated at 20° C. in Petri dishes and treated with gibberellic acid in concentrations of 0, 0·01, 0·10, 1·00 and 5·00 p.p.m. Again, two light treatments (continuous light and continuous darkness) were employed. Radicle elongation-rate over a 24-hr. period was measured on 45 roots from each treatment, chosen so that three size classes (<5 mm., 5–10 mm. and >10 mm. in initial length) were equally represented.

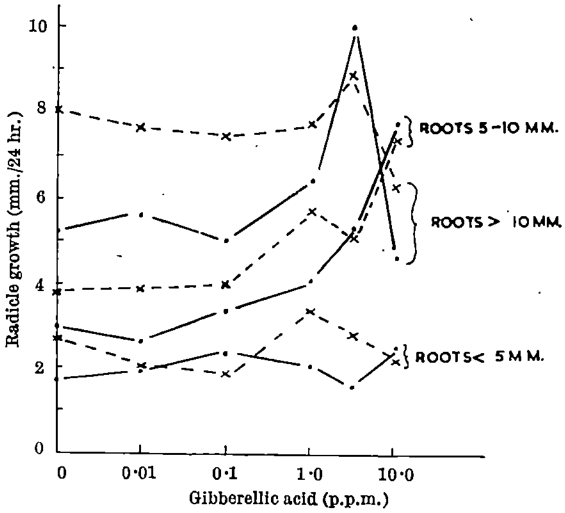

Fig. 1. The effect of light and gibberellic acid on radicle elongation of *Pseudotsuga menziesii* as related to initial root length. × --- ×, Growth in darkness; ● — ●, growth in light

In Fig. 1, mean growth-rates are plotted against acid concentration by size class and light treatment. Roots greater than 5 mm. in initial length show a marked response to gibberellic acid treatment, the optimum concentration shifting from 10 p.p.m. to 5 p.p.m. with an increase in initial length of root.

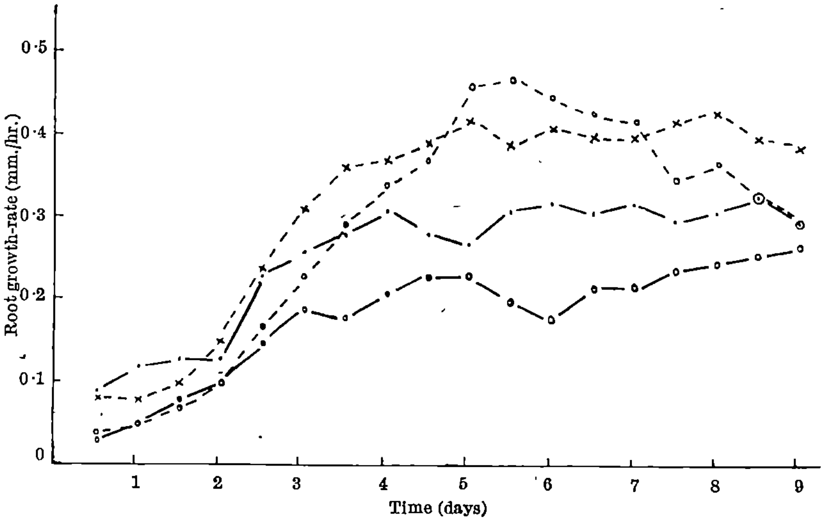

Fig. 2. The effect of light and gibberellic acid on the time course of radicle elongation in *Pseudotsuga menziesii*. ● — ●, dark; × -- ×, dark + gibberellic acid; O — O, light; O -- O, light + gibberellic acid

The inhibiting influence of light is also demonstrated, the effect increasing with increasing root size; and there is an apparent interaction between light and gibberellic acid. The response to optimal concentration of gibberellic acid is greater in light than in darkness and the inhibiting effect of light on the growth-rate is more than overcome.

Fig. 2 presents the results of another experiment in which the course of root growth in response to 8 p.p.m. gibberellic acid was followed over a period of time. Again there is a marked response to acid treatment though it is initially much greater in light- than in dark-grown roots.

In spite of certain difficulties in interpretation of these results, it is clear that gibberellic acid can stimulate root elongation. It is also apparent that light inhibits root elongation, and that, under some conditions, gibberellic acid and light interact. Nevertheless, the results presented are not incompatible with Lockhart's[3] contention that the action of artificially supplied gibberellic acid is specific on elongation and not directly connected with light responses. With the view of analysing the light inhibition of root elongation, studies of its action spectrum have been initiated. There are preliminary indications that the light-reaction peaks at 5400–5800 A. with subsidiary peaks at 3800 A. and 6600 A. A full report on this work will be published elsewhere.

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Partial Inhibitory Effect of *Plistophora culicis* on the Sporogonic Cycle of *Plasmodium cynomolgi* in *Anopheles stephensi*

DURING some experimental work carried out on the cytology of early oocysts of *Plasmodium cynomolgi* in *Anopheles stephensi* an interesting observation was made. Three batches of laboratory-bred *Anopheles stephensi* were fed on a rhesus monkey (*M.* 172) infected with *P. cynomolgi*. Dissections of 4–10 mosquitoes on each subsequent day showed that the first and third batches of these mosquitoes were also infected with a microsporidian (*Plistophora culicis*). (Such infections have previously been described by Garnham[1] and Canning[2].) Nearly 50 per cent of the dissected mosquitoes showed a moderate infection of *P. culicis* in the first batch, a light infection of about 5 per cent in the second batch, and approximately 100 per cent with heavy infections of *P. culicis* in the third batch. A poor rate of infection by *P. cynomolgi* was found in the first and third batches of *A. stephensi,* and this was considered due to the partial inhibitory influence of *P. culicis* on the development of the oocysts in these mosquitoes. This view was supported by the findings of good oocysts counts in the mosquitoes dissected from batch two in which the *P. culicis* infections were very light.

Plistophora culicis had not only invaded the fat bodies and Malpighian tubules, but also in many mosquitoes the whole surface of the mid-gut was covered by the microsporidian. The inhibitory influence on the development of *P. cynomolgi* in such insects was primarily reflected in a low oocyst count; in most mosquitoes only one or two oocysts could be found on each mid-gut. The growth of these oocysts was also retarded. Thus five-day-old oocysts measured 19μ in diameter compared with the normal oocyst size 21μ seen in mosquitoes uninfected with *P. culicis* after this time. Seven-day-old oocysts measured only 55μ in diameter compared with the normal size of 60μ. The diameter of mature oocysts in the mid-guts heavily infected with *P. culicis* was only 84μ compared with the usual 90μ. The highest rate of infection with *P. cynomolgi* oocysts in the mosquitoes concomitantly infected with *P. culicis* was 20 per cent and the lowest 10 per cent. Many degenerating oocysts were seen.

One may conclude that the partial inhibitory effect of *Plistophora culicis* on the sporogonic cycle of *P. cynomolgi* in these batches of *A. stephensi* may be due to the following possibilities: (1) The scarcity of essential nutriments in the body of the host may be responsible for the retarded growth and degeneration of fully developed ookinetes and young oocysts. These essential substances were presumably taken up by *P. culicis* for its own development. (2) Many specimens devoid of oocysts showed the whole surface of the mid-gut covered with *P. culicis*. The presence of this microsporidian may have prevented the penetration of ookinetes through the stomach wall and resulted in the degeneration of these 'vermicules' inside the lumen. (3) The heavy infection of Malpighian tubules with *P. culicis* may cause abnormality in their function. Afterwards the deposition of toxic substances might interfere with the development of oocysts and sporozoites of *P. cynomolgi* in the insect host.

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Isolation of a Soil Coccus capable of utilizing 'Tween 80' as a Sole Source of Carbon

IT is interesting that some organisms can utilize as their source of carbon a synthetic substance such as 'Tween 80' (polyoxyethylene sorbitan mono-oleate). My collaborators and I[1] have proved that tubercle bacilli can utilize 'Tween 80' as a sole source of carbon, and Yamane *et al.*[2] then devised a simple and practicable 'Tween'-agar medium for tubercle bacilli containing 'Tween 80' as a main source of carbon. I wished to investigate[3] the details of the mechanisms of 'Tween' metabolism, but tubercle bacilli are not suitable for this purpose because their growth is so slow, their endogenous substrates are too abundant[4], and experiments with the bacilli can be dangerous. I therefore decided to try to isolate bacteria more suitable for the purpose from the soil.

The isolation was carried out on Yamane–Minami–Yasui agar[1], which contained 'Tween 80' as a sole source of carbon. After incubating the supernatant of soil suspension at 37° C. for 24 hr., a few bacterial colonies were developed, among which there was a coccus. This organism was a Gram-negative coccus

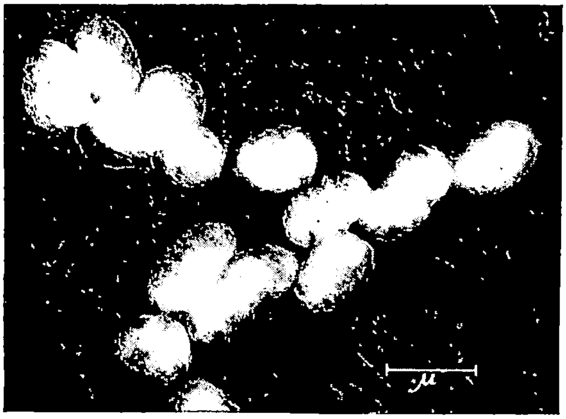

Fig. 1. Electron micrograph of the newly isolated coccus grown in a synthetic medium containing 'Tween 80' as a sole source of carbon for 6 hr. Shadowed with chromium. Flagella-like structures around the cell periphery were observed. The electron-transparent regions immediately inside the cell wall were observed only in the cells in the logarithmic growth phase; their nature and the mechanism of formation are now under investigation

of 0·5–1·2μ in diameter, occurring singly, in pairs or in clumps. It was non-motile, but flagella-like structures were observed by electron microscopy (Fig. 1). Growth occurred well on nutrient agar, blood agar and especially well on 'Tween'-agar[2] under aerobic conditions, developing smooth, flat and greyish-white colonies. Sugar fermentation was very poor: glucose, arabinose, xylose and galactose gave slight acid formation only after long incubation (2–4 days). Simmons's citrate test was positive; urease was negative. Nitrates were not reduced to nitrites; catalase was positive; indole was not formed; gelatin was not liquefied within 2–3 weeks.

In general, taxonomic characteristics of this organism resembles closely *Neisseria catarrhalis* (Frosch and Kolle) Holland[5], but it differs in its habitats and some of its sugar fermentations. So this organism belongs to the Micrococcaceae rather than to the Neisseriaceae, but no description corresponding to this organism has been found in Bergey's system[5]. I believe it is a new strain of Micrococcaceae, and propose the name *Micrococcus tweenis* for it. (The details of the taxonomic description will be presented elsewhere.)

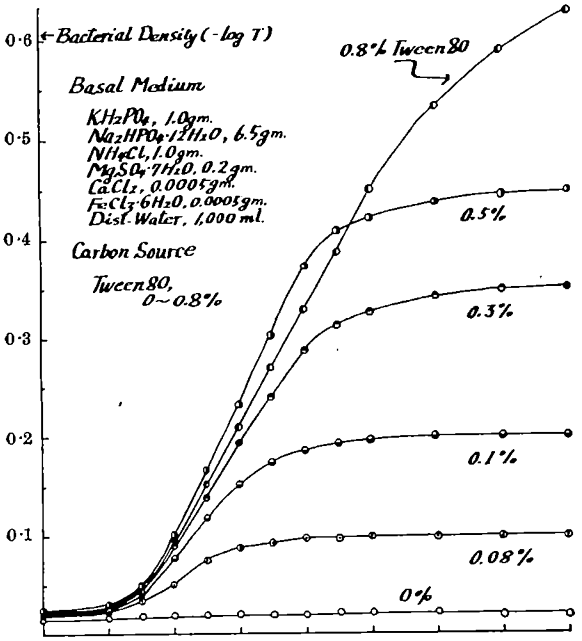

Fig. 2. Growth curves of a newly isolated coccus grown in synthetic media containing 'Tween 80' as sole source of carbon. The concentration of 'Tween 80' was varied from 0·08 to 0·8 per cent. The culture was shaken at about 55 strokes per min. at 87° C.

Fig. 2 shows the growth-curves of this organism grown in synthetic media[1] containing 'Tween 80' as a sole source of carbon. The higher the concentration of 'Tween 80' used, the more abundant was the growth; and if no 'Tween 80' was added, no growth was observed.

'Tween 80' (0·05–0·8 per cent) stimulated the oxygen uptake of the cell suspension prepared from an 18-hr. culture grown on 'Tween'-agar medium. The oxygen uptake was also stimulated vigorously by such long-chain higher fatty acids and substances related to the tricarboxylic acid cycle such as oleate, stearate, palmitate, acetate, succinate, malate, fumalate, glutamate and aspartate, and to some extent by citrate and lactate.

Details of investigations with this organism will be reported elsewhere.

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Polyploidy in Bluebells

IN my preliminary account[1] on polyploidy in bluebells (*Endymion nonscriptus* (L.) Garcke, and *E. hispanicus* (Mill) Chouard), I mentioned that some of the huge forms in gardens which I found to be triploids looked very much like the central one of Turrill's coloured figures[2]. Owing to the absence of any caption on Turrill's figures, I was led to take this huge central figure as the putative hybrid between the two species which Turrill mentions in his text. A few months after my publication, Turrill[3] explained his figures and pointed out that the central figure was *E. hispanicus*; he also suggested that since I did not examine his own material cytologically the material which I examined and found to be triploid might be different from his in ploidy.

I therefore asked for some of his material of *E. hispanicus*, most of which on cytological examination I found to be triploid. Thus it seems there is little doubt but that the huge bluebell represented by the central figure of Turrill's coloured figures is the triploid of *E. hispanicus* and not the ordinary (diploid) form.

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Micro-fungi in Pine Litter

ALTHOUGH a certain amount of work has been carried out on the microbiological characteristics of horizons in podzol soils, there is as yet little relating to the subdivisions of the A_0 horizon. In any such work there are obvious advantages in studying litter derived from a single species. Plantations of *Pinus sylvestris* have the added advantage that slow decomposition of the litter leads to the accumulation of a considerable A_0 horizon readily divisible into distinct layers. The A_0 horizon of forest soils can be subdivided in the following way : *L* layer, undecomposed litter ; *F* layer, decomposing but still recognizable litter ; *H* layer, amorphous humus. In cases of considerable accumulation the *F* layer may be further subdivided into *F*1, needles dark in colour, often still intact, and *F*2, needles greyish, fragmentary, compressed[1].

Samples of the *L*, *F*1 and *F*2 layers of the A_0 horizon of the podzol at Delamere Forest, Cheshire, were selected by inspection and transported to the laboratory in separate, sterile containers. Preliminary work with the standard dilution plate technique proved unsatisfactory, and records of the fungi on the needles were made therefore by two methods : (1) direct observation of freshly sampled needles ; (2) observation of needles rigorously washed to remove surface-borne spores and maintained on a nutritive medium for two weeks. The type of result obtained is shown in Table 1. The abundance of the different fungi is expressed as the percentage of the total number of needles on which each fungus was observed.

Table 1 demonstrates both qualitative and quantitative differences in the fungal populations of the three subhorizons investigated. Direct observation showed maximal fungal activity to occur on needles of layer *F*1. Numerous fruiting structures of several fungi not represented on nutritive media were also seen in this layer. In layer *L* only *Lophodermium pinastri* was regularly observed, but in layer *F*1 three species other than *Lophodermium* occurred with very high frequency. *Verticicladium trifidum* has been recorded by Hughes[2], but the *Helicoma* species will be described elsewhere as a new species, and isolate 1/6 will be described elsewhere as a new genus. The two new forms are darkly pigmented, and produce reticula on the needle surface from which the conidiophores arise. Layer *F*2 showed mutilated remains of these fungi, a result of the activities of mites and other microfauna. Basidiomycete mycelium was, however, observed most frequently in this layer.

The cultural method of isolation revealed several fungi not seen by direct observation. Certain of these, that is, *Antennularia*, sterile dark isolate 3/10 and *Fusicoccum* were seen to occur with decreasing frequency from layer *L* to layer *F*2, while there was a corresponding increase in the occurrence of *Trichoderma* and *Penicillium* species. Little indication of this clear-cut succession was obtained by the use of the dilution plate technique. The above data are based on isolations carried out in March 1957, but comparable differences between the subhorizons have been recorded for all other months.

Table 1

Method	Layer *L*		Layer *F*1		Layer *F*2	
	Spp. recorded	Frequency (per cent)	Spp. recorded	Frequency (per cent)	Spp. recorded	Frequency (per cent)
Direct observation	*Lophodermium pinastri*	35	*Helicoma* sp.	92	*Basidiomycete* mycelium	55
			Verticicladium trifidum	89		
			Isolate 1/6	89		
			Lophodermium pinastri	40		
			Basidiomycete mycelium	12		
Washing and plating on nutritive agar	*Antennularia* spp.	75	*Trichoderma viride*	75	*Trichoderma viride*	100
	Isolate 3/10	60	*Antennularia* spp.	40	*Penicillium* spp.	45
	Fusicoccum bacillare	35	*Penicillium* spp.	25	*Antennularia* spp.	5
	Trichoderma viride	35	Isolate 3/10	10		
			Fusicoccum bacillare	10		

I wish to express my thanks to Prof. A. Burges and Dr. D. Parkinson for their guidance during this work, which was carried out during the tenure of an Agricultural Research Council Research Studentship.

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Protogynous Hermaphroditism in *Coris julis* L.

Coris julis L. and *C. giofredi* Risso have long been regarded as separate species, although Steindachner[1] claimed *julis* to be the male and *giofredi* the female individuals of the same species. In the Bay of Naples Lobianco[2] found mature male and female individuals both in *C. julis* and in *C. giofredi* and therefore rejected Steindachner's hypothesis of sexual dimorphism in *Coris*.

Work on this subject was resumed in the summer of 1956 following reports of transformation of *giofredi* into *julis* individuals in the basins of the Leghorn Aquarium (Razzauti). As hermaphroditism has been shown to be widespread among teleosts[3], researches were undertaken upon the hypothesis of the existence of false gonochorism[4] in *Coris*.

Statistical and histological investigations were conducted on 329 samples taken during August 1956–January 1957 from populations living at a depth of between 8 m. and 30 m. in the vicinity of Leghorn.

Typical, fully grown individuals in the *julis* livery have a mean length of 14·81 ± 0·32 cm. and they are distinguished by a marked prominence of the first three rays of the dorsal fin and by a prominent tooth at the proximal end of each upper jaw. Their colours are very bright: the dorsal region is blue-green, a long deep orange band runs from the opercular region to the tail and a short black strip extends under it from the attachment of the pectoral fin to a region below the eleventh dorsal ray. The sides of the ventral region are white or shaded with light blue.

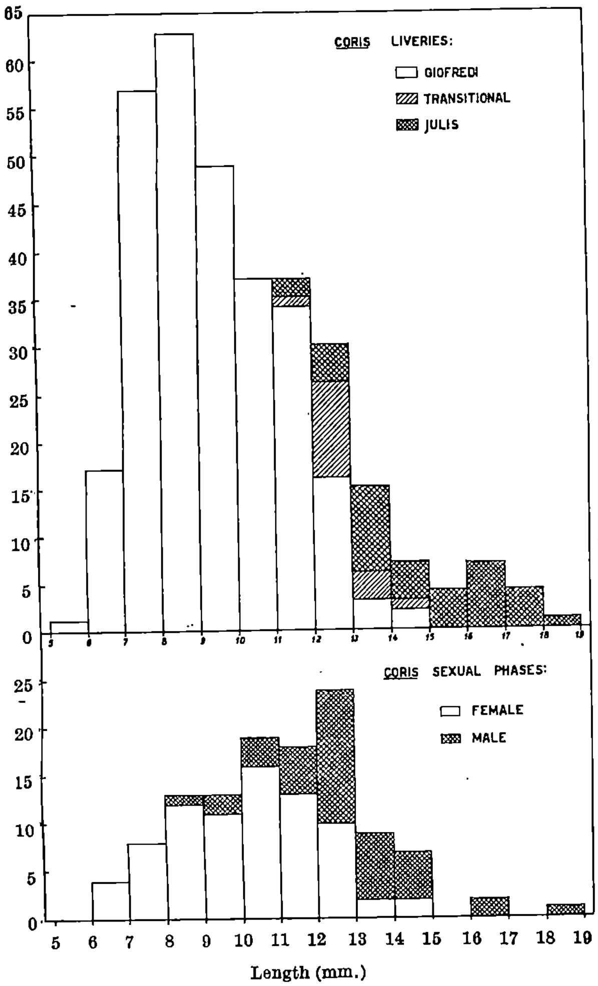

Fig. 1. Frequencies of *Coris* individuals in the different liveries (above) and in male and female phase (below) at various lengths (in millimetres)

Conspicuous black and red spots are evident between the first three rays of the dorsal fin.

Individuals in the *giofredi* livery have a mean length of 9·29 ± 0·57 cm. The above characters are missing, the dorsal region is brown and a golden band is visible on each side of the ventral region.

Intermediate characters are found in individuals with a mean length of 12·76 ± 0·10 cm.: the first *julis* character which appears among smaller transition individuals is a prominence of the first three dorsal rays, and the teeth at the ends of the upper jaws are the last character to be established in *julis* individuals (Fig. 1, above).

Gonads are reduced during the months from August to January and therefore individuals were sexed by histological methods. The examination of 118 paired gonads showed that smaller specimens (mean length 10·14 ± 0·22 cm.) are females, bigger specimens (mean length 12·75 ± 0·30 cm.) are males. A few big individuals in the *giofredi* livery (15·9 per cent) are nevertheless males. Transitional individuals are mostly (66·6 per cent) males (Fig. 1 below). Thus the livery appears to be partly independent of sex-conditions. Only a few specimens showed signs of a preceding female phase (small and degenerating oocytes) in gonads where most germinal cells were beginning spermatogenesis. These individuals (which were classified in the male phase) were either large sized *giofredi*, transition forms or small sized *julis*. Young individuals were all females and they showed the *giofredi* livery.

No regional preference of male and female germ cells in the reversing gonad has been detected so far, and the developing male germ cells rapidly replace oocytes after their expulsion or degeneration. For this reason gonads appear generally in pure female or male conditions.

Investigations are now being conducted with samples both from Leghorn and from the north-western coast of Sardinia in order to study the whole annual cycle and sex variation in *Coris*. Nevertheless the following conclusions can be drawn from the present results: (*a*) *C. giofredi* and *C. julis* are the younger and older individuals of a single protogynous hermaphrodite species (or intersexual species according to D'Ancona's terminology) that must be named as *Coris julis* L.; (*b*) since the sex change from female to male phase runs roughly parallel to the change of the livery, the female and the male phases in most individuals (but not in all of them) are represented by the *giofredi* and the *julis* livery respectively; (*c*) as a supposed 'sex dimorphism' is widespread among members of the Labroid family, it may indicate the existence of false gonochorism among other species of the group.

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Size Variation in *Entamoeba histolytica*

The human bowel is inhabited by amoebæ with the morphology of *Entamoeba histolytica*, but of differing mean size. The larger of these can be tissue-invading pathogens or may, usually in a smaller form, remain as a commensal in the bowel[1]. Further, there is considerable overlap in size range, at least in the commensal form, with a still smaller amoeba of similar morphology which has variously been known as *E. hartmanni* Prowazek, 1912; *E. histolytica hartmanni* Hoare, 1949; or as the small race of *E. histolytica* of Dobell, 1919. Of these views, the latter two have been the most widely favoured, but the work of Burrows[2] has indicated that there are morphological differences which suggest that the small amoeba should be considered a distinct species. However, there is, even on Burrows's criteria, still overlap with the large form, certain features being found sometimes in one and not in the other and vice versa.

Recently, we encountered a stool in which there were, fairly obviously, two different sizes of amoebæ, both with *histolytica* morphology. In a culture, this difference continued over a period of months. Fig. 1 shows a histogram based on the diameters of 600 live trophozoites from such cultures and shows a superimposed normal distribution from the hypothetical mean (4·6 micrometer units—10 micrometer units = 25·75μ) and its standard deviation (1·89). The

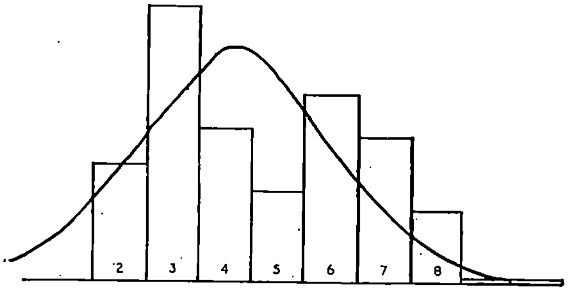

Fig. 1. Histogram of line *Z* based on the diameter of 600 live trophozoites with a superimposed normal curve based on the hypothetical mean and its standard deviation (10 micrometer units = $25 \cdot 75 \mu$)

bimodal curve actually found indicates that there were clearly two different types present.

In the course of experimental work to be reported elsewhere on the isolation of amoebæ from human liver abscesses, we noted that the size of these amoebæ is apparently governed by the type of bacterial associate provided. Fig. 2 shows three frequency polygons showing the size of lineal descendants from the same specimen (*L*) of liver pus. *L*.68 (mean diameter $20 \cdot 8 \mu$; standard deviation $3 \cdot 0$) was isolated in culture with *Clostridium welchii* as associate; *L.M.* (mean diameter $15 \cdot 4 \mu$; standard deviation $2 \cdot 9$) was isolated by the provision of a mixed flora *M*. The difference in size is significant, being more than three times its standard error ($P < 0 \cdot 001$). When, however, these lines were mixed and cultured together the resultant curve was unimodal (mean diameter $16 \cdot 9 \mu$; standard deviation $2 \cdot 3$) and lay between the two parent curves, showing that the difference in size was due to environmental effects.

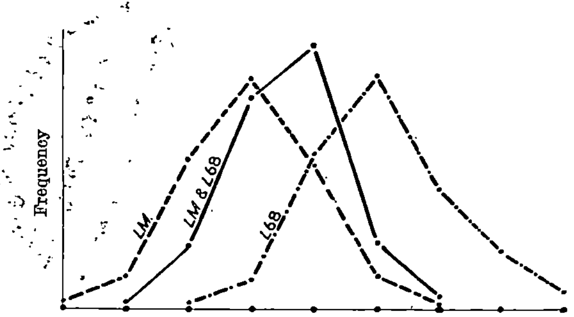

Fig. 2. Size-frequency polygons in lines *L*.68 and *L.M.* and in their combined culture *L.M.* and *L*.68, which gives a unimodal curve

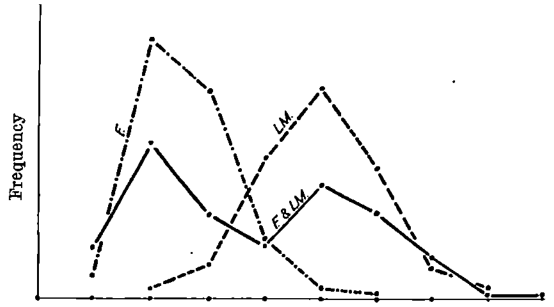

Fig. 3. Size-frequency polygons in lines *F* and *L.M.* and in their combined culture *F* and *L.M.*, which gives a bimodal curve indicating that *F* and *L.M.* segregate

We therefore mixed amoebæ which would be considered as 'large' and 'small' races. Fig. 3 shows the effect of culturing line *F* (mean diameter, $9 \cdot 3 \mu$; standard deviation $2 \cdot 1$) with its full associated flora, with line *L.M.* (mean diameter, $15 \cdot 4 \mu$; standard deviation $2 \cdot 9$), originating from the liver, but associated with a stool flora *M*. The mixture shows a significantly bimodal curve similar to that found with *Z*. An apparently commensal large line *B* (mean diameter, $19 \cdot 2 \mu$; standard deviation $3 \cdot 1$) when mixed with *F* also gave a bimodal curve.

It would thus appear that, although size can be varied by changing the bacterial associate of a line of 'large' *E. histolytica*, the 'small' race is genetically different and is distinguishable from the large when the two are cultured together in a single test-tube. This phenomenon is analogous to reproductive isolation in sexually reproducing organisms, a valid criterion for specific separation. This would suggest that the small amoeba with *histolytica* morphology occurring in human stools, and hitherto known as 'small race' or *E. histolytica hartmanni*, should be a separate species, *Entamoeba hartmanni* Prowazek, 1912.

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Lapse-time Motion Picture Studies of Soil-burrowing Insects

During the past few years, studies of the movements of soil-burrowing insects have been made using radioactively tagged insects[1]. Originally, the method involved finding the position of maximum response of a manually operated portable Geiger tube and ratemeter, but later a machine was developed which would record automatically the movement of a radioactively tagged insect such as a wireworm[2]. The sensing element in this machine was a thyrode tube (Victoreen 1*B* 85), rotated about a vertical axis at the end of a fixed arm. Translatory movements of the axis of Geiger revolution were recorded on an operating surface by a stylus.

The possibility of using this machine for obtaining motion-picture studies of insect movements has been investigated. In effect, the wireworm, by means of the tag and the machine, was provided with a pencil. The movements of the pencil and machine were photographed, using lapse-time technique to give a speeded-up picture of the worm movements.

A wireworm was tagged and liberated in a tray of soil placed on the floor. A table was placed over the tray and the machine set on the table. A sheet of glass was placed over the machine. A piece of grease pencil was attached to the machine on the Geiger axis and held in contact with the under-surface of the glass by a spring. The path taken by the wireworm was thus traced on the lower side of the glass sheet (Fig. 1).

A 16-mm. ciné camera was mounted above the machine so as to view it through the glass sheet. The camera was equipped for solenoid-controlled

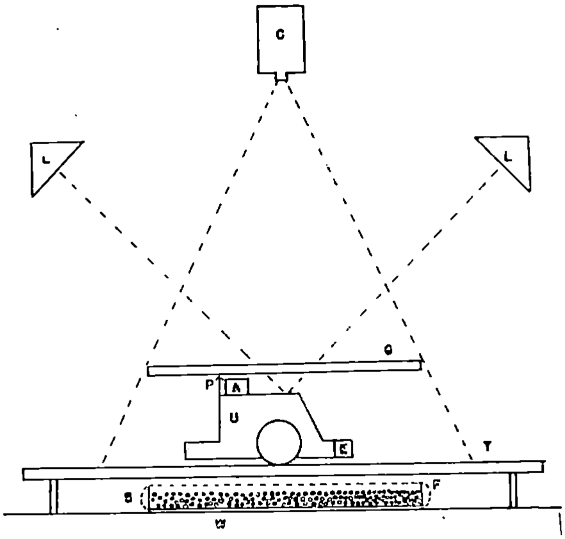

Fig. 1. Equipment used for lapse-time pictures. *C*, camera; *L*, lights; *G*, glass sheet; *P*, writing stylus; *U*, tracking unit; *T*, table; *S*, tray of soil; *F*, plastic moisture seal; *W*, tagged wireworm; *A*, clock; *E*, camera timing unit

single-frame exposures. The solenoid was operated by a clock-controlled microswitch mounted on the tracking unit. The exposure interval chosen was 30 sec. and pictures were taken over a 3-hr. period. The result was essentially a speeded up ciné film of the wireworm's movement in a period of 3 hr. (Fig. 2). The particular wireworm involved travelled at the rather high speed of 23 in./hr. As it turned out, the whole operation was rather abbreviated and the exposure interval chosen was too long. However, the short film obtained serves to demonstrate the value of the technique.

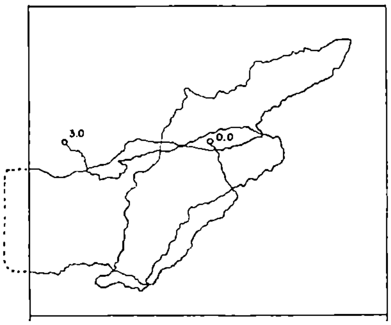

Fig. 2. Copy of the final trace obtained in lapse-time test. Figures give the time in hr. after the worm was introduced. The part of the trace indicated by a broken line was outside the field of view of the camera for a short time. Soil layer 15 in. × 22 in. × 1 in.

We are grateful to the Dominion Department of Agriculture, Division of Entomology, for generous financial assistance.

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An Assemblage of Arthropod Remains from a Roman Occupation Site at St. Albans

IN the course of an excavation of a Roman occupation site at St. Albans, Hertfordshire, in 1955, a ditch was discovered which had been partly filled in, during the first century A.D., with a large quantity of organic material. Among this mass, bracken, grass, moss, leaves, twigs, seeds, etc., could still be recognized, and at one point it reached a depth of 7 ft. At least one wooden building had been erected on top of this; but when it had fallen into disuse the site had been levelled off by dumping clay and earth on it to a depth of about one foot. Afterwards a succession of substantial stone houses had been built, between the first and fourth centuries A.D., forming a succession of strata about 8 feet thick, which sealed this ditch-filling in an undisturbed state until the present time.

Among the organic material in this deposit there was found a colony of living earthworms (*Eophila oculata* Hoff.)[1] which may have persisted there since Roman times, and another interesting find was the large number of insect and other arthropod remains in quite a good state of preservation. Of about 60 specimens recovered, 40 could be identified at least to the family, and many to the genus, and, tentatively, to the species. The following is a shortened list of the specimens, identified as nearly as possible:

- Insecta
  - Dermaptera: *Labia minor* L. (many specimens)
  - Lepidoptera: *Arctia caja* L. (puparium)
  - Coleoptera
    - Carabidae:
      - *Clivina fossor* L.
      - *Nebria brevicollis* F. (several specimens)
      - *Feronia madidus* F.
    - Hydrophilidae:
      - *Megasternum obscurum* Marsh.
    - Histeridae:
      - *Hister* spp.
      - *Onthophilus striatus* Forst
      - *Abraeus granulum* Er.
    - Staphylinidae:
      - *Staphylinus* sp.
      - *Homalota* sp.
      - *Philonthus* sp.
    - Scarabaeidae:
      - *Aphodius* sp.
    - Cucujidae:
      - *Monotoma spinicollis* Aube.
    - Tenebrionidae:
      - *Tenebrio* (cf. *obscurus* F.)
  - *Hymenoptera:* Fragments of an ant
- Acarina
  - *Fuscuropoda marginata* Koch.
  - *Tectocepheus velatus* Mich. and George.
  - *Oppia nitens* Koch.
  - *Scheloribates laevigatus* Koch.

University College of Science
Physics Dept.

Fine structures such as setæ, wing scales of Lepidoptera, and tracheæ were well preserved, and although pigmentary colours had either blackened or faded, structural colours were as bright as ever. The ditch contents presented a very moist and strongly reducing environment, as shown by the presence of quantities of vivianite (a hydrated ferrous phosphate), and such conditions may be important for the preservation of chitinous arthropod parts.

The layer of clay and earth which had been dumped on top of the deposit had trapped an ecological assemblage of insects, etc., from which conclusions about the nature of the deposit may be drawn. First of all, it represents what one would expect to encounter in a refuse heap, with incidental species entering by chance from neighbouring grassland habitats. Insect remains were found at all levels in the deposit, although they were most plentiful in the upper part. This suggests that the deposit was accumulated during a fairly short period of time, a few years at the most, as the arthropod cuticle does not withstand prolonged weathering.

The species found in the lower levels suggest the presence of rotting vegetation ; but at the top large numbers of puparia of *Lucilia* and *Calliphora* (the bluebottle and greenbottle flies) indicated the presence of carrion and dung. It is interesting to note that the layer of clay which sealed the whole deposit was probably dumped on a day in late summer. The assemblage of species trapped immediately under it would suggest this, and also, although most of the fly puparia were vacated, a few clusters still contained remains of the immature flies.

For the identification of the specimens I am indebted to Mr. J. Balfour-Browne, and Dr. Owen Evans of the British Museum (Natural History), and Prof. F. E. Zeuner of the Institute of Archæology, University of London. I must also thank Mr. John Lunn of the Verulamium Museum for making the material available to me.

P. L. BRADLEY

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[1] Dobson, R. M., and Satchell, J. E., *Nature*, 177, 796 (1956).

A Case of Limitation of Phenotypic Variation

JINKS[1] suggests that where phenotypic variation is caused by a cytoplasmic system, the range of phenotypic expression attainable by the system would have quite definite limits imposed by the system itself (cytoplasmic limits) or, by the non-viability of phenotypes lying outside these limits (physiological limits). Cytoplasmic limits would result where further changes in cytoplasmic content are impossible, as when all cytoplasmic elements involved in the change are lost. Physiological limits would result where although more extreme changes in the cytoplasm are possible they would lead only to non-viable phenotypes. Jinks's results suggested a physiological basis to limits of variation obtained in *Aspergillus glaucus*.

Results from *Neurospora crassa* provide an example of a physiological limit to what appears to be cytoplasmically determined variation in the expression of a certain genotype. This genotype, which differs from the wild type by at least two genes, can show two different extremes of expression. At one extreme the culture forms no protoperithecia and instead produces many discrete areas of dark brown pigment (*bk* phenotype), while at the other extreme there is no sign of the dark pigment and weakly developed protoperithecia, which may be functional, are produced in limited parts of the culture (*S* phenotype). Stages intermediate between these two are formed. Cultures initiated from ascospores can show any stage in the range of phenotypes ; but subcultures derived from them almost invariably show intermediate or *S* phenotypes only. The *bk* phenotype can be induced to appear, or reappear in subcultures by certain treatment, when its appearance, and later disappearance after the treatment are typical of the behaviour of a dauermodification. This and other evidence suggest that the phenotypic range results from the interaction of the genotype with varying cytoplasmic states or conditions. Prolonged continuation of the treatment used for inducing the appearance of phenotype *bk* intensified formation of the brown pigment and was accompanied by a reduced growth rate and decreased viability. It appears that the induced cytoplasmic state led to the production of an abnormal phenotype, and that increase of the cytoplasmic state was limited by its causing an increasingly abnormal phenotype that led to the death of the cultures. In other words, there was a physiological limit to the extent to which the cytoplasmic state could be produced or selected for.

This view is supported by the results of a number of crosses involving these mutant strains. The crosses were first made after both strains had been subjected to the treatment leading to induction of phenotype *bk* and again seven months later with the same strains, but from stocks which had never been subjected to the induction treatment. At both times crossing was carried out by simultaneous inoculations of parent strains in the crossing tubes. There was a marked difference in the results obtained from the two sets of crosses, and these are illustrated in Table 1 with data from a typical cross.

Table 1. ASCUS TYPES PRODUCED BY CROSS 3–1 *A* × 5–7 *a*

	Ascus types	No. of asci
First crossing	*L L* *L L* *bk* *bk* — *bk*	2
	L L *L L* — *bk* — *bk*	2
	L L *L L* *bk* *bk* — —	3
	L L *L L* *bk* — — —	2
		9
Second crossing	*L L* *L L* *S* *S* *S* *S*	6
	L L *L L* *S* *S* *S* *bk*	3
	L L *L L* *S* *S* *bk* *bk*	1
		10

L, Wild type protoperithecia ; *bk*, *bk* phenotype ; *S*, intermediate and *S* phenotypes ; —, non-viable ascospore.

The cross was such that a 1 : 1 segregation of wild type to mutant would be expected. The mutant segregants in the progeny from the first crossing all had a strongly expressed *bk* phenotype, and 50 per cent of the mutant ascospores were non-viable. In the progeny from the second crossing 87·5 per cent of the mutant segregants showed an intermediate or *S* phenotype, while the remaining 12·5 per cent showed phenotype *bk*. There were no non-viable ascospores.

In all the crosses strong expression of phenotype *bk* was associated with high ascospore non-viability, while expression of phenotype *S* was associated with low ascospore non-viability. It appears that in the first series of crosses the cytoplasmic state of the progeny was such as to produce the extreme *bk* phenotype, and that in many of the ascospores this cytoplasmic state was intensified to beyond the limit of phenotypic viability. In the progeny of the second series of crosses a more normal cytoplasmic state existed and led to a considerable amount of protoperithecial formation in the mutant segregates, and complete ascospore viability.

This work was carried out largely at the Department of Genetics, University of Adelaide, while I held a New Zealand National Research Fellowship.

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[1] Jinks, J. L., *Proc. Roy. Soc.*, B, 146, 527 (1957).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 10

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. M. Ginsberg: "Evolution, Development, Progress".

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "The Herbert Report and the 1957 Act", opened by Mr. E. R. Wilkinson.

Royal Institute of Chemistry, London Section (at Norwood Technical College, Knight's Hill, West Norwood, London, S.E.27), at 7 p.m.—Dr. J. Green: "Recent Advances in the Chemistry and Function of the Vitamins".

Monday, February 10—Saturday, February 15

Department of Scientific and Industrial Research (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 10 a.m. daily—Exhibition—"Road Research in the Colonies".

Tuesday, February 11

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. A. R. Collins and Mr. D. R. Sharp: "Design and Construction of Concrete Roads Overseas".

Institution of the Rubber Industry, London Section (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. J. Mann: "Moulding". 7 p.m.—Mr. B. Ellis and Mr. G. N. Welding: "Characteristics of Accelerated Sulphur Vulcanization of Natural Rubber".

Royal Institute of Chemistry, London Section (joint meeting with the Sir John Cass College Chemical Society, at the Sir John Cass College, Jewry Street, London, E.C.3), at 6.30 p.m.—Prof. C. K. Ingold, F.R.S.: "An Organic-Chemical Contribution to the Inorganic Chemistry of Nitrous Acid".

Wednesday, February 12

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Sir Gavin de Beer, F.R.S.: "The Inhabitants of Switzerland".

University of London (at Guy's Hospital Medical School, St. Thomas's Street, London, S.E.1), at 5 p.m.—Prof. C. D. Waddington, F.R.S.: "Evolutionary Adaptation to Environmental Stress".*

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

Bedford College (at Regent's Park, London, N.W.1), at 5.15 p.m. —Dr. D. M. MacKay: "The Brain as an Information System".*

Institute of Physics, Education Group (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Discussion on "The Graduateship Examination". Speakers: Prof. J. G. Wilson, Mr. A. E. De Barr Prof. M. R. Gavin, Mr. J. Yarwood and Mr. N. Clarke.

Cement and Concrete Association (at the Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1), at 6 p.m. —Dr. S. Champion: "Grouted Concrete Construction".

Institution of Electrical Engineers (at the Central Hall, Westminster, London, S.W.1), at 6 p.m.—Mr. R. Ledger: "The Electrification of Railways" (Faraday Lecture prepared by the late Mr. G. H. Fletcher).

Society of Chemical Industry, Food Group—Nutrition Panel, (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Third Meeting on "Some Nutritional and Allied Problems Confronting the Food Manufacturer". Dr. C. G. Sumner and Dr. F. Aylward: "Emulsifying and Dispersing Agents".

British Association of Chemists, London Section (at the Wellcome Building, 183 Euston Road, London, N.1), at 7 p.m.—Assistant Divisional Officer Dennett (London Fire Brigade): "Fire Prevention".

Radar Association (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 7.30 p.m.—Sir Robert Watson Watt, F.R.S.: "The Early Days of Radar".

Society for Visiting Scientists (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Science in General Education". Speakers: Dr. A. W. Barton, Mr. Richard Fort, M.P., and Sir Frank Ewart Smith, F.R.S.

British Psychological Society, Social Psychology Section (at Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Papers on "Recent Developments in Advertising". Dr. Donald Melvon: "Motivation Research"; Dr. N. F. Dixon: "Sub-threshold Advertising".

Thursday, February 13

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. B. C. Abbott, Dr. A. V. Hill, F.R.S., and Mr. J. V. Howarth: "The Positive and Negative Heat Production Associated with a Nerve Impulse".

University College, London (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Dr. H. F. C. Crick: "The Nucleic Acids".* (Further Lectures on February 20 and 27.)

University of London (in the Hatton Lecture Theatre, Queen Mary College, Mile End Road, London, E.1), at 5.30 p.m.—Prof. M. W. Humphrey Davies: "Electrical Engineering in the Future" (Inaugural Lecture).*

Royal Aeronautical Society (at the Institution of Mechanical Engineers, Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. H. L. Cox: "The Application of the Theory of Stability in Structural Design".

Society of Chemical Industry, Microbiology Group (in the Department of Botany, Imperial College, London, S.W.7), at 6.30 p.m. —Meeting on "The Enzymic Degradation of Carbohydrates".

Chemical Society (in the Large Chemistry Lecture Theatre, Imperial College of Science and Technology, South Kensington, London, S.W.7), at 7.30 p.m.—Prof. B. Lythgoe: "Some Recent Advances in the Chemistry of the Vitamins D" (Tilden Lecture).

Friday, February 14

Institute of Physics, Non-Destructive Testing Group (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. E. L. Ripley: "The Analysis of Wreckage in Aircraft Accident Investigation".

Antiquarian Horological Society (at the Science Museum, South Kensington, London, S.W.7), at 7 p.m.—Mr. W. J. Gazeley: "Clock Escapements".

Society of Chemical Industry, Fine Chemicals Group (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Mr. F. W. Thomas: "Fine Chemicals in the Textile Industry".

British Glaciological Society (in the Geology Department, The University, Oxford), at 8.30 p.m.—Mr. W. H. Ward: "Glaciology and Mountaineering".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. J. Z. Young, F.R.S.: "The Structure of Cells".

Saturday, February 15

Biochemical Society (in the Beveridge Hall of the Senate House, University of London, W.C.1), at 10.30 a.m.—Symposium on "Glutathione".

British Psychological Society (in the Gustave Tuck Theatre, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. Desmond Morris: "An Analysis of Paintings and Drawings by Chimpanzees".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Secretary (graduate of a British university, preferably in science or engineering, with some experience of industry) to the University Appointments Board—The Registrar, The University, Liverpool (February 15).

Physicist, Senior grade (with an honours degree in physics and previous experience in hospital physics, preferably in the application of radioisotopes to clinical problems), in the Isotope Laboratories —The Personnel Officer, St. Thomas's Hospital, London, S.E.1 (February 15).

Lecturer (Grade I or II) in Applied Mathematics—The Registrar, The University, Bristol 8 (February 21).

Lecturer or Assistant Lecturer in the Department of Aeronautical Engineering—The Secretary and Registrar, The University, Southampton (February 22).

Lecturer or Assistant Lecturer in the Department of Zoology—The Secretary and Registrar, The University, Southampton (February 22).

Lecturer (preferably with experience with electrical machines and an interest in physical phenomena in machines) in the Department of Electrical Engineering—Prof. A. Tustin, Electrical Engineering Department, Imperial College, London, S.W.7 (February 22).

Scientific Officer (with an honours degree in zoology) in the Nematology Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (February 22).

Senior Lecturers or Lecturers (2) in Physics at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 28).

Chairs of Philosophy, Biochemistry, Pharmacology, Agriculture and Mechanical Engineering in the University of Ceylon —The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Ceylon, March 1).

Lecturers or Assistant Lecturers (2) in the Department of Physics—The Secretary and Registrar, The University, Southampton (March 1).

Tutorial Research Student in Mathematics (Pure or Applied) —The Principal, Royal Holloway College, Englefield Green, Surrey (March 1).

Farm Demonstrator (with a degree in agriculture or an honours degree in pure science followed by an adequate postgraduate qualification in agriculture, and preferably with some training in field experimentation), for duties which will include farm classes on the University Farm to undergraduate and postgraduate students—The Secretary, School of Agriculture, The University, Cambridge (March 5).

Lecturer or Assistant Lecturer in the Department of Philosophy—The Secretary and Registrar, The University, Southampton (March 8).

Lecturer (with appropriate qualifications in chemistry, and preferably a working knowledge of geology and mineralogy) in Geology (Geochemistry)—The Secretary, The University, Edinburgh (March 8).

Lecturer in Geology at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 10).

Lecturer in Physiology—The Secretary, The Queen's University, Belfast (March 15).

Research Assistants (2) (with research experience) in the Department of Theoretical Physics, for special research in fundamental particle and nuclear physics—The Registrar, The University, Liverpool (March 15).

Lecturer in Technical Mathematics—The Secretary, The University, Edinburgh (March 28).

Lecturer in Archæology; Assistant Lecturer in Social Anthropology and a Demonstrator in Physical Anthropology—The Secretary of the Appointments Committee, Faculty of Archæology and Anthropology, The University, Downing Street, Cambridge (March 31).

Lecturer or Assistant Lecturer in the Department of Electronics—The Secretary and Registrar, The University, Southampton (March 31).

Imperial Chemical Industries Research Fellows in Chemistry, Physics, Engineering, Pharmacy, Chemotherapy and related subjects—The Secretary, Academic Council, Queen's University, Belfast (April 1).

Professor and Head of the Department of Dairying—The Dean, Faculty of Agriculture, University of Alberta, Edmonton, Alberta, Canada (April 1).

Imperial Chemical Industries Fellows for research in Physics, Chemistry, Colloid Science, Biochemistry, Engineering, Metallurgy, Pharmacology, Chemotherapy or related subjects—The Secretary-General of the Faculties, The Old Schools, The University, Cambridge (April 30).

Lecturer in Fuel Technology and Chemical Engineering—The Registrar, The University, Sheffield (May 1).

Lecturer in Forest Botany—The Secretary, The University, Edinburgh (May 15).

Agricultural Economist (with a university degree in agricultural economics, agriculture, or economics, and practical experience in the organization of the export of horticultural produce, local marketing, and distribution problems) to act as Marketing Adviser to the Maltese Government—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/19/04.

Assistant Lecturer in Physics—The Registrar, The University, Nottingham.

Biochemist, Basic grade (with a science degree preferably with honours in biochemistry or chemistry)—The Secretary, Horton General Hospital, Banbury, Oxon.

Experimental Officer (with a degree in chemistry or agricultural chemistry or equivalent qualifications), to carry out chemical analyses of soils and plants—The Secretary, Rothamsted Experimental Station Harpenden, Herts.

Fisheries Officer (with a university degree in biology with emphasis on zoology, and experience of fisheries work) in the Northern Region of Nigeria, to execute plans for the development of river fisheries, and the demonstration and organization of peasant fish culture—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/408/01.

National Research Council of Canada Post-Doctoral Fellows in the Department of Chemistry—Dr. R. P. Graham, Chairman, Department of Chemistry, McMaster University, Hamilton, Canada.

Research Assistant (preferably graduate in chemistry, biochemistry or physiology) in the Department of Pathology, for work in connexion with steroid investigation—The Clerk to the Governors, St. Bartholomew's Hospital, London, E.C.1, marking envelope "Research".

Research Officer (Soils) with a university degree in geology or natural science and at least two years postgraduate experience in tropical soils research) in the Forest Research Department, Federation of Nigeria, to initiate and carry out investigations and studies of forest soils—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.61/14/07.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Scottish Home Department. Marine Research, No. 3 (1957): The Food and Feeding Habits of Larval and Post-Larval Herring on the Northern North Sea. By Dr. R. N. Bhattacharyya. Pp. 15. (Edinburgh and London: H.M. Stationery Office, 1957.) 7*s*. net. [1811

British Broadcasting Corporation. B.B.C. Engineering Monograph No. 14: The B.B.C. Riverside Television Studios—Some Aspects of Technical Planning and Equipment. By H. C. Nic' els and D. M. B. Grubb. Pp. 32. (London: British Broadcasting Corporation, 1957.) 5*s*. [2011

Full Automation of the Telephone System. Pp. 14. (Cmnd. 303.) (London: H.M. Stationery Office, 1957.) 9*d*. net. [2011

Society for Freedom in Science. Occasional Pamphlet No. 17 (November, 1957): Freedom in Research. By John R. Baker. Pp. 8. (Oxford: Dr. John R. Baker, Dept. of Zoology, University Museum, 1957.) 1*s*. 3*d*. [2011

Ministry of Pensions and National Insurance. Digest of Statistics Analysing Certificates on Incapacity, 1954/55. Pp. xxii+1 chart+76 tables. (London: Ministry of Pensions and National Insurance, 1957.) [2011

The Registrar General's Statistical Review of England and Wales for the year 1952. Supplement on Cancer. Pp. x+153. (London: H.M. Stationery Office, 1957.) 8*s*. 6*d*. net. [2511

The Survival of Animals in Hot Deserts. By Prof. E. B. Edney. (An Inaugural Lecture given in the University College of Rhodesia and Nyasaland.) Pp. 32. (London: Oxford University Press, 1957.) 4*s*. net. [2511

Planning, Vol. 23, No. 416 (25 November, 1957): Plans for Oxford's Roads. Pp. 213–228. (London: Political and Economic Planning, 1957.) 2*s*. 6*d*. [2511

Royal Institute of Chemistry. Lectures, Monographs and Reports, 1957. No. 2: Cereal Carbohydrates. By Dr. I. A. Preece. Pp. ii+24. (London: Royal Institute of Chemistry, 1957.) 4*s*. net. [2511

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University of Natal, Pietermaritzburg. Wattle Research Institute (South African Wattle Growers' Union; University of Natal; Union Department of Forestry). Report for 1956–1957 (Tenth Year). Pp. 33. (Pietermaritzburg: Wattle Research Institute, University of Natal, 1957.) [1811

Bechuanaland Protectorate. Annual Report of the Geological Survey Department for the year ending 31st December, 1956. Pp. 30. (Lobatso: Geological Survey, 1957.) 2*s*. 6*d*. [1811

Coal in South Africa. By Edna P. Plumstead. Pp. ii+25. (Johannesburg: Witwatersrand University Press, 1957.) 4*s*. [1811

Twelfth Annual Report of The Council of the Queensland Institute of Medical Research. Pp. 18. (Brisbane: Queensland Institute of Medical Research, 1957.) [1811

Hanunoo Agriculture: a Report on an Integral System of Shifting Cultivation in the Philippines. By Harold C. Conklin. (FAO Forestry Development Paper, No. 12.) Pp. xii+209+42 plates. (Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1957.) 10*s*.; 2 dollars. [2011

Journal of Ultrastructure Research, Vol. 1, No. 1 (November, 1957). Pp. 108. Subscription rate: Vol. 1 (4 issues), 15 dollars. (New York: Academic Press, Inc., 1957.) [2011

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New Zealand Forest Service. Annual Report of the Forest Research Institute for the year ending 31 March 1957. Pp. 76. (Wellington: Government Printer, 1957.) [2511

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British Honduras. Annual Report of the Forest Department for the year 1956. Pp. 29. (Belize: Forest Department, 1957.) [2511

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2-Aminochrysene	42	H
Anthanthrene (m.p.265° C.) (10 mgm. amps)	20	A
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[1,2-2′,1′]-Anthracenoanthracene (m.p.400° C.) (10 mgm. amps)	9	A
1,1′-Azonaphthalene	48	D
2,2′-Azonaphthalene	25	D
Azulene	42	G
2,3-Benzocarbazole (95%)	30	D
1,12-Benzperylene (10 mgm. amps)	25	A
3-Chloropyrene (m.p.118° C.)	65	d
Coronene	36	d
3,4-9,10-Dibenzpyrene (m.p.280° C.) carcinogenic 10 mgm. amps	15	A
9,10-Dihydroanthracene (m.p.110° C.)	12	D
9,10-Diphenylanthracene (m.p.248–250° C.)	33	G
*iso*Durene	145	D
Hexahydrocarbazole	17	D
1,2,3,6,7,8-Hexahydropyrene	12	D
unsym-Hexahydropyrene	9	D
sym-Octahydroanthracene	15	D
Octahydrophenanthrene (octanthrene)	68	H
Pentacene	38	d
2-Phenylanthracene (m.p.216° C.)	23	d
Picene	16	G
Tetrahydroacenaphthene (tetraphthene)	11	D
1,2,3,4-Tetrahydro carbazole	25	D
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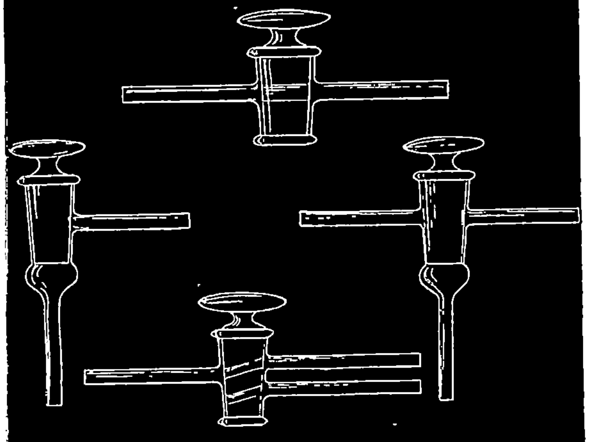

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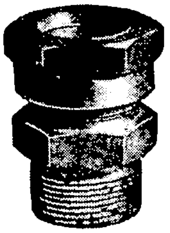

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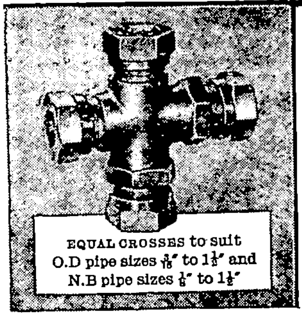

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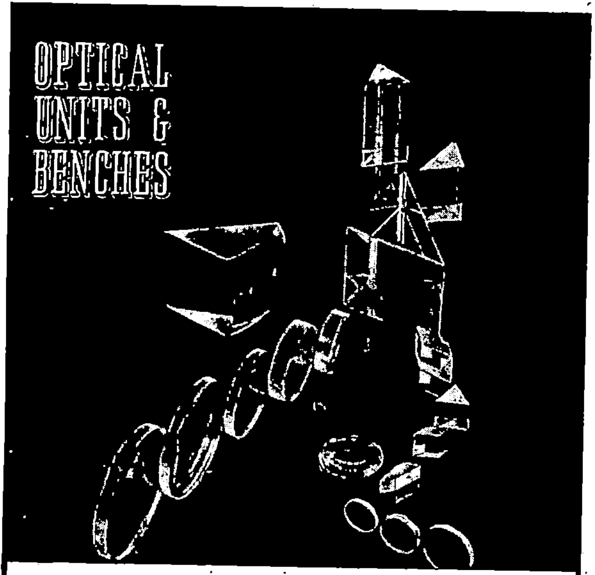

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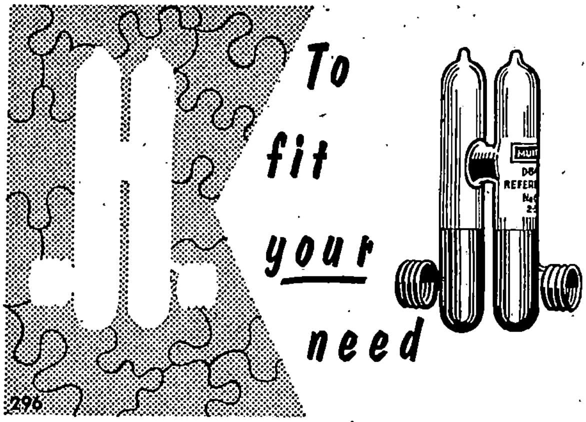

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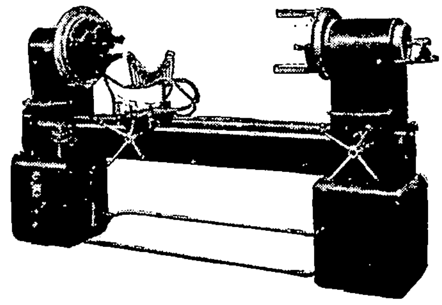

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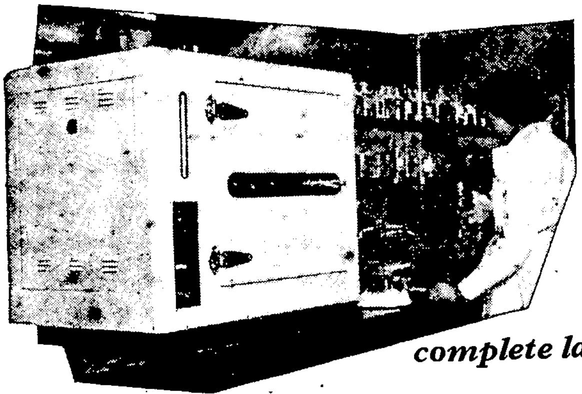

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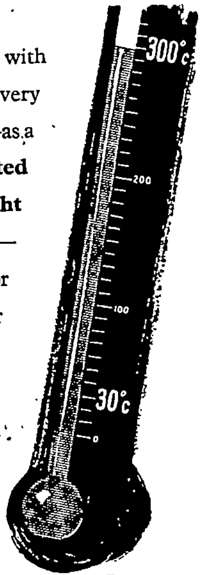

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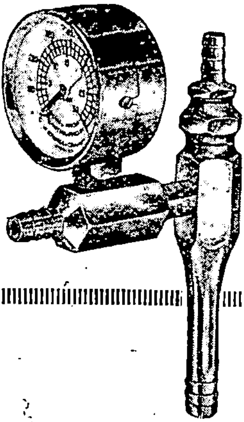

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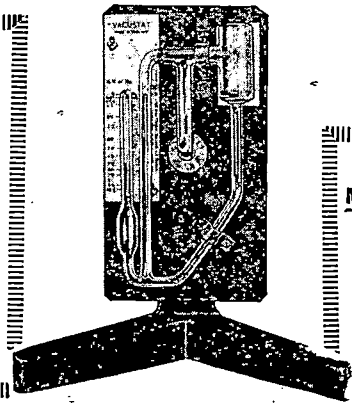

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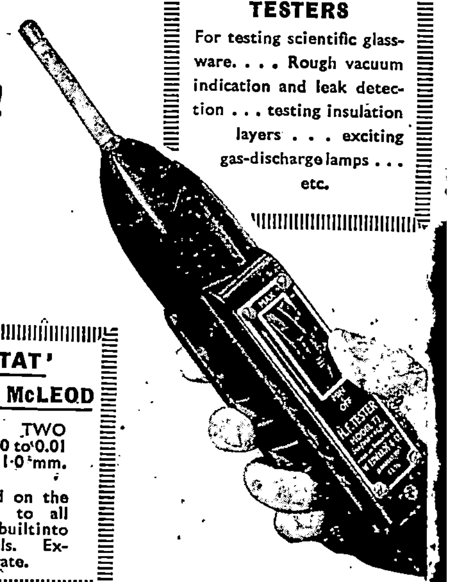

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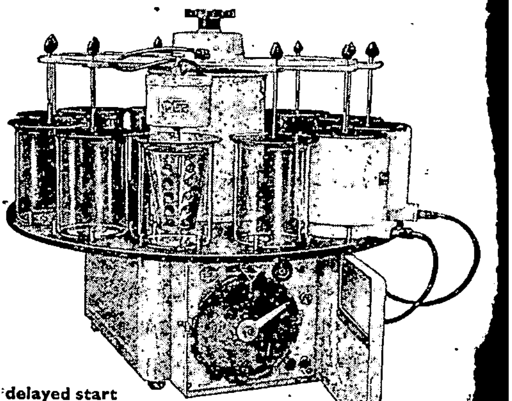

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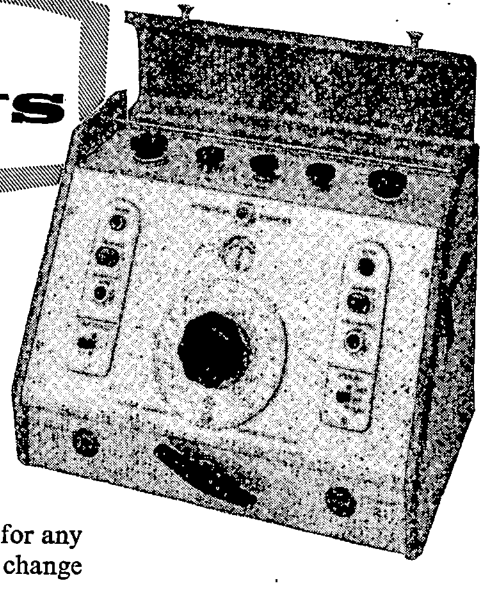

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MAN-POWER IN THE ATOMIC ENERGY AUTHORITY

IN its first annual report, published in October 1955, the Atomic Energy Authority discussed its difficulty in recruiting sufficient staff, particularly senior staff and the younger engineers and technicians needed to form the base of the pyramid to-day and to provide the leaders in years to come; it also recognized that inadequacy of staff is a constant threat to achievement of the Authority's programme and admitted frankly that, even if dates continued to be achieved, details might be skimped which would cause operating troubles in future. That report was written in the context of the nuclear power programme outlined in the White Paper of February 1955. Since then, as Lord Mills announced in February of last year, the programme has been further expanded to provide almost treble the capacity of nuclear power; and although it is not expected that the number of nuclear power stations originally contemplated will be increased, the demands made upon scientific and technical man-power for such accelerated development as well as for operating will be appreciably greater.

It is therefore scarcely surprising that the Committee set up by the Prime Minister, under Sir Alexander Fleck's chairmanship, to examine the organization of certain parts of the United Kingdom Atomic Energy Authority should conclude that the continuous pressure on the Authority's Industrial Group to take on new tasks has strained its resources to the utmost, and left those responsible for operating factories within the Group with insufficient technical staff and inadequate technical assistance*. The many and varied commitments of the Group are fully recognized and also its remarkable success in bearing the tremendous load piled upon it. None the less, there are limits to what can be achieved with limited man-power, and the Fleck Committee is clear that the weaknesses in the Group's present organization arise primarily and noticeably from an insufficiency of senior technical staff in the Operations Branch. The Committee was impressed by the speed and success with which the Industrial Group has been built up; but the Group's ever-widening commitments have left it considerably under-manned, particularly in the more senior posts. In consequence, those in charge of operating existing plant have had inadequate technical assistance and advice, while liaison between the various branches of the Group and with the Research and the Weapons Groups at Harwell and Aldermaston is poor. Such factors as these were emphasized by the Windscale accident, which led to the appointment of the Committee, as was recognized at the time by the chairman of the Authority, and the Committee rightly considers it is essential to remedy them.

The recommendations of the Committee in this connexion have implications which extend far beyond the activities of the Atomic Energy Authority itself; but before considering them, the Committee's full terms of reference should be noted. It was first to review the organization and staffing of the Operations Branch of the Industrial Group of the Atomic Energy Authority and to make any recommendations necessary to ensure that the Branch is able adequately to discharge its responsibilities. It was to review similarly the staff engaged on the operation of reactors in the Authority's Research Group. It was to review the relation of the Operations Branch to the other branches and directorates of the Industrial Group and to the technical advisers in the Research Group, and to make any recommendations necessary to ensure that this relation is the one that best enables the Operations Branch to fulfil its functions, and that the division of responsibility between these various parts of the Authority is clearly defined. The relation of the staff engaged on the operation of reactors in the Research Group to other parts of organization was to be reviewed similarly.

The report begins by outlining general principles which the Committee considers should guide the organization of a large technological production group and then reviews the development of the Industrial Group and its present organization. On this basis are formulated the proposals for the reorganization of the Industrial Group Headquarters and for the reorganization at the works, and recommendations regarding the duties of the technical sections of the Operations Branch, the operation of reactors in the Research Group, and the special problems of Dounreay. Although in these latter respects the report enters into more detail than that of the Advisory Committee on the Organization of the Coal Board, it can fairly be placed with that report as an outstanding paper on administrative management, as well as one of profound importance for the efficient and economic use of scientific and technical man-power in general.

The Committee summarizes the present position in the Operations Branch by suggesting that the Branch has become seriously out of balance with the Engineering and the Research and Development Branches, and it insists that nothing should interfere with the provision of adequate staff, both for the safe and efficient operation of existing plant, and the development of completely safe and efficient plant for the nuclear power programme. These are the primary tasks of the Industrial Group, and the Committee points out that to ensure that the first stations for the nuclear power programme are designed and operated with the maximum efficiency and safety requires that those responsible for design, construction and subsequent operation have the benefit of full advice from the whole of the Authority, as well as full information based on the experience gained by the Industrial Group in operating its own reactors. The advancement of new techniques, while of high national importance, is secondary to this; and the Committee considers that should it become necessary to concentrate the Authority's development effort on fewer projects; this must be accepted as an inevitable consequence of the national shortage of suitably qualified technical staff.

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* Report of the Committee appointed by the Prime Minister to examine the Organization of certain parts of the United Kingdom Atomic Energy Authority. Pp. 40. (Cmnd. 338.) (London: H.M. Stationery Office, 1957.) 2*s*. net.

The Committee is clearly right in this view; but before considering its various implications, the recommendations may be briefly noted. First, as regards the headquarters of the Industrial Group, no major change in the organization of the Group is recommended; after stressing the paramount importance of the two major tasks already indicated, the Committee emphasizes the importance of the principle of collective responsibility of board members and the vital role of the personnel branch in advanced technological work of the character on which the Group is engaged. A sound policy of recruitment, training and promotion of technical staff is so important that the director of personnel should be recognized as holding a key position in the organization, and in particular he should be responsible for ensuring that the available technical staff are distributed so as to ensure the proper functioning of the Group as a whole. It is also suggested that it should be his duty to press within the Authority for an active policy on staff recruitment, training and the interchange of staff.

The changes recommended with such conditions in mind are designed to give more time to think. Appointment of two deputy managing directors to assist the managing director, and, like him, substantially free from routine duties, is the first recommendation. Next, the board of management should include a director, appointed for a limited period and chosen for his scientific ability, specifically responsible for ensuring liaison with other Groups and appropriate external bodies, as well as a few visiting members from other Groups. In the detailed proposals for re-organizing the headquarters of the Operations Branch, stress is laid upon the importance of the senior posts being occupied by men of proved technical ability, while the need to strengthen the Administration Branch, which should be renamed Personnel and Administration Branch and its status enhanced, is also recognized. A new director, with a seat on the Board, should be appointed to take charge of the Dounreay site, while a review of the committee's structure relating to Industrial Group operations is also recommended.

The responsibilities of the director of the new Health and Safety Branch will be discussed fully in the report of the Health and Safety Committee, the third of the three Committees appointed by the Prime Minister following the Windscale accident; they are briefly summarized in this report as providing supervisory services both to the health and safety organizations at the works and to the Engineering and Research Development Branches in the design of all new plant and installations. At the works level, the Committee recommends that the existing practice of appointing works general managers to the major establishments, supported by works managers responsible for individual plants, should be continued. In particular, a separate works general manager, responsible direct to headquarters, should be appointed for Chapelcross. Emphasis is again laid on the importance of clearly laying down the chain of command at the works, and of encouraging interchange of staff between the Operations Branch and the Engineering and Research and Development Branches and the other Groups of the Authority; and it is pointed out that a works general manager should himself be a good technologist, and that the number of scientists and technologists available to him should be substantially increased.

The organization at the Research Group responsible for the operation of reactors is regarded as correct in principle and adequate for the present purposes; but it will require constant review as the complexities of the reactors operated by the Group increases. Besides the creation of a new post of director of Dounreay, as already noted, the Committee recommends that the functioning of this site should be reviewed in two or three years time, and it suggests that this experience may be of great value when the Winfrith Heath organization is being considered. Further, it suggests that the Authority should carefully review the time-scale and staffing problems of the Dounreay project in the light of its other commitments, and it points out that the very high fuel ratings of the fast reactor and the nature of the other facilities at Dounreay call for exceptional technical competence in its management.

These proposals involve the creation of numerous new senior technical posts, and although the filling of such posts is a matter for the Authority and not for the Committee, the latter recognizes that some of the posts can only be filled by transfer, and that time will be required to make such transfers and the related adjustments. None the less, it is emphatic that the posts must be created and filled, even if this necessitates some curtailment of the work at present being done. Nothing must interfere with the provision of adequate staff, both for the safe and efficient operation of existing plant and the development of completely safe and efficient plant for the nuclear power programme.

It is obvious that the Fleck Committee is not optimistic about the prospect of the Authority recruiting in the near future the substantial number of highly qualified men it requires to fill these new senior posts and to strengthen the technical staff of the Operations Branch at a lower level. It is possible that the Fleck Committee is too optimistic as to the possibility—or practicability—of finding the men from within the organization. Personal qualities and preferences can be a decisive factor in determining the choice of a post by a scientist or technologist, quite as much as ability; and it should not be assumed too readily that those who find satisfaction in research and advanced development at Harwell or Risley will necessarily be attracted to running a production plant. There are, moreover, the actual conditions to be considered: isolation itself will be a deterring factor to those keen on technical progress or creative work, unless a good deal of care is taken to offset such disadvantages as are inherent in sites like Dounreay.

The Fleck Committee does not doubt that, given the right leadership, the business of plant operation can be made attractive to highly qualified men, and it suggests that such posts may well become a good recruiting ground for men with both technical background and ability and some experience in management. None the less, it is fully alive to the plain truth that, on the whole, industry pays its men better; and that the Government decision that salaries of senior staff should not be seriously out of scale with those paid by public corporations, and the inheritance of a Civil Service grading structure, may continue to hinder both the recruitment from within established industry of sufficient senior staff and the grading of scientific and technical staff so as to cause the minimum obstacles to movement. The present difficulties will scarcely be settled so easily, and they demonstrate once more the relation of the whole problem to an adequate supply of scientific and technical man-power, to the esteem and status accorded to the technologist and to the far-reaching effects of a really adequate system of selection and training for the highest managerial positions.

Very clearly, although the problems lay outside the survey of the Fleck Committee, the Atomic Energy Authority cannot leave the matter there. It must reconsider its whole organization from the level of the main Board downwards. Only in the light of decisions as to the extent of its ever-growing responsibilities and what responsibilities in the long run can be transferred to industry or to other public bodies is a clear idea possible as to the magnitude and balance of the staff it needs.

The greatest importance of the report may well lie, however, in the wider implications that arise in this connexion. First, it is a convincing demonstration of the dependence of Britain's economic and industrial development upon the condition of scientific and technological education. It is our neglect to attend to this that is responsible for the present handicap under which the Atomic Energy Authority labours and which may cause us to miss some of the opportunities now opening to us.

Secondly, such weaknesses in education cannot be remedied quickly, but require the study and imaginative pursuit of a long-term policy, not only in educational circles but also in industry. Moreover, the report indicates once more that such a policy is unlikely to be formulated and implemented in industry, or for that matter in Government circles, unless there are men at the board and other high administrative levels who have themselves scientific and technical experience as well as vision and sound judgment. Such men are unlikely to be found in these positions except as a result of deliberate policy involving the careful search for talent and its selection, testing and training from early years. The extent to which the Government and industry in general ponder and apply the lessons to be learnt from this report, and bring a new understanding and urgency to the expansion of technological education, and to the selection and training of managers and administrators, will determine the speed with which the present difficulties of trained man-power which hinder the progress of Britain's nuclear power programme will be relieved—either by an increased intake at lower levels from the universities or colleges of technology, or at more senior levels from elsewhere in industry.

The key factor is management, for the best hope of providing the conditions most likely to attract the highly skilled scientists and technologists and to encourage them to give of their best depends on wise, resourceful and imaginative management. It is such management again that will minimize the shortage by seeing that such skilled man-power is adequately supported by technicians, craftsmen and clerical assistance, and that it is not wasted on tasks that could be done as efficiently or even better by less highly trained workers. It will be alert to eliminate misunderstandings and to check any tendency to disparage a post and so deter people from filling it; and in this matter of status, management will need, and should receive, the full support of all those who appreciate the nature and worth of the work of the scientist, the technologist and the technician in industry. The Fleck report could provide an admirable text for lecturers in the new programme of activities which the British Association has announced.

BREWING

A Textbook of Brewing

Vol. 1. By Prof. Jean de Clerck. Translated by Kathleen Barton-Wright. Pp. xx+587. (London: Chapman and Hall, Ltd., 1957.) 84*s*. net.

Of the two volumes which this translation will comprise, the present one is concerned primarily with the various sections of the brewing process, including malting, and with commercial equipment for that purpose, but it rightly incorporates considerable discussion and numerous references to relevant topics in pure science. A reviewer soon becomes keenly aware, as he reads this book, of the wide scholarship and great achievement of the author when in 1948 in the original French edition he brought together so many diverse facts and opinions from the different worlds of science and commercial brewing. In the present instance, a reviewer must indeed attempt to see the outcome from at least four points of view; in short he must regard the book as a text-book of brewing, as a contribution to science, as a translation and lastly as an attempt on the part of the translator to bring the original text up to date.

Clearly it would not be reasonable to expect this to be a text-book of brewing in the sense that it might take the place of practical experience. The object of the author has rather been to add to a general account of brewing practice a discussion of various modifications adopted in the major beer-producing countries of the world, and indeed the comparative differences encountered in malting and brewing procedure form a valuable feature of the book. The emphasis is, perhaps naturally, on Continental practice, and, although British and American usage is not forgotten, the unwary reader could sometimes be misled. For example, even remembering the possible injustice of quoting isolated statements, the assertion that in Great Britain certain types of wood are used as fuel in kilning malt so that the smoke may impart a special flavour is literally true but is scarcely a fair summary of British methods. As a translation the English version of the brewing sections is in every way excellent; practically no indications remain of the original having been in French. Valuable efforts have been made to bring the technical aspects up to date. In particular the section on malting is notable because of the paucity of modern texts on this topic, while other chapters like those on filtration and bottling will also be generally welcomed. Perhaps some readers will expect a rather less superficial and descriptive approach or will be disappointed that certain aspects, such as the formation of haze in beer and the related topics of the amount of air included with bottled beer, have not received the detailed critical appraisal which they would often seem to demand.

Turning to scientific content, the account is primarily factual and, probably unavoidably, gives much weight to empirical rules which are sometimes based on little or no scientific evidence. For example, hand evaluation of barley is said to lead only rarely to mistakes, but obviously this can be justified only by experience of those relatively few varieties which have been under long observation, and it does not necessarily apply to new hybrids such as are now commonly grown and which have been developed for special characteristics. Again, the unwary reader could sometimes be misled, perhaps to some extent as a result of restriction of space. Thus on p. 60 an erroneous structure is given for colupulone, it is wrongly stated that humulone and lupulone are derivatives of quinone, while in some respects the discussion of hard and soft resins of hops is scarcely consonant with modern thought on this topic. It must be added that these considerations mostly arise in connexion with recent advances in rapidly moving subjects, and that they arise at all must be set against the fact that recent work on the science of brewing, especially since the Second World War, has been more exhaustively covered than technical advances over the same period. These are, in any event, only minor deficiencies, for the main object of the book is not to turn the scientist into a brewer but to explain to the latter something of the scientific basis of his craft so that technical improvements can be devised more surely than by guesswork alone. If that basis were to concern one department of science alone, the task would have been formidable enough. Actually it involves many quite widely separated sciences such as agronomy, structural organic chemistry, colloid chemistry and the genetics of micro-organisms, to mention only a few. It is the more remarkable, therefore, that the author and translator have jointly succeeded in producing the most comprehensive international work of its kind to have appeared for a long time.

A. H. COOK

DEMOGRAPHY OF AN UNDER-DEVELOPED TERRITORY

The Population of Jamaica

By George W. Roberts. Pp. xxii+356. (Cambridge: At the University Press, 1957. Published for the Conservation Foundation.) 40*s*. net.

A NOTABLE feature of the progress of demography in recent years has been the increasing attention paid to the under-developed—that is, poor and relatively non-industrial—territories. Typically, these have a high birth-rate and a mortality which is decreasing owing to famine control and improved hygiene and medical services. As a consequence, there is steady, and often rapid, population growth which is a major factor in any attempts to raise living standards. Only a few full-length studies of such areas have appeared, and this account of the demographic history of Jamaica is an important addition to their number. It was written as part of a research project sponsored by the Conservation Foundation, an American organization formed to promote knowledge of the Earth's resources, and is the first of three reports on Jamaica's population problems. The others are to be about a field study of family relationships and attitudes as they affect reproduction and the use of land and resources, respectively.

In some ways Jamaica is a particularly useful choice for such a study. The population of one and a half million is sufficiently homogeneous for the overall demographic characteristics to have meaning. A further advantage is the existence of fairly early records. In addition, the main trends are of almost text-book form. Fertility has been stable and fairly high over a long period but is now declining, while mortality has fallen steeply since about 1920; the rapid population growth is associated with serious unemployment. Mr. Roberts has made a very thorough study of the demography of the island from the early eighteenth century to the present day. Most of the data on which the account is based come from censuses (held since 1844) and birth and death registration, but other records, particularly for the earlier periods, are used skilfully, including those relating to importations of slaves and indentured labour. The nine chapters of the book are divided in the following way. After an opening chapter on the demographic material there are one each on the growth of population and its major characteristics, two on migration, one on mortality and two covering the inter-linked subjects of fertility, mating and reproduction. The final chapter gives some projections of the population up to 1971. Throughout, considerable attention is paid to details for regions, as well as for the island as a whole, particularly in relation to urban development.

Data for studies of this kind are always faulty and incomplete and one of the main criteria of their merits is how these difficulties have been handled. The book is very strong here. Wherever possible, the accuracy of records is cross-checked and a number of ingenious methods of analysis are applied. Interesting use is made of the survivorship table approach to illuminate problems. Mr. Roberts's judgment is always sound, but in a few places his close knowledge of Jamaican conditions leads him to tentative explanations which are not too convincing since they are a product of personal experience rather than of the evidence presented. He never, however, confuses speculation with reasoned conclusion. The discussions and presentation are clear, but some of the descriptions of analysis techniques are too cursory, and careful reading is needed to determine exactly how they were applied and the assumptions made.

The records for Jamaica have the great advantage of fair accuracy but, in many respects, they are very limited. In particular, there is little break-down of the number of births and child deaths by the characteristics of the parents. Thus no close study of differentials in fertility and mortality—the most satisfactory approach in the search for causes—is possible. This is a serious restriction, notably in connexion with the complex pattern of mating which involves 'keeper' unions and consensual and legal marriages; here differentials can only be guessed at by indirect means. It seems possible, then, that the weaknesses of the basic material will greatly reduce in scope the studies of further aspects of Jamaican demography. Some small-scale sample surveys of the mating and reproductive histories of women would surely give results of enormous value in this area.

W. Brass

A BROAD VIEW OF ECOLOGY

Agricultural Ecology

By Prof. Girolamo Azzi. Pp. xv+424. (London: Constable and Co., Ltd., 1956.) 45*s*.

The ecology of agricultural crops is a subject which is well worked and yet little known. There is a mass of undigested information about an enormous range of crops. In fact, much more is available than for wild plants, which are the plants with which ecologists usually deal. For this reason, a new book is very welcome, especially so since it is written by someone who has been intimately connected with the subject for thirty-five years.

With such a wide field it would be possible to write a safe, factual, rather prosaic book. However, Prof. Azzi has preferred to write differently. "Agricultural Ecology" is a book of imaginative ideas, around which is woven a considerable amount of information, most of which has not been available in English before. While to some Prof. Azzi's treatment may be annoying, it is both stimulating and provoking, and sorts out some of the tangle of factors affecting the growth of plants in the field.

The author begins with climate. Looking at it from the point of view of the plant, he shows very clearly the division of the growth of plants into periods. As the plant passes from one period to another, so its climatic needs—cold, heat, water, etc.—vary. In each period a different factor is critical and may be limiting to growth and final yield. A mass of data is given for a considerable variety of crops, both tropical and temperate, and it includes critical estimates of crop needs in each period. Of particular interest are the figures for rainfall need and the passing references to the critical factors concerned in such things as different as wheat rust and cotton boll weevil.

With the help of the critical factor concept, the normal maps of climatic factors are converted into maps of crop physiographic zones, and polygon figures combining factors together are used for representing crop climatic ranges diagrammatically.

Soil is treated in the same cavalier but provoking fashion. Soils are classified on the basis of an index derived from chemical content, water balance and workability, and not on a more classical pedological basis. As a result, it is possible to correlate productivity with soil characteristics.

The last part of the book is concerned with the yield of the plant as such, and its relation to specific ecological factors. Quality is linked to quantity, and seed quality and the effects of vernalization are not forgotten. Out of it all Prof. Azzi develops a general concept of the inter-relations of velocity of growth, size and structure of crop plants, and again he is able to relate it to productivity.

Here then is a curious book, both delightful and infuriating. The publishers say that it is the definitive text-book in agricultural ecology. I cannot agree with them. In one romantic sweep, Prof. Azzi has turned inside out every conceivable aspect of the growth of plants. He has thrown on one side almost every traditional approach, omits almost completely references to work published in English, and makes no use of statistics. Many will think his ideas are not so proper as classical ones. Yet perhaps they are nearer to fundamentals. It is remarkable but true that we still know very little about crop yields and that most of us are content to accept variations in yield as we find them or to explain them piecemeal in terms of individual factors. Prof. Azzi is not. Perhaps his book will stimulate others to enter this field and to continue his good work.

A. D. Bradshaw

WOMEN GRADUATES

Wives Who Went to College

By Judith Hubback. Pp. viii+164. (London: William Heinemann, Ltd., 1957.) 12*s*. 6*d*. net.

Women who have had a university education want to use their capacities to the full and to make a contribution to society. How can they combine this with marriage and motherhood? Mrs. Judith Hubback, herself a graduate mother, tried to find this out by sending out, in 1953, a questionnaire to 2,000 married women graduates (of whom 58 per cent replied) asking about their types of training, marital status, domestic and social circumstances, number of children, incomes, professional careers and their state of overtiredness or satisfaction. She wanted facts to refute prejudice and to establish whether these women were actually mis-employed, what types of part-time work they followed and what form of education really intelligent girls should be given. As a control, 420 non-graduate wives with a similar social background were asked the same questions.

The first account of this research, financed partly by the Leche Charity, appeared as a Political and Economic Planning broadsheet entitled "Graduate Wives". The present book analyses the answers and discusses the issues raised. It is found that the marriage-rate for women graduates is almost up to the normal, that they tend to be more fertile than average, that it takes some fifteen years before the last child is at school, that circumstances during the period of raising children give little opportunity for systematic intellectual pursuits or for an outside career, but that part-time teaching is the career most easily combined with family life, although many other paid or voluntary occupations are followed by some of the sample. At the time of the survey 64 per cent are at home full-time, but a large proportion of the graduates intend to follow a career later, in contrast to the control group. A whole chapter is devoted to overtiredness, due to diffuse, routine domestic work, which leads to frustration, and it is found that work outside the home, even part-time, results in a freshness of outlook and not in extra fatigue.

In the discussion, the need is stressed for a sane compromise between the biological aspects of a woman's life, as a mother carrying on the race, and the intellectual side developed by a university education.

It is suggested that modern emphasis should be on the diversity, rather than the identity of the sexes, and that a girl's education should enable her to evolve from the exclusive femaleness of the family stage, where, however, intelligence is not wasted, to the fulfilment of a wider personality later in life, given sufficient stamina, patience and a sense of proportion.

Practical issues are dealt with, and it is shown that the effect of the change in the balance of the population from a surplus of women to a surplus of men with the present early marriage-rate will lead within the next twenty years to a shortage of unmarried women of professional status, so that it will be more and more necessary to adapt conditions to the employment of married women. One essential change will be in the system of assessing income-tax paid by a married woman.

By collecting actual facts, Mrs. Hubback has done valuable work in raising this subject one step above the surmise and prejudice usually associated with it. From the trends observed, although the sample is small and not claimed to be statistically perfect, she draws valuable information leading to the conclusion that, while admitting the educational dilemma due to her probably dual role in life, an intelligent girl should be educated to the highest level of which she, as an individual, is capable and that she should continue her education to qualify for professional status. Because the author herself and the majority of her sample are at the family-raising stage she puts, perhaps, too low a value on the potentialities of highly educated women. It would be interesting and possibly more encouraging to career-minded girl students to have a further survey of the careers followed at the next stage, later in life, when so many professionally trained married women are tending to return to outside work. C. E. Arregger

THE SCIENCE OF COSMETICS

Cosmetics

Science and Technology. Edited by Edward Sagarin. Pp. xix+1433. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 25 dollars.

The avowed intention of the editors of this volume is "to bring together a number of authorities each of whom has acquired a thorough familiarity with some special phase of cosmetics or of some related science or technique". In this object they appear to have succeeded since sixty-one men and women have written fifty-three chapters covering the whole range of cosmetics.

This very large quantity of material is subdivided into five parts: 1, The Scope of Cosmetics; 2, Toilet Preparations; 3, Manufacture and Technology; 4, Physiological Considerations; 5, Legal Considerations.

Part 1 includes a chapter on the origin and development of cosmetic science from the days of the Egyptian and Babylonian Dynasties until the nineteenth century when the basis of modern cosmetic formulation begins to appear.

The major part of the book is to be found in Part 2. Fifty types of cosmetic preparations are grouped into thirty-five chapters, two or more allied preparations being incorporated together in some chapters. Each chapter is prefaced by a discussion of the requirements of the preparation to be compounded. This discussion involves a consideration of pharmacology, of presentation and of storage problems.

A lengthy chapter is included on aerosol cosmetics. This contains a discussion on the various types of propellants, the advantages and disadvantages of each, with numerous graphs showing the vapour pressures of various mixtures of these propellants. Types of containers and production methods are also considered. The chapter also includes a glossary of terms used in the aerosol industry—terms approved by the Chemical Specialities Manufacturers Association.

The numerous and varied formulæ are well set out in the text with the reasons for the inclusion or exclusion of any particular ingredient. Manufacturing instructions are given for nearly every formula, and where they are not included they can be deduced from similar formulæ.

Part 3 includes a very useful chapter on quality control emphasizing the necessity of statistical analysis. The subject of statistics is treated in as simple a manner as possible—formulæ are given but not proved. Consideration is given to the standard deviation, the Student *t* test, confidence limits, correlation and regression lines, analysis of variance. Useful information on the design of experiments is supplied.

Part 4 includes chapters on "The Physiology of Olfaction", "Hormones in Cosmetics" and "Sensitivity Testing". Part 5 includes a chapter on American patents and trade marks and a copy of the relevant parts of the Federal Food, Drug and Cosmetic Act, 1955.

The editing of the book has been extremely good, and little overlapping of information occurs in its many chapters. Each chapter is fully and widely referenced. The theoretical knowledge given, where it is required in each chapter, is generally good, although occasionally it is a little ambiguous when emulsions are being considered, but as the book is essentially one of cosmetic practice, these statements do not interfere with its usefulness.

The line diagrams are clear and well annotated; the graphs and tables self-explanatory. The photographs are good, although pictures of large-scale plant are not very enlightening. In the photographs of the mineral oil emulsions, two reference letters are missing.

An index of trade names is given, including details of chemical composition and manufacturers' names and addresses. The author index appears to be complete and is certainly well cross-referenced. The subject index is extensive, but, and this is probably the most serious fault with the book, it is not complete. Many substances are mentioned in several places in the text but only receive one reference in the index. Some substances are, unfortunately, mentioned in the text but not in the index.

These faults apart, the editors can congratulate themselves and the authors on producing a book which cannot help but be of great use to every cosmetic manufacturer (or would-be manufacturer) throughout the world. Cyril W. Ridout

l'Énergie Nucléaire dans le Monde

Programmes et Développements Prévus. Par T. Reis. Pp. x+296. (Paris: Dunod, 1957.) 2,900 francs.

THIS book provides a useful summary of the world's energy consumption and its distribution among available sources. It provides statistics of the energy consumption of most of the countries of the world and summarizes the predictions that have been made about the future growth of energy requirements.

The second chapter describes the atomic energy organizations of more than forty countries, lists their reactors of different types and gives their nuclear power programmes—where they exist. The information given is as accurate as could be expected when programmes change rapidly.

The third chapter summarizes the conclusion about the world's future requirements and predicts that in Western Europe nuclear energy will be providing between 15 and 20 per cent of all electricity generated by 1975. This would still only be 18 per cent of the indigenous energy deficit of the Organization for European Economic Co-operation countries.

A final table classes eight countries in order of nuclear power output by 1960, 1965 and 1970/75. According to this, Britain will take third place in 1960 and second place in later years, Canada being credited with second place in 1960. These predictions are of little value in the present shifting phase of national programmes. J. D. Cockcroft

Contributions to the Flora of Venezuela

By Julian A. Steyermark and Collaborators. (Fieldiana: Botany, Vol. 28, No. 4.) Pp. ii+512. (Chicago, Ill.: Chicago Natural History Museum, 1957.) 7.50 dollars.

THIS volume is the final instalment of new records, notes on range extensions, and descriptions of new species based on Dr. Steyermark's notable botanical collections on the mountains of Venezuela, especially on those of the Guayana Highlands, some of which had never before been explored by biologists. These contributions are of absorbing interest for the taxonomist and plant geographer, but the promise to include special notes on geology, topography, floral zones and ecological aspects in the sections devoted to certain mountains can scarcely be said to have been fulfilled. This final volume closes with a list, in taxonomic order, of all the new plants which have been described in the contributions. A complete set of Dr. Steyermark's specimens is placed in the Chicago Natural History Museum.

BBC Handbook, 1958

Pp. 288. (London: British Broadcasting Corporation, 1957.) 5*s*.

THE B.B.C. Handbook 1958 includes the balance sheet and accounts for the year ended March 31, 1957, as well as a brief analysis of income and expenditure for that year among the regions, an analysis of both sound and television programmes and a comparison of programme services costs. It also gives a comprehensive account of the Corporation's activities prior to the recent changes in the sound programmes. Following Sir Alexander Cadogan's foreword, a chapter on the constitution of the Corporation refers briefly to the 'fourteen-day rule' forbidding the anticipation of Parliamentary debates, but neither there nor elsewhere is there any discussion of live issues. The Handbook is essentially factual and descriptive: besides a review of the year's broadcasting, there are chapters on the domestic broadcasting services; the external services; the work and responsibilities of the engineering departments and their technical facilities and installations; programme policy and practice; and relations with the public, the latter including some advice on how to get the best reception. The texts of the Corporation's charter, licence and agreement and supplementary agreement are given, and the Handbook includes a useful select bibliography.

The Terpenes

By the late Sir John Simonsen and Dr. W. C. J. Ross. Vol. 4: The Triterpenes and their Derivatives: Hydrocarbons, Alcohols, Hydroxy-aldehydes, Ketones and Hydroxy-ketones. Pp. ix+524. (Cambridge: At the University Press, 1957.) 70*s*. net.

THIS is the fourth volume of a series, so it needs little in the way of general introduction. It contains accounts of the structures, degradations and general reactions of the compounds listed in the title, and some indication of stereochemistry. References are given up to 1956, but there are indications that some sections were substantially completed rather earlier than this, which is a disadvantage, although perhaps an inevitable one in a rapidly moving field. The volume is otherwise a very clear and complete account of the subject. The one quarrel which the reviewer has with it is the inadequate consideration given to stereochemistry. The results are stated in most cases, it is true, but without much account of the way they are derived. Conformations are not given. This is clearly a matter of deliberate policy, but the result is rather like raspberry jam without the seeds, wholesome and nourishing but a trifle unreal. It is a definite drawback to the use of the single volume. However, nobody who has the earlier volumes or who is interested in research or teaching in this field can afford to be without this book.

A. J. Birch

Kandelman's Krim

A Realistic Fantasy. By Prof. J. L. Synge. Pp. 175. (London: Jonathan Cape, Ltd., 1957.) 15*s*. net.

AN Orc, a Kea, a Unicorn and a Plumber, meeting to discuss the nature of infinity and the attributes of God, are joined by a sky-blue Goddess; her knowledge of arithmetic resembles Sam Weller's knowledge of London, but she does not understand why the debaters appear to be so interested in mathematics. Instruction is thrust upon her—integers, fractions, complex numbers, sequences, limits. Controversy is enlivened by flashes of wit and chunks of Carrollian nonsense.

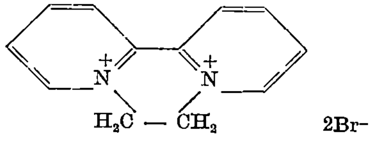
Temptation to see an allegory is strong. Surely the Plumber, with his strong constructive sense, his appreciation of mathematical techniques and his deprecation of formalism and academic subtlety, is the modern mathematical physicist, while the sceptical and pedantic Orc is the orthodox pure mathematician, roused only once or twice to a passion which suggests descent from the Orc of William Blake. But the allegory is obscure, and the long preface, with its discussion of meaningful and meaningless statements, its references to Berkeley and to the author's ancestor, Bishop Hugh Hamilton, may be a veiled warning against seeking a meaning where none exists. The fun is there to be enjoyed, and only the careless reader will miss the implication that real mathematics is as much the product of imagination as of logic. T. A. A. Broadbent

A NEW HERBICIDE

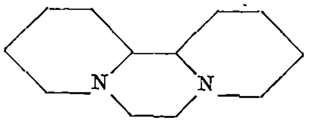
I : 1'-ETHYLENE-2 : 2'-DIPYRIDYLIUM DIBROMIDE

By R. C. BRIAN, R. F. HOMER and J. STUBBS
Imperial Chemical Industries, Ltd., Jealott's Hill Research Station, Bracknell, Berks
AND
R. L. JONES
Imperial Chemical Industries, Ltd., Pharmaceuticals Division, Alderley Park, Macclesfield, Cheshire

DURING the early spring of 1955, in the course of an investigation at Jealott's Hill Research Station into the herbicidal properties of a series of quaternary ammonium compounds, one chemical showed exceptional activity. This was originally prepared by R. J. Fielden at Blackley by the quaternization of 2 : 2'-dipyridyl with ethylene dibromide ; a reaction which gives rise to a single well-defined crystalline product which has been shown to be 1 : 1'-ethylene-2 : 2'-dipyridylium dibromide (*X*)[1].



(*X*)



(*Y*)

Elementary analysis agrees with the empirical formula $C_{12}H_{12}N_2Br_2$, in which all the bromine is ionic, and hydrogenation over Raney nickel in the presence of sodium acetate gives a fully saturated base $C_{12}H_{22}N_2$(*Y*), b.p. 74–76°/0·2 mm., which has molecular weight (cryoscopic in benzene) 186. $C_{12}H_{22}N_2$ requires 194. This eliminates possible dimeric or polymeric structures.

1 : 1'-Ethylene-2 : 2'-dipyridylium dibromide forms a pale yellow monohydrate from water m.p. > 320° decomp. having in aqueous solution $\lambda_{\text{max.}}$ 308,311 mμ ; $\varepsilon \sim 18{,}000$. The material is readily soluble to the extent of 70 gm. in 100 c.c. of water at 20° C. and is stable in acid or neutral solution. In alkaline solution coloured complex products are formed which appear to arise from the opening of one of the pyridine rings, a process associated with the uptake of one molecule of alkali.

In the greenhouse, aqueous solutions of *X* with added wetter (0·3 per cent 'Agral *LN*'), applied as foliage sprays at the rate of 100 gal./acre, gave complete kill of wheat, sugar beet, white mustard, marigold (*Calendula* sp.), red clover and cleavers (*Galium aparine*) at dosages down to ½ lb./acre. At ¼ lb./acre, there was 100 per cent kill of marigold, almost complete kill of mustard and serious damage to the remaining species. Even at ⅛ lb./acre, *X* seriously damaged all the plants other than cleavers. In the absence of wetter, the chemical was almost equally effective, though it was less damaging to wheat and clover. Similar results were obtained with low-volume (20 gal./acre) applications. The action of the chemical was very rapid.

From general observations on the effects of the treatment, and because the volume of application had so little effect on the activity, it seemed likely that *X* was acting systemically. Proof of the uptake and translocation through the aerial parts of broad bean and oat was readily obtained. Further, it was found that entry through intact bean leaves was very rapid, taking place within five minutes of application. Root uptake by oats growing in culture solution also occurred, though soil drenches had no effect on pot-grown plants. This apparent anomaly was explained when it was found that *X* was rapidly and completely adsorbed by soil.

Subsequent greenhouse tests showed that *X* was highly active against several common weeds at ¼–½ lb./acre, including the species resistant to 2,4-D and MCPA, chickweed (*Stellaria media*), groundsel (*Senecio vulgaris*), mayweed (*Matricaria* spp.) and speedwell (*Veronica* spp.). Russian thistle (*Salsola pestifer*), a common arable weed of North America, was highly susceptible, being killed at rates as low as ¼ lb./acre.

Because of its high activity in these initial tests, *X* was clearly worthy of further evaluation as a herbicide. Preliminary field trials confirmed that there was generally little difference between high-volume and low-volume application. For this reason, in most of the later trials the treatments were applied at 20 gal./acre.

Excellent potato haulm destruction was given by *X* at 1–2 lb./acre in a series of fourteen trials carried out in the period 1955–57, haulm kill being equal to that given by the standard sulphuric acid and sodium arsenite treatments and faster than the latter. Kill of common annual weeds, including fat hen (*Chenopodium album*), red shank (*Polygonum persicaria*), annual nettle (*Urtica urens*), chickweed (*Stellaria media*) and black nightshade (*Solanum nigrum*) by the new chemical at these rates was usually superior to that given by either sulphuric acid or sodium arsenite. Rain falling shortly after application had no effect on the herbicidal activity of *X* although it reduced that of the arsenite. The storage properties of the potato tubers were unaffected by the *X* treatments.

Indications that *X* was of value as a pre-harvest desiccant of red clover seed crops were obtained in a preliminary trial in 1956. This finding was confirmed in a more detailed trial later in that season and again in 1957, when it was shown that low-volume application of *X* at 1–2 lb./acre desiccated the crop at least as well as sulphuric acid (15 per cent B.O.V.) applied at 100 gal./acre.

Damage to cereals by X in the field was less than had been anticipated from the greenhouse observations. Oats proved to be the most resistant, and rates of up to 2 lb./acre mainly caused only localized foliar scorch. Wheat, maize and barley showed increasing damage in that order. Temporary chlorosis of the younger leaves sometimes developed, particularly with the more susceptible species. Grain yields in weed-free stands of spring oats and wheat in 1956 were not reduced following spray application at the 2–3 leaf stage of up to 1 lb./acre, but were affected by later treatments. Yields of spring barley were reduced in all cases; maize was not taken through to yield. In a series on weed-infested crops in the same season the treatments had no effect on yield in one trial on winter wheat and two on winter oats. Significant yield reductions, however, were recorded at two other centres where spring wheat and oats had been sprayed at later stages of development at 40 and 100 gal./acre, respectively.

Most species of broad-leaved annual weeds present in these cereal trials were adequately controlled by X at 1 lb./acre, exceptions being corn poppy (*Papaver rhoeas*), corn marigold (*Chrysanthemum segetum*) and parsley piert (*Aphanes arvensis*), which were markedly resistant. The activity shown by X in greenhouse tests against cleavers, chickweed, groundsel, mustard and speedwell was confirmed in these field trials. In addition, knotgrass (*Polygonum aviculare*), black bindweed (*P. convolvulus*), redshank (*P. persicaria*), charlock (*Sinapis arvensis*), runch (*Raphanus raphanistrum*), cut-leaved dead-nettle (*Lamium hybridum*), many-seeded goosefoot (*Chenopodium polyspermum*), fat hen (*C. album*), orache (*Atriplex* spp.) and scarlet pimpernel (*Anagallis arvensis*), all proved to be susceptible at rates of 1 lb./acre or less.

In these, and other trials, X gave good kill of top growth of several broadleaved perennial species, including dock (*Rumex* spp.), creeping thistle (*Cirsium arvense*), mint (*Mentha* spp.), field bindweed (*Convolvulus arvensis*), ox-tongue picris (*Picris hieracioides*) and ground elder (*Aegopodium podagraria*). Basal regeneration in these perennials, however, quickly nullified the effect of the treatment. Similar responses were given by a range of grass species.

Low-volume applications of X at 2–5 lb./acre gave good top kill of various brushwood species, including bramble (*Rubus* spp.), briar (*Rosa* spp.), hawthorn (*Crataegus monogyna*), elder (*Sambucus nigra*), elm (*Ulmus* spp.). In all cases, however, the initial dieback was followed by basal regeneration.

Clearly, 1 : 1′-ethylene-2 : 2′-dipyridylium dibromide is a very potent, translocatable, rapid-acting, non-persistent, post-emergence herbicide. Potential outlets seem to lie mainly in the field of potato haulm destruction, crop desiccation and non-selective weed-killing, though it may find some application as a selective weedkiller in cereals. More research is needed before the full potential of this new herbicide can be defined.

Considerable assistance with the field trials reported here was given by H. C. McIlvenny and L. G. Spencer.

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[1] Imperial Chemical Industries, Ltd. (Fielden, R. J., Homer, R. F., and Jones, R. L.), British Patent Specification No. 785,732.

NON-CONSERVATION OF PARITY

The situation in the field of elementary-particle decay interactions altered profoundly during 1957. With experiments demonstrating violation of parity in β-decay[1] and π–μ–e-decay[2] early in the year a new phase began in experimental work as well as in theoretical understanding of these weak interactions. A symposium, organized by Prof. R. E. Peierls, was held at the Royal Society on December 5 to assess the present situation in the field. The meeting was organized in two formal and one discussion session. An introductory talk by Prof. Peierls was followed by one from Dr. D. L. Pursey (Edinburgh), who gave a summary of β-decay and μ-decay theory. Dr. M. A. Grace (Oxford) surveyed the experimental situation in β-decay, and Prof. J. Cassels the situation in π–μ–e-decay. Drs. P. E. Cavanagh and E. C. Ridley described experimental techniques for measuring electron polarization and electron–neutrino correlation, and Prof. A. Salam (Royal College of Science, London) spoke on 'strange' particle decays. This article offers a brief discussion of some of the material presented.

The principle of space-reflexion symmetry asserts that there is no fundamental difference between right and left; that the results of any experiment look the same to an observer viewing the experiment directly as to one looking at its reflexion in a mirror. In elementary-particle physics this implies that transition probabilities for any reaction must not involve any pseudoscalar quantity. Pseudoscalar quantities are those which change sign on reflexion ($\mathbf{r} \rightarrow -\mathbf{r}$). Simple examples of these are products such as $\mathbf{p}_1 \wedge \mathbf{p}_2 \cdot \mathbf{p}_3$, where $\mathbf{p}_1$, $\mathbf{p}_2$, $\mathbf{p}_3$ are three (momentum) vectors, or $\mathbf{J} . \mathbf{p}$., where $\mathbf{J}$ is an angular-momentum vector. (It may be recalled that angular momenta behave similarly to $\mathbf{r} \wedge \mathbf{p}$ for reflexions. For $\mathbf{r} \rightarrow -\mathbf{r}$, $\mathbf{p} \rightarrow -\mathbf{p}$, $\mathbf{J} \rightarrow \mathbf{J}$ and thus both $\mathbf{p}_1 \wedge \mathbf{p}_2 \cdot \mathbf{p}_3$ and $\mathbf{J} . \mathbf{p}$ change sign.)

The principle of space-reflexion symmetry is known to hold in classical physics as well as in atomic and nuclear physics to all measurable accuracy. Yang and Lee[3] were the first to point out, in the summer of 1956, that no experimental confirmation had been obtained whether pseudoscalar quantities do in fact occur in expressions for transition-rates of decay processes. The first experiments performed with polarized neutrons[1] and μ-mesons[2] showed unmistakably that these rates are proportional to $a + b <\mathbf{J}> . \mathbf{p}_e$, where $<\mathbf{J}>$ is the vector representing neutron or μ-meson spin and $\mathbf{p}_e$ is the momentum of the electron emitted. These experiments also showed one other characteristic which has proved extremely valuable for their theoretical interpretation. This was the observation that in all neutron (n) decays the emitted electrons spin in the opposite sense to their direction of motion[4] (left-polarization) with a polarization of magnitude v/c, while in the inverse transitions and in μ^+-decay[5] the emitted positron possesses right-polarization of the same magnitude.

All decays can be classified into two categories:

Category (1). Decays involving neutrinos (ν) as one of the decay products: (1) $\mu^\pm \rightarrow e^\pm + 2\nu$; (2) $n \rightarrow p + e^- + \nu$; (3) $\pi^\pm \rightarrow \mu^\pm + \nu$; (4) (*a*) $K^\pm \rightarrow \mu^\pm + \nu$; (*b*) $K^\pm \rightarrow \mu^\pm + \nu + \pi^0$; (*c*) $K^\pm \rightarrow e^\pm + \nu + \pi^0$.

Category (2). Decays not involving neutrinos: (5) $\Lambda \rightarrow p + \pi^-$; (6) (*a*) $\Sigma^+ \rightarrow p + \pi^0$; (*b*) $\Sigma^+ \rightarrow n + \pi^+$; (7) $\Sigma^- \rightarrow n + \pi^-$; (8) (*a*) $K^\pm \rightarrow \pi^\pm + \pi^0$ (θ-mode); (*b*) $K^\pm \rightarrow \pi^\pm + \pi^\pm + \pi^\pm$ (τ-mode).

The decays in the second category involve 'strange' particles only and violate 'strange-ness' conservation. Thus these present the deeper problem.

Before considering experimental results, we wish to make some theoretical remarks regarding decays in category 1. From experience, one has learnt that the simplest procedure in neutrino theory is to consider only Majorana neutrinos (ψ). A Dirac (4-component) neutrino, ψ_D, is simply two Majorana neutrinos, ψ_1 and ψ_2, with a definite phase-relation between them ($\psi_D = \psi_1 + i\psi_2$). There are two independent basic assumptions which have been made in all present theoretical thinking, namely, (1) that the neutrino mass and self-mass are identically zero; and (2) that there is a conservation law for light particles (μ-mesons, electrons and neutrinos). In any process the total number of light particles minus anti-particles remains unaltered.

Specializing to the case of single Majorana neutrino, these two assumptions lead to the so-called 2-state theory[6]. In this theory: (*a*) Both parity as well as charge-conjugation invariance must be violated. (*b*) Neutrinos are polarized, either along (ν_R), or opposite (ν_L) to their direction of motion. ν_L may be considered as the anti-particle of ν_R ($\overline{\nu_L} = \nu_R$). (*c*) The electron (or positron) accompanying ν_R is right-polarized (with polarization of magnitude v/c) if the interaction is of 'vector' (V) or 'axial-vector' (A) type; it is left-polarized if the interaction is of 'scalar' (S), 'tensor' (T) or 'pseudoscalar' (P) type.

One may consider two completely independent Majorana neutrinos, ψ_1 and ψ_2, or a Dirac neutrino, $\psi_D = \psi_1 + i\psi_2$, obtaining further generalizations of the theory. In the latter case the distinction between a neutrino and anti-neutrino does not depend on the state of polarization of these particles ($\overline{\nu_L}$ and ν_R are both right-polarized but not identical).

Consider briefly the experimental data for processes in category 1 and their theoretical interpretation:

(1) $\mu \rightarrow e + 2\nu$.

(*a*) Experiments with electrons emitted by polarized μ-mesons show a backward–forward asymmetry, demonstrating parity non-conservation[2].

(*b*) The most accurate determination[7] of the Michel parameter, ρ, in the μ-decay spectrum gives a value of $0{\cdot}68 \pm 0{\cdot}02$. The 2-state theory predicts a value of $0{\cdot}75$ provided that, in μ-decay: $\mu^\pm \rightarrow e^\pm + \nu_L + \nu_R$.

(*c*) In the 2-state theory, writing the decay interaction in the form $g_V H_V + g_A H_A$, where V and A refer to vector and axial-vector couplings, $\{H_V = \overline{(\mu^+ Ve^+)}\ (\nu_R\ V\nu_L)$, etc.$\}$, the asymmetry parameter mentioned in (*a*) corresponds to equal V and A ($|g_V| = |g_A|$). The measurement of positron polarization and the result that these are right-polarized gives $g_V = -g_A$.

(*d*) The μ-mesons in these experiments were produced from π-decays at rest, and (in accordance with the expectation from 2-state theory) were nearly 100 per cent polarized. From the experimental observation that positrons from these μ^+-decays are emitted predominantly in the direction opposite to the μ^+-direction of motion[5], one may infer that μ^+-mesons from π^+-decay are also right-polarized.

(*e*) Assuming light-particle conservation, from $\mu^+ \rightarrow e^+ + \nu_L + \nu_R$, and $\pi^+ \rightarrow \mu^+_R + \nu_R$ (necessarily so from the conservation of angular momentum) one would infer that μ^+, e^+, ν_L form the set of 'particles' and μ^-, e^-, ν_R the set of 'anti-particles'.

It is to be noted at this stage that the 2-state theory gives no explanation of why $g_A = -g_V$.

(2) β-Decay:

As mentioned before, experiments with polarized nuclei demonstrate unmistakably that parity is not conserved. The fact that electrons and positrons emitted in β-decay possess a high degree of longitudinal polarization provides a new tool for the determination of the fundamental β-interaction. If the 2-state theory with lepton conservation is assumed, the experimental result that positrons are right-polarized implies that positrons are always emitted together with ν_R-neutrinos. This would mean that the β-interaction is A and V.

The experimental situation on this question is in confusion. First, most experiments seem to agree on the interaction being S or V plus A or T. This follows from the absence of Fierz-interference terms (plus the assumption of time-reversal invariance). The detailed distinction between S or V and T or A is made by electron–neutrino correlation experiments which have nothing to do with violation of parity as such. Experiments with argon-35 seem to show V, experiments with helium-6 show T; neon-19 and neutron data are compatible with either (S,T) or (V,A) combinations. It would appear that if the helium-6 experiments[8] stay firm, the 2-state theory with lepton conservation will have to be abandoned, notwithstanding its successes.

Turning to a consideration of decays in category 2, data have recently become available which demonstrate violation of parity in these processes also. The most conclusive evidence comes from $\Lambda \rightarrow p + \pi^-$. For a sample of polarized Λ-particles at rest, with spin pointing along $<\mathbf{J}>$, it is sufficient to show that the decay probability, W, depends on $<\mathbf{J}> \cdot \hat{\mathbf{p}}_{out}$ ($\hat{\mathbf{p}}_{out}$ is the direction of π-momentum). It transpires, providentially, that in the production reaction $\pi^- + p \rightarrow \Lambda + K$, the Λ-particles produced by π-mesons of about 1-BeV. energy possess a high degree of polarization. Since, quite generally,

$$<\mathbf{J}> \propto \mathbf{p}_{in} \wedge \mathbf{p}_\Lambda$$

where $\mathbf{p}_{in}$ is incident π^--momentum and p_Λ the Λ-momentum in the centre-mass frame, it is sufficient to look for an asymmetry in the number of decay π's in a direction normal to the Λ-production plane and in the opposite direction. Writing

$$W = 1 + \alpha <\mathbf{J}> \cdot \hat{\mathbf{p}}_{out}$$

the combined results of the Columbia, Bologna, Pisa, Michigan, Brookhaven and Berkeley groups give $\alpha\,\overline{<\mathbf{J}_\Lambda>} = 0{\cdot}52 \pm 0{\cdot}10$. Here $\overline{<\mathbf{J}_\Lambda>}$ is an average taken over a number of production angles. From angular distribution data in Λ-production it has been estimated that $\overline{<\mathbf{J}_\Lambda>} \leq 0.68 \pm 0{\cdot}03$, so that the fundamental asymmetry parameter[9], $\alpha \geqslant 0{\cdot}77 \pm 0{\cdot}15$. The corresponding results for Σ^+ and Σ^- particles give

$$\alpha\,\overline{<\mathrm{J}>_{e+}} = -\,0{\cdot}36 \pm 0{\cdot}20$$
$$\alpha\,\overline{<\mathrm{J}>_{e-}} = -\,0{\cdot}13 \pm 0{\cdot}26$$

The two decay modes of K^+-meson (θ-mode, $\pi^+ + \pi^0$, and τ-mode, $\pi^+ + \pi^+ + \pi^0$) provide additional evidence for violation of parity. The final state consisting of $\pi^+ + \pi^0$ mesons has spin-parity assignments 0 +, 1 −, 2 +, etc. It is easy to show that corresponding assignments for the $(\pi^+ + \pi^+ + \pi^-)$ state are 0 −, 1 +, 1 −, 2 +, etc. There is considerable evidence that the spin of the K-meson is zero. Thus, K-particles decay through two modes, with opposite intrinsic space-reflexion properties.

For the theoretical interpretation of 'strange'-particle decays there is nothing analogous to the neutrino to carry the blame for violation of parity. It may be recalled that it was the possibility of making the gauge transformation $\psi_\nu \rightarrow \gamma_5\psi_\nu$ for the neutrino (on account of its zero-mass) which led to the 2-state theory. One would like to have something analogous to this transformation for 'strange'-particles.

Already in neutrino physics there are indications that the transformation, $\psi_\nu \rightarrow \gamma_5\psi_\nu$, is not enough. There is the obstinate fact in μ-decay that $g_A = -\,g_V$. One can perhaps find a natural explanation for this by generalizing the neutrino gauge to electrons or μ-mesons, in the following manner. We postulate that all μ-interactions or electron-interactions are invariant for the transformations

$$\psi_e \rightarrow \gamma_5\psi_e, \quad m_c \rightarrow -\,m_e$$
$$\text{or } \psi_\mu \rightarrow \gamma_5\psi_\mu, \quad m_\mu \rightarrow -\,m_\mu$$

In so far as the electro-magnetic interaction is not changed by these (mass-reversal) transformations, invariance for mass-reversal appears as a universal law for all light particles.

Unfortunately, the current theories of strong interactions are not mass-reversal invariant. J. Sakurai[10] has, however, proposed that as a start towards obtaining the interaction for 'strange'-particle decays one may postulate that all 'strange'-particle decays arise from weak couplings of the type $(\overline{\Lambda} N)\ (\overline{N} N)$, where N stands for nucleons, and that mass-reversal applies to these. One then obtains the result that there exists a universal 4-field interaction between Fermi fields with equal mixtures of A and V. In the particular case of Λ-decay, this gives $\alpha = 0{\cdot}89$. This unified point of view appears attractive although it suffers from a number of theoretical objections. The chief experimental evidence against it, however, is the result of $e - \nu$ correlation experiments on helium-6 decay, mentioned before.

This discussion would not be complete without some mention of the so-called PCT theorem[11]. It can be shown that invariance of a theory for Lorentz rotations automatically implies its invariance under each of the six products PCT, TPC, PTC, etc., where P stands for parity, C for charge-conjugation and T for time-reflexion invariance. It is clear that —besides parity—at least one other invariance must be violated in weak decays. It can be shown that all experiments imply C-violation. Weak interactions are not charge-conjugation symmetric. It is still an open question whether or not time-reflexion symmetry holds in these processes.

A. SALAM

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VACANCIES AND OTHER POINT DEFECTS IN METALS AND ALLOYS

IN recent years there has been considerable interest in the behaviour of lattice vacancies, interstitial atoms and other more complex point defects in metals. In order to survey this subject, the Metal Physics Committee of the Institute of Metals invited six papers which would form the basis of a symposium. By kind permission of Sir John Cockcroft, the symposium was held at the Atomic Energy Research Establishment, Harwell. On December 9, following visits to the reactors DIDO and PLUTO and some laboratories, an introductory lecture was given by Prof. R. W. K. Honeycombe (University of Sheffield). He showed that a knowledge of the characteristics of point defects is necessary for the understanding of a wide range of metallurgical phenomena, including quench- and irradiation-hardening, fatigue and creep.

On December 10 the six invited papers were briefly presented to an audience of about three hundred, and general discussion followed. Dr. A. H. Cottrell (Atomic Energy Research Establishment, Harwell) considered how point defects can cause or contribute to hardening and softening processes in metals at temperatures lower than those at which conventional high-temperature creep occurs. The most spectacular hardening is that produced by quenching very pure metals from temperatures near the melting point. If the quench is sufficiently rapid, the high-temperature equilibrium concentration of vacancies remains randomly dispersed, and there is little or no hardening. Then if the metal is warmed sufficiently for the vacancies to agglomerate or migrate to dislocations, considerable hardening can occur. The detailed interpretation of quenching experiments was repeatedly shown to be of crucial importance for the understanding of the behaviour of lattice vacancies. When a metal is bombarded by energetic particles, occasional collisions lead to the knocking of atoms from lattice sites and the consequent production of equal numbers of vacancies and interstitials. The hardening produced by irradiation is often considerable, but the processes are apparently complex. It appears that both the initiation of plastic deformation and its continuation are usually made more difficult, indicating that point defects do interact with dislocations to give 'source hardening', and with each other to give general lattice hardening. During plastic deformation of annealed metals, lattice vacancies are produced and in certain circumstances can lead to readily observed increases in local diffusion rates. This is particularly prominent in fatigue, and it is probable that there is also a characteristic fatigue-hardening produced by point defects which more resembles quench- and irradiation-hardening than work-hardening.

The effects of point defects on some physical properties afford means for the study of their generation, movement and disappearance. The existing theoretical and experimental evidence was summarized by Dr. T. Broom and R. K. Ham (University of Birmingham). It was concluded that while the measurement of electrical resistivity is often experimentally simple, the uncertainties in interpretation are often such as to render more desirable the rather difficult measurement of stored-energy. The other properties considered were density, thermo-electric power, magnetic behaviour, thermal conductivity and nuclear magnetic resonance. The most useful experiments are obviously those in which the changes of many properties are studied simultaneously.

Dr. W. M. Lomer (Atomic Energy Research Establishment, Harwell) considered the transport of atoms through metallic lattices in various types of diffusion processes, of which vacancy diffusion is the most important. In many face-centred-cubic metals the details are well understood, but in other lattices the 'structure' of a vacancy and of other point defects remains uncertain and hinders agreement between theory and experiment. Vacancies in alloys usually associate preferentially with one species of atom, and useful information can be gained about this indirectly from quenching experiments and directly from tracer diffusion measurements in homogeneous alloys. It is probable that non-equilibrium concentrations of vacancies introduced into homogeneous alloys, for example, by irradiation, can only lead to accelerated diffusion over very small distances because of the density of vacancy traps. Chemical diffusion in inhomogeneous systems is more complex on account of the complication of the gradient of chemical potential. Briefly, each species of atom will migrate at a different rate along the gradient leading to shifting of diffusion interfaces, to 'vacancy pumping' and frequently to formation of porosity due to local vacancy supersaturations. The detailed behaviour of sinks (and sources) for vacancies is important not only in such systems but also in vacancy-creep and in sintering.

The activation energy for creep at high temperatures has frequently been found to be very close to that required for self-diffusion. In a general account of high-temperature mechanical properties, Dr. D. McLean (National Physical Laboratory) showed how this is accounted for by mechanisms involving climb of dislocations caused by their absorption of thermal vacancies. The relative rates of creep in various metals can be qualitatively explained by considering the structure of the dislocations involved and whether they can readily act as sinks for vacancies. Alloying usually reduces the rate of secondary creep, and it is possible by simple calculations to indicate what modifications to the dislocation climb model may occur in particular cases. During the later stages of creep tests, voids frequently appear at grain-boundaries. The hypothesis that these are formed by the condensation of vacancies is confirmed after critical examination of the conditions for nucleation and growth.

Dr. P. L. Pratt (University of Birmingham) contributed a paper discussing the role of point defects in determining the mechanical properties of ionic crystals. Historically, there is good precedent for such studies casting light on similar properties in metals, and it was shown that quench-hardening, generation of vacancies by moving dislocations, dislocation-pinning and vacancy cluster hardening all occur in crystals of sodium chloride. However, an important contribution to hardening in ionic crystals arises from the positive charge carried by dislocations which itself is a consequence of differing energies of formation of positive and negative ion vacancies. The line charges are screened by clouds of oppositely charged vacancies and this causes additional dislocation-pinning.

The last paper of the symposium, by E. C. Williams and P. C. S. Hayfield (Imperial Chemical Industries, Metals Division, Birmingham), dealt with the character of the metallic surface conceived of as containing an abnormal concentration of point defects and the influence that this has upon dry corrosion. Many new experimental results were presented from work in progress, and it was considered that they could best be explained by introducing into the theory of oxidation the concept of the trapping of electrons by localized structural defects.

In opening the general discussion, Prof. R. Maddin (University of Pennsylvania) gave new results for the hardening of polycrystalline copper by quenching. Specimens which had been rapidly quenched to room temperature could be hardened by slight warming, but heating at a higher temperature caused softening. Both processes occurred with an activation energy of 0·7 eV. and were believed to be associated with the movement of single vacancies. In a new theoretical interpretation of the effects of quenching on the electrical resistivity of gold it was proposed that quenching from low temperatures (~ 500° C.) produced single vacancies but that during quenching from high temperatures (~ 900° C.) some pairs, clusters and collapsed clusters (sessile dislocations) were created and then later modified appreciably the kinetics of annealing-out of the extra resistivity. Other experimental results were presented on the effect of straining and rate of strain on self-diffusion in silver single crystals. At appreciable rates of strain the activation energy for diffusion fell to ~ 0·7 eV., indicating this value as that required for the diffusion of vacancies produced by straining. Dr. M. C. Inman (National Physical Laboratory) gave some results for the effects of straining on the diffusion of antimony in copper and Dr. B. S. Berry (Fulmer Research Institute) for the energies for diffusion in quenched aluminium 4 per cent copper alloy.

Quenching of aluminium was discussed by M. M. Wintenberger (Vitry, France) both with reference to hardening and effects on electrical resistivity. Evidence was given which showed that annealing after a rapid quench gave a large residual resistivity and, because slight deformation reduced this, it was likely that it could be attributed to clustering of vacancies. The importance of clustering of vacancies in the hardening and subsequent softening of quenched sodium chloride crystals was emphasized by Dr. B. H. Kear (Tube Investments Research Laboratories). Describing work done at the University of Birmingham, he showed the effects of various quenching media, specimen sizes and quenching temperatures. After eliminating effects due to quenching strains there remained features closely analogous to those produced by single vacancies and vacancy clusters in metals.

Dr. T. H. Blewitt (Oak Ridge, temporarily at Harwell) referred to recent results in his own laboratory. Tensile tests on copper single crystals had been carried out at 20° K. in a nuclear reactor after maintaining the specimens at that temperature throughout a bombardment of 4×10^{17} neutrons. The hardening produced remained unchanged by pulse anneals up to about 250° K. despite the large drop of extra resistivity at $\sim 35°$ K. and its subsequent slow fall. Some slight decrease in critical shear stress occurred at $\sim 250°$ K. but complete annealing did not occur until higher temperatures. New measurements of the energy associated with the 35° K. resistivity-annealing process yielded 0·3 cal./mole for a bombardment of 4×10^{17} neutrons. Dr. Blewitt suggested that these results, taken in conjunction with his own previously published work on the effects of alloying on the 35° K. process in copper, precluded any simple interpretation of hardening as due to dispersed single vacancies and interstitial atoms. The annealing kinetics at 35° K. were apparently first order with a range of activation energies, and might provisionally be ascribed to the migration of crowdions.

The mechanisms of irradiation-hardening of copper after neutron bombardment were discussed by Dr. M. J. Makin (Harwell). His experiments on single crystals and polycrystalline copper showed that there is a large and temperature-dependent increase in the stress required to generate dislocation loops; this must originate from the interaction of one or more of the products of bombardment (vacancies, interstitials, etc.) with dislocations. In addition, there is a general lattice hardening (independent of temperature) which makes it difficult to maintain the movement of dislocations; this could be attributed to the clustering of point defects or to the formation of sessile dislocations. Some preliminary results were given for the effects of electron irradiations on the strength of copper single crystals. Evidence for the dual nature of irradiation-hardening was also given by Dr. A. T. Churchman (A.E.I. Research Laboratories, Aldermaston) in an analysis of the dependence of neutron-bombardment hardening of mild steel upon grain size and temperature, and by Dr. A. D. Whapham (Atomic Energy Research Establishment, Harwell), who showed photomicrographs illustrating the propagation of slip in lithium fluoride crystals hardened by electron bombardment. Dr. R. E. Smallman (Atomic Energy Research Establishment, Harwell) gave results showing how X-ray measurements indicate that a change occurs in the neutron bombardment of lithium fluoride at a critical dose of about 10^{17} nvt. Below this dose the lattice parameter increases with dose, but it remains constant above it; below, there are no diffraction streaks from single crystals and there is no line broadening and little low-angle scattering, but above 10^{17} nvt all these increase. Again, this may indicate condensation of point defects at high doses.

Various considerations suggest that such alternating strain as occurs during fatigue tests may be a prolific source of vacancies. R. K. Ham (University of Birmingham) presented new results which showed that the fatigue hardening of copper single crystals at room temperature is somewhat analogous to that produced by irradiation. Plastic flow in a tensile test following a fatigue treatment starts in the fatigue striae, and then at a stress some 30 per cent higher than the fatigue stress (and typically about 50 times higher than the critical stress of the virgin crystal) there is a small yield drop and a Lüders band passes through the crystal. The temperature-dependence of this fatigue hardening is high. Less-detailed results obtained for zinc crystals were described by Dr. G. B. Greenough (U.K. Atomic Energy Authority, Windscale). Dr. H. M. Rosenberg (University of Oxford) considered that electrical resistivity changes during fatigue of copper suggest that many more defects are created than during unidirectional deformation. The production of vacancies by unidirectional deformation is believed to be responsible for discontinuous flow in strain-ageing alloys: previous work has been done on dilute alloys, but S. G. Harris (University of Birmingham) showed how the Portevin–Le Chatelier effect in concentrated commercial and high-purity binary aluminium alloys is modified by a strain-induced precipitation process. This in turn can result in strikingly unusual 'shear' fractures after considerable plastic extension.

Recent experiments on copper bombarded with α-particles were described by Dr. R. S. Barnes (Atomic Energy Research Establishment, Harwell). On subsequent heating, bubbles of helium only appear where there is a prolific source of vacancies. The major sources of vacancies thus revealed are free surfaces and grain boundaries, with apparently only occasional dislocations. Dr. J. Nutting (University of Cambridge) suggested that, in technical creep-resisting alloys, vacancies could be produced as a result of the volume changes involved in the dissolution of small precipitates or their change in composition.

The analysis of new results for the creep of copper between 400 and 750° C. was discussed by Dr. P. Feltham (University of Leeds). Below a critical stress the rate of creep is controlled by the climb of edge dislocations, occasioned by the condensation of vacancies at jogs, and the activation energy is about 1·4 eV.; above the critical stress (identified as the strength of Cottrell–Lomer barriers) creep is controlled by the movement of screw dislocations containing jogs and the activation energy is about 2·2 eV.

Dr. A. B. Lidiard (University of Reading) contributed a discussion of diffusion in ordered alloys, and Dr. R. W. Cahn (University of Birmingham) indicated how in such alloys creep phenomena depend markedly upon the degree of order near the critical temperature.

Some criticism of the theory of Williams and Hayfield was offered by Dr. T. P. Hoar (University of Cambridge), who thought that their derivation of logarithmic oxidation rates could depend on other rate-controlling processes. New evidence for the effects of point defects on physical properties was given by Dr. H. M. Rosenberg (heat conductivity in strained α-brass single crystals) and by Dr. E. O. Hall (University of Sheffield) concerning effects of neutron-bombardment on the magnetic behaviour of single crystals of 2 per cent silicon ferrite. Fairly detailed analysis of the magnetic results was possible, and interpretations were offered in terms of an increase in density of dislocations and jogs and the creation of aggregates of point defects. T. Broom

INTERNATIONAL COMMISSION ON ENZYMES

AT the second general assembly of the International Union of Biochemistry, held in Brussels in August 1955, it was agreed to establish an International Commission to consider those problems of enzymology in which international co-operation would be useful, and especially to make recommendations for a more logical and a more generally satisfactory system for the nomenclature and classification of enzymes.

In the following year, Prof. M. Florkin, the president of the International Union of Biochemistry, called an *ad hoc* committee together in Paris. At this meeting it was finally agreed that the terms of reference of this Commission should in the first instance be: "To consider the classification and nomenclature of enzymes and co-enzymes, their units of activity and standard methods of assay, together with the symbols used in the description of enzyme kinetics". It was further agreed that the Commission should consist of ten ordinary members and two corresponding members. Dr. Malcolm Dixon was appointed president of the Commission and Prof. O. Hoffmann-Ostenhof secretary. Prof. E. Cherbuliez was present at this meeting as a representative of the Section of Biological Chemistry of the International Union of Pure and Applied Chemistry.

As a result of this meeting the following people agreed to serve on the Commission: *Ordinary members:* A. E. Braunstein (U.S.S.R.), S. P. Colowick (United States), P. A. E. Desnuelle (France), M. Dixon, president (United Kingdom), W. A. Engelhardt (U.S.S.R.), E. F. Gale (United Kingdom), O. Hoffmann-Ostenhof, secretary (Austria), A. L. Lehninger (United States), K. Linderstrøm-Lang (Denmark), F. Lynen (Germany); *Corresponding members:* F. Egami (Japan), L. F. Leloir (Argentine).

The work of the Commission was begun shortly after the appointment of members was completed, and a number of documents dealing with various different topics were circulated by the president and secretary for the consideration of the members.

The next meeting of the Commission took place in Paris in July 1957. One of the first pieces of business to be taken up at this meeting was a proposal by Dr. Gale that a philologist should be invited to participate in the work of the Commission. This somewhat novel and highly acceptable proposal was welcomed by the Commission, and Mr. H. S. Davies, Fellow of St. John's College, Cambridge, has now agreed to serve as a corresponding member. Although the work of the Commission is still in its early stages, a number of important decisions have been reached, and it is possible already to see the shape of the final recommendations. For example, it was agreed that a dual system of nomenclature should exist in enzymology, in which each enzyme should be given an exact systematic name, which in most cases will be a new name coined by the Commission, and also a short, trivial name, using for this, whenever possible, the present-day name. The systematic name for a given enzyme should as far as possible be descriptive of the reaction catalysed by the enzyme; thus, in the case of transferring enzymes the systematic name would be in accordance with the scheme 'donor–acceptor–group transferred–transferase', for example, alanine-α-ketoglutarate-amino-transferase, although 'transaminase' might well remain as a permissible trivial name. Enzymes catalysing oxido-reductions would be named oxidoreductases in the systematic nomenclature, according to the scheme 'donor–acceptor oxidoreductase', although again for everyday use it would probably be recommended that the terms 'dehydrogenase' and 'reductase' should be retained. A special sub-commission was set up to consider the nomenclature of cytochromes.

A preliminary discussion also took place on the question of the units of enzyme action and on the kinetic symbols to be used in the description of enzyme-catalysed reactions.

A joint meeting of the Commission on Enzymes with the Commission on Biochemical Nomenclature of the International Union of Pure and Applied Chemistry was also held in July, at which the nomenclature of 'pyridine nucleotides' was raised. It was agreed that the International Union of Pure and Applied Chemistry Commission should be asked to bring forward recommendations as to the naming of these compounds, so that the Commission on Enzymes would be provided with an internationally agreed terminology for this group of co-enzymes, and would therefore be in a position to deal with the nomenclature of enzymes functioning with these co-factors.

It would be misleading at this early stage in the work of the Commission to attempt to set down in any detail the recommendations that have been put forward. Much more work remains to be done, and in suggesting new proposals relating to nomenclature and classification of any group of compounds it is clearly necessary to view the field as a whole. One important practical point that faces any nomenclature Commission has already been discussed, namely, the means of bringing into general use the newly proposed names. Here it will, at some stage, be necessary to seek the help of the major biochemical journals in different countries, and it is to be hoped that the final recommendations of this Commission will be given the widest publicity in order to facilitate their adoption by working biochemists and so minimize the existing confusing and reduplication of names that exist in this field.

The Commission will welcome suggestions from non-members and from outside bodies on all aspects of the field. These should be sent to the president or to the secretary of the Commission, but it is hoped that they would not be published before being considered by the Commission.

O. Hoffmann-Ostenhof
R. H. S. Thompson

OBITUARIES

Mr. D. L. Chapman, F.R.S.

David Leonard Chapman, who died on January 17 at the age of eighty-eight, was little known personally outside the Universities of Manchester and Oxford, but the scientific work he quietly pursued for so many years was of the highest quality.

From Manchester Grammar School he went as an Open Exhibitioner to Christ Church, Oxford, and graduated with first-class honours in natural science in 1893. After teaching for a period at Giggleswick, he was appointed lecturer and demonstrator in chemistry under Prof. H. B. Dixon at the University of Manchester. In 1907 he was elected a Fellow of Jesus College, Oxford, to take charge of a new laboratory built by the College, which, because of the inadequacy of University laboratory accommodation, played a full part in the general teaching of chemistry in the University. The College laboratory remained open until his retirement in 1944.

In 1899 Chapman, who had excellent mathematical ability, published a paper of fundamental importance on maximum explosion-rates. Five years later similar results were obtained by Jouguet, and the two names have usually been associated in this field. The theory was a development of the mathematical results of Riemann and of Hugoniot, which showed that a discontinuity or 'shock wave' of very high velocity is set up in an explosion. This theory has proved both sound and valuable, and is still basic for modern work on explosion velocities. Chapman used it for calculating velocities for mixtures of nitrogen with electrolytic gas which were in excellent agreement with the experimental findings of Dixon; but since the theory required the knowledge of the magnitudes of high-temperature specific heats, which were then not obtainable directly, it did not for some years receive adequate recognition of its importance.

Early in the present century Chapman took up the study of the photochemical combination of hydrogen and chlorine, where investigators had found confusing results due to mysterious inhibiting effects. Long 'induction periods' were observed which appeared to vary in a very capricious manner from experiment to experiment. These were traced by Chapman to the presence of minute amounts of ammoniacal or other nitrogenous compounds in the water used in the reaction vessels, and a technique of high-temperature chlorine treatment was devised to minimize the irregularities. During the following forty years he continued a systematic study of this very difficult reaction, assisted by his wife Muriel (*née* Canning) and his research pupils. The effect of surface-area of the reaction vessel in affecting the dependence of the reaction-rate on the light intensity was carefully analysed. He also worked out the 'sector-technique' for finding chain-carrier lives by measuring the change of rate with sector speed, and applied it to the photochemical combination of hydrogen with bromine. In all this photochemical work he showed very great experimental skill in the planning and technique.

His approach to research was one of equal parts of penetration and caution; he was intensely honest and fair-minded, with a very clear vision of what had and what had not been proved. Although almost a recluse in scientific work, and indifferent to its reception by others, he was personally most friendly and approachable, and beloved by all his students. His high mathematical and experimental powers were recognized by his being brought into secret work on gaseous diffusion during the Second World War as part of the 'Tube Alloy' programme.

Chapman's absorption in scientific work did not prevent him from taking a part in College and University affairs. He never sought office or power, but in such positions he showed himself a practical administrator of great ability and common sense. For ten years he undertook bursarial duties in Jesus College, and acted as vice-principal from 1926 until his retirement. He also served as senior proctor and was from time to time a member of University boards and committees, including the Hebdomadal Council.

E. J. Bowen

Prof. Bjørn Helland-Hansen

Born in Oslo on October 16, 1877, Bjørn Helland-Hansen's advent to oceanographical science, in which he soon became a leading international figure, was almost fortuitous. The loss of most of his fingers by frostbite, while he was still a medical student in Oslo, induced him in 1898 to turn to the natural sciences. These he pursued in Oslo and, with oceanographical bias, particularly towards physical oceanography, also in Stockholm, where he sat under Vilhelm Bjerknes on dynamic meteorology and hydrography and where he met his life-long friend, V. W. Ekman, and in Copenhagen, where he worked with the already well-known Danish oceanographer, Martin Knudsen. Thus early, too, began his friendship and collaboration with Fridtjof Nansen, which produced two notable treatises on "The Norwegian Sea" and "The Eastern North Atlantic", in 1909 and 1927, respectively.

In 1900, Helland-Hansen was appointed assistant at the Norwegian Fishery Directorate in Bergen and for ten years participated in the cruises of its research ship, *Michael Sars*, the outcome of which, in 1912, was the oceanographical classic, "The Depths of the Ocean". In 1903, however, he made his own significant contribution to the developing science when, in collaboration with J. W. Sandstrøm, he derived the method which has since been extensively used for the dynamic computation of ocean currents.

In this same period, until 1914, Helland-Hansen was the brilliant leader of international courses in ocean researches which attracted marine scientists from far and near to Bergen; and in 1906, although primarily a physicist, he became director of the Marine Biological Station in Bergen. Four years later he was given the status of a university professor and approval to build a new research ship according to his own ideas. The *Armauer Hansen*, superseded only in 1957 by the appropriately named *Helland-Hansen*, was paid for entirely by the people of Bergen.

In 1917, as the result of his advocacy, the Geophysical Institute of Bergen, now part of the University of Bergen, was founded, and it is further significant of Helland-Hansen's sterling qualities that once again the new building occupied by the Institute in 1928 was paid for by citizens of Bergen. Besides being professor of oceanography, Helland-Hansen, until he resigned his professorship in 1946, was head of the Institute, which houses also Departments of Meteorology and of Cosmic Physics and Terrestrial Magnetism.

The scope and range of Helland-Hansen's enterprise and achievement embraced yet another project. In 1925 he was one of three trustees nominated by the testator to administer the residual estate of more than five million krøner of the late Christian Michelsen, a former Prime Minister of Norway and millionaire shipowner. As the Chr. Michelsen Fund, the estate endowed the establishment in 1930, and the maintenance, of a Chr. Michelsen Institute of Science and Intellectual Freedom. Besides compiling the statutes for its administration, Helland-Hansen, as chairman of the Board of Administrators, was for twenty-five years the presiding genius in its conduct.

He was the recipient of many honours, among which may specifically be cited the honorary rank of a Commander, with Star, of the Order of St. Olav, and the Portuguese Order of the Great Cross of St. Jago. He was doctor *honoris causa* of several universities and a fellow of numerous scientific and learned societies in Europe and America. Medals, in commemoration mostly of oceanographical research expeditions or investigators, were awarded him on many occasions. He was elected president of the International Association of Physical Oceanography in 1936 and president of the International Union of Geodesy and Geophysics in 1945.

Helland-Hansen died in Bergen on September 7, 1957, and the sympathy of countless colleagues, friends, and admirers the world over is offered to his widow, Anna Marie Krag, of Copenhagen, whom he married in 1902, and their family of one daughter and five sons.

J. B. TAIT

Prof. M. Damodaran

PROF. MANAYATH DAMODARAN, who died after a prolonged illness last December, was a graduate of the University of Madras, and after some preliminary training in research at the Indian Institute of Science, Bangalore, he was awarded a Government of Madras Research Studentship. He spent his first year in Germany with Abderhalden at Halle a.S., where he worked on the preparation and enzymic digestion of myristic acid peptides, and his last two years with me at the Imperial College of Science and Technology, London. He was then, as he always remained, a quiet unassuming scholar, and he already possessed the connoisseur's appreciation of research, a quality that his friends always found so attractive, and which inspired his own students later in Madras and Poona. Until recent years his main interest was in protein chemistry and metabolism, a field in which he was a pioneer in India and by far its best exponent. At heart he was an analyst and never happier than when applying his great experimental skill to problems concerned with amino-acid analysis of proteins.

At the Imperial College he was responsible, during 1929–32, for the isolation of asparagine and glutamine from enzymic digests of edestin and gliadin respectively, an achievement which provided the first direct proof of the 'amide hypothesis' in proteins and gained him the degree of D.Sc. (London). On his return to India at the end of 1932 he was made first reader and then professor in his old University at Madras, a post he held for sixteen years. There, in spite of very limited laboratory equipment, he embarked on a series of researches which soon made him one of the foremost biochemists in India. One may mention his work on phosphopeptone from casein, the isolation of canavanine from many seeds, new sources of urease, and the proteins of local foodstuffs. He also demonstrated for the first time the presence of glutamic dehydrogenase in plants, which he found in germinating seedlings. The results of all these valuable researches were accepted for publication in the *Biochemical Journal*.

In 1948 came the call to the new National Chemical Laboratory in Poona, where he was invited to assume directorship of the Biochemical Department and later the deputy-directorship of the Laboratory. At first the task was rather an uphill one, as accommodation was limited and equipment scarce. But in the early 1950's, with the new building in operation, conditions improved, and during his last five years or so Damodaran had at his disposal a laboratory as well equipped as any in Europe or America. The National Chemical Laboratory had been created to fulfil a national need, and Damodaran never lost sight of this aspect of his job. In the early stages of its development, proteins had to be relegated to the background and prominence given to problems that might have economic or medical application. For example, he bred a remarkably active and reliable strain of *Aspergillus niger* for the production of citric acid from sugar, and his process based on it is now in commercial operation. The synthesis of ascorbic acid from sorbitol, with a 99 per cent intermediary yield of sorbose, has also passed the pilot stage. Another important line he introduced was a gelatin plasma substitute preparation, based on a tryptic digestion, which has already been tested clinically with excellent results. Damodaran entered whole-heartedly into the work of the National Chemical Laboratory, and his retirement through ill-health in the summer of 1956 was deeply regretted by the Director and all his staff. All who knew him in Britain and India will mourn the passing of a very lovable colleague.

A. C. CHIBNALL

Prof. Claude Fromageot

CLAUDE FROMAGEOT, director of the Laboratory of Biological Chemistry at the Faculté des Sciences, Paris, since 1946 and professor of biochemistry at the Sorbonne since 1954, died on January 10, at the age of fifty-eight. The unexpected loss of this distinguished scholar comes as a great shock to his many friends all over the world.

Fromageot received his early scientific education at the Institut National Agronomique. After a year at the Collège de France, he spent a further year as assistant to Victor Henri at Zurich. In 1928 he went as a Rockefeller Fellow to Berlin-Dahlem, where he worked in the laboratory of Carl Neuberg. In 1929 he became director of the Biochemical Laboratory at the Faculté des Sciences at Lyons, and there he remained (with an interruption of ten months in 1933 spent at the University of Wisconsin, in Madison) until he went to Paris in 1946.

His early work was devoted mainly to the study of bacterial fermentations, particularly to the relation between fermentation and respiration in *Propionebacterium pentosaceum*. In later years he became interested in the study of the chemical composition of proteins endowed with biological activity; for example, of lysozyme and of the pituitary hormones. Some of his more recent results in this field were presented at Bristol in April 1956, when he took part in the Colston Research Society Symposium on the neurohypophysis.

Fromageot's name is most intimately connected with our present knowledge of the metabolism of sulphur, both in micro-organisms and in higher animals. Much of this work was reviewed in his Harvey Lecture, given in New York in 1953. One of the main advances that we owe to him and his colleagues is the recognition of the central position held by cysteinesulphinic acid in the degradation of cysteine. They discovered and investigated a number of enzymic reactions in which this important intermediate metabolite takes part. The role of vitamin B_6 in these reactions and the action of hormones on the enzymes involved have been studied in his laboratory. Many of these results are embodied in the "Colloque sur la Biochimie du Soufre", the outcome of a gathering held in May 1956 at the Station Maritime, Roscoff, under the auspices of the Centre National de la Recherche Scientifique, where Fromageot and his colleagues discussed outstanding problems with other workers in this field. Here his unique mastery of the subject was evident, and this volume will now serve to remind us of some of his more recent achievements and of his aims. At the time of his death, Fromageot was busy planning another session on sulphur metabolism for the Fourth International Congress of Biochemistry, to be held at Vienna this year.

Fromageot did much to strengthen international co-operation in research. He travelled widely and lectured in many countries, helped by his great linguistic abilities. Biochemists everywhere owe him a debt, as one of the founders of *Biochimica et Biophysica Acta*, and as the president of the Organizing Committee of the Second International Congress of Biochemistry, held at Paris in 1952.

In the remarkable development of French biochemistry in the post-war years, Fromageot played his full part. Some of his earlier colleagues followed him from Lyons to Paris; later his name attracted an ever-increasing number of workers from France as well as from many other countries. He was able in recent years greatly to develop his laboratory from its modest beginnings and to provide it with modern equipment. It is sad to think that his untimely death did not allow him to direct for a longer period what had grown into one of the world's leading centres of biochemical research. H. BLASCHKO

NEWS and VIEWS

Entomology at McGill: Prof. E. M. DuPorte

PROF. E. M. DUPORTE, who is retiring from the chair of entomology at MacDonald College, McGill, was born on the island of Nevis in the British West Indies and received his first college education at Basseterre on St. Kitts. He went to Canada in 1910 as a student at Macdonald College and has been attached to that institution either as a student or as a member of the staff throughout his academic life. He took his Master's degree in 1914 and his Ph.D. in 1921. Morphology became his principal interest, and his world-wide reputation was earned in this field. Prof. DuPorte has played an important part in establishing and maintaining the reputation of Macdonald College as a graduate school. He taught a remarkably wide range of subjects: ecology, protozoology, histology, parasitology, insect taxonomy, morphology, physiology, comparative vertebrate anatomy and embryology, and was one of the two members of the committee responsible for the establishment of the present Institute of Parasitology at Macdonald College. In spite of his wide range of interests in his own subjects, he has still found time for other activities, and is a keen golfer as well as a puppet player who builds and handles his own puppets. His friends and students thoroughout Canada will wish him a happy and enjoyable retirement.

Dr. D. K. McE. Kevan

THE appointment of Dr. D. K. McE. Kevan to succeed Prof. DuPorte at Macdonald College, McGill, will be welcomed by his many friends in Britain and Europe. Dr. Kevan graduated from the University of Edinburgh with first-class honours in zoology in 1941, and proceeded to the Imperial College of Tropical Agriculture, Trinidad, where he obtained his associateship in 1943. He was then appointed to the Colonial Service, and stationed in Kenya, where he became interested in the problems of the taxonomy of locusts and other bush hoppers. These have remained his abiding interest, and in a series of able papers he has undertaken considerable revision of the classification of certain Orthoptera, especially Chrotogonus, and has brought some degree of order to what had been a confused and tangled field.

He returned to England in 1948 as the senior member of the agricultural zoology section of the youngest Faculty of Agriculture in Britain, at the newly established University of Nottingham. In this, his first teaching post, he quickly established a reputation as an able teacher, and he played an active part in developing the curriculum for the new structure of the degree. He has been active both in the prosecution and in the encouragement of research, and a remarkable stream of papers has flowed from his department. His work in taxonomy has been assisted by a wide knowledge of foreign languages which is becoming unusual in a scientist, and papers in both German and French testify to his fluency. More recently he has become interested in soil zoology and has developed an effective undergraduate course in this field, while his own key for the identification of soil-inhabiting fauna, published with the Proceedings of the Second Nottingham Easter School in Agricultural Science, constitutes something of a classic. A critical and independent mind, he has been an admirable tutor, whose succinct reports on the vagaries as well as the virtues of both male and female students will be sadly missed by his colleagues at Sutton Bonington.

Civil Engineering at Nottingham: Dr. R. C. Coates

DR. R. C. COATES, who was appointed to the newly established chair of civil engineering in the University of Nottingham on January 1, began his education at

New Mills School and the Herbert Strutt School, Belper, Derbyshire. After a period of articled pupillage with Waude Thompson, borough engineer and surveyor, Mansfield, Nottinghamshire, Dr. Coates entered University College, Nottingham, and read for a degree in civil engineering. He then worked with Messrs. Lehane, Mackenzie and Shand, Ltd., as an engineer on factory construction for the Ministry of Supply, before joining the Corps of Royal Engineers during the Second World War, in which he served in the Mediterranean theatre. On demobilization, he worked as an engineering assistant to Mansfield Corporation, until appointed lecturer in civil engineering at University College, Nottingham, late in 1946.

He has carried out research on the fatigue strength of compression-type coil springs, and was awarded the Ph.D. degree of the University of Nottingham in 1953. In the same year he was appointed senior lecturer responsible for civil engineering in the joint Departments of Civil and Mechanical Engineering. Dr. Coates's research has included the fatigue of metals and structural analysis. In recent months he has co-operated with Mr. C. E. E. Gibson, county architect of Nottinghamshire, in the design of buildings to resist mining subsidence, and with Mr. L. E. Richardson, chief civil engineer to the East Midlands Division of the Central Electricity Authority, on the design of the experimental power station using coal gasification at Newman Spinney.

National Physical Laboratory, Ship Division : Dr. F. H. Todd

Dr. Frederick Henry Todd has been appointed superintendent of the Ship Division of the National Physical Laboratory, in succession to the late Dr. J. F. Allan (*Nature*, **180**, 68; 1957). Dr. Todd, who graduated from King's College, Newcastle upon Tyne, was at the National Physical Laboratory for twenty years before going to the United States in 1948 to become chief naval architect at the David Taylor Model Basin, Washington, D.C. Before the Second World War, Dr. Todd did much work on hull and propeller design and hull vibration for all classes of merchant ships and among his war-time activities were the testing and development of units of 'Mulberry' harbour. While in the United States he was responsible for the technical direction of the U.S. Bureau of Ships' hydrodynamics research programme in a variety of fields, including research into the hull-form of single-screw ships. Dr. Todd is returning to the National Physical Laboratory at a time of great activity in the Ship Division. The new Ship Hydrodynamics Laboratory, now under construction at Feltham at a cost of £2 million, together with present facilities, should make the National Physical Laboratory one of the best-equipped establishments in the world for ship research work. Dr. Todd spent his last year at the National Physical Laboratory before going to Washington working on a preliminary design of the main features and layout of this Laboratory.

British Trust for Ornithology : Mr. K. Williamson

The British Trust for Ornithology has received a five-year grant from the Nuffield Foundation, enabling it to appoint a migration research officer to carry out the work of analysing past observations and to make recommendations for the future. Mr. Kenneth Williamson, who has accepted the appointment, was during 1948–56 the director of the bird observatory on Fair Isle (between Orkney and Shetland) and last year spent a season on St. Kilda as warden for the Nature Conservancy. Previously he had extensive museum experience and served during the Second World War in the Faeroe Islands. During his time on Fair Isle, Mr. Williamson not only carried out extensive bird-ringing activities and day-to-day observations, but also made a particular study of the effect of the weather on migratory movements. He also studied the ectoparasites of birds as providing a possible clue to their place of origin and for several years he followed the fortunes of a breeding colony of the parasitized Arctic skua, a bird of great interest to biologists because of its two plumage phases. Mr. Williamson's first task will be to arrange for the copying by some photographic method of the massive observations accumulated by the bird observatories. In June he, with other officials of the British Trust for Ornithology, will attend the twelfth International Ornithological Congress in Helsinki and will read a paper on the work of the British bird observatories.

The International Atomic Energy Agency

A number of offers of fissionable materials, radioelements and special materials for reactors, and fellowships and training facilities, have been officially communicated by member States to the headquarters of the International Atomic Energy Agency at Vienna, for use in atomic energy programmes to be carried out under its auspices. The prices and conditions on which the materials are to be made available to the Agency have yet to be determined. Canada has informed the Agency that, for several years at least, it could provide the natural uranium necessary for its atomic energy programmes, while India states that it could supply all the thorium needed ; Ceylon has offered 30 tons of refined monazite of about 9 per cent thorium content ; Norway has offered to supply isotopes produced in the Norwegian reactor at Kjeller, which is operated in collaboration with the Netherlands, and special reactor materials such as niobium, aluminium and molybdenum ; Portugal has made available to the Agency 100,000 kgm. of uranium oxide in concentrate form ; South Africa is prepared to supply uranium oxide concentrates, beryllium, lead, tantalum, cadmium, lithium, vanadium, chromium and nickel ; the U.S.S.R. has offered 50 kgm. of contained uranium-235 in any concentration up to 20 per cent, and is prepared to make available further supplies of fissionable and other materials ; the United Kingdom has offered 20 kgm. of contained uranium-235 ; and the United States of America has offered 5,000 kgm. of contained uranium-235, and will also make available nuclear materials equal in quantity to the total amount of such materials supplied by other members of the Agency, and on equivalent terms, up to July 1, 1960. Contributions of 250,000 dollars have also been offered to the fellowships fund and several member States have placed at the disposal of the Agency fellowships and training facilities to be taken up in the countries offering them. The United States has also announced its intention of presenting a technical library to the Agency.

Molecular Physics

The editor, Prof. H. C. Longuet-Higgins, and the associate editor, Dr. J. H. van der Waals, of the new journal, *Molecular Physics* (1, No. 1; January 1958. Pp. 98. Published quarterly. Annual subscription: 95*s.*; 13.30 dollars. Single issues: 25*s.*; 3.50 dollars. London: Taylor and Francis, Ltd., 1958), state in their brief editorial to the first number that the subject of molecular physics occupies a key position in modern science and that the frontier between physics and chemistry is disappearing as the methods of physics are brought to bear on the problems of chemistry. Probably not all chemists and physicists would agree with this rather bold statement; nevertheless they would agree that the introduction of a periodical devoted solely to contributions on the structure and physical properties of molecules is timely. Papers on molecular structure and dynamics, the electric and magnetic properties of molecules, and the processes of molecular excitation, ionization and dissociation, and the equilibrium transport and relaxation properties of molecular assemblies, will be particularly welcome, in addition to research notes. The first number contains ten articles and one research note. These deal with such subjects as nuclear magnetic resonance in substituted ethanes; dipole moments of azines; critical opalescence in solid solutions; and six papers are devoted to theoretical problems, mainly of a mathematical nature, in quantum and statistical mechanics. One paper is in German, but all have abstracts in English, French and German. The format is similar to, and of the high standard associated with, other such scientific journals as the *Philosophical Magazine* published by Taylor and Francis, Ltd.

Science and Education

An important statement on policy has been issued by the Committee of the Science Masters' Association (pp. 12. London: John Murray (Publishers), Ltd., 1957). Recognizing that science must be taught as a major human activity and as a cultural study of supreme importance because of its effects on human life and thought, the Committee suggests that the aims of science teaching should be three-fold: to lead pupils to observe, and to solve problems by controlled experiments, to draw conclusions from observations, and to appreciate the systematic laws and principles of science; to give knowledge and understanding of the origins and development of science, of the achievements of scientific pioneers and of the implications, now and in the future, of modern scientific and technological developments; and for science specialists, to provide a suitable preparation for further scientific or technological education. The Committee recommends that all pupils should devote the same time to science subjects up to the end of the fifth-form year; that all sixth-form pupils should follow a cultural course in science and that subject-specialization should be retained in sixth forms and that science syllabuses at Advanced Level should be reduced in factual content. The recommendations raise many problems of syllabuses, of teaching methods, of suitable training for science teachers, and of examinations which will be examined in a future report.

Clouds on Filmstrip

Two filmstrips entitled "Clouds", accompanied by a 20-page booklet of lecture notes by F. H. Ludlam and Dr. R. S. Scorer of the Imperial College of Science and Technology, London, have been produced by Diana Wyllie, Ltd. (18 Pont Street, London, S.W.1), in co-operation with the National Committee for Visual Aids in Education. In recent years much has been learned about the motions of the air and properties of the water droplets and ice crystals which compose the clouds, the growth and decay of which can be used to exemplify many branches of physics. The filmstrips, which are in colour, and made in many cases from photographs of great beauty, are chosen principally to illustrate the process of development of various types of cloud rather than their classification. The colour suffers slightly in the reproduction process, which, however, also tends to increase the contrast between cloud and sky, with advantage. The filmstrips, which deal respectively with haze (in relation to condensation nuclei), convection clouds and ice clouds (24 frames) and with layer, wave and billow clouds, with three explanatory diagrams (25 frames), are intended chiefly for use in schools and universities.

Nucleonic Thickness Gauge

Baldwin Instrument Co., Ltd., Dartford, Kent, has published details of a new nucleonic thickness gauge for use in the cold-rolling of copper, brass or steel strip. The instrument can be used for thicknesses of steel up to 0·40 in., which is claimed to be about twice the upper limit for the normal β-ray gauge. This increased range is obtained by using bremsstrahlung emitted when β-rays from strontium-90 impinge on a metal target. The intensity of the radiation after passing through the strip, which is related to strip thickness, is measured by the intensity of the scintillations produced in a sodium iodide crystal. The instrument would appear to be well suited to automatic gauge control, for which it feeds a bridge circuit that indicates the deviation of thickness from any desired value. When this deviation reaches a predetermined level, the screw-down mechanism of the mill is brought into operation. The intervals during which no strip is passing through the mill are utilized for automatic standardization.

Bibliography of the Mysidacea

A useful "Bibliography of the Order Mysidacea", which is carried up to the end of 1955, has recently been prepared by Joan Gordan (*Bull. Amer. Mus. Nat. Hist.*, 112, 279; 1957). It is divided into three sections; the first, containing about 1,180 entries going back to O. F. Muller (1776), is a list of references arranged alphabetically. The second part is a list of the recorded species arranged in alphabetical order in their genera, which again are arranged alphabetically and grouped under five families. Under each species are listed the relevant page references in order of their date of publication. This arrangement makes it very easy to refer to the literature of any species for it includes the synonymy by cross-reference. The author points out that the work is not intended as a contribution to the systematics or taxonomy of the order and accepts the works of W. M., and W. M. and O. S. Tattersall (both of 1951) for these purposes. The third part arranges the literature under ten arbitrary but acceptable headings. That for distribution is subdivided into "Fresh and Brackish Water" and "Oceanic", and then each category is further divided into geographical regions. The printing and format are of the usual excellence of the *Bulletin* and the author is to be congratulated on a commendable contribution that will save future workers on the order a great deal of time.

Mond Nickel Fellowships

THE Mond Nickel Fellowships for 1957 have been awarded to Mr. E. J. Williams (John Summers and Sons, Ltd.) and Mr. R. J. D. Acheson (Mufulira Copper Mines, Ltd.). The Committee now invites applications for Fellowships of an approximate value of £900–£1,200 for 1958. Fellowships will be awarded to selected candidates of British nationality with degree or equivalent qualifications to enable them to obtain wider experience and additional training in industrial establishments, at home or abroad. Further information can be obtained from the Secretary, Mond Nickel Fellowships Committee, 4 Grosvenor Gardens, London, S.W.1. Completed application forms are required by June 1.

Progress in Atomic Power

THE United Kingdom Atomic Energy Authority is to hold a Conference at Harwell on June 11, at which recent developments in nuclear reactor technology will be discussed with representatives of British industry. Accommodation will be available for about two hundred representatives from industry. Requests for further details and for reservations should be made to the Director (Industrial Liaison Office), Building 329, Atomic Energy Research Establishment, Harwell, Nr. Didcot, Berkshire, not later than March 15.

Gordon Research Conferences

THE Gordon Research Conferences for 1958 will be held during June 9–August 29 at Colby Junior College, New London, New Hampshire; New Hampton School, New Hampton, New Hampshire; and Kimball Union Academy, Meriden, New Hampshire. The Conferences, established to stimulate research in universities, research foundations and industrial laboratories, consist of informal meetings, scheduled lectures and free discussion groups intended as a means of disseminating information and ideas which otherwise would not be realized through the normal channels of publication and scientific meetings. No publications are prepared as emanating from the Conferences, attendance at which is limited to one hundred persons. The programme includes ceramics, chemistry, structure and physiology of bones and teeth, magnetic resonance, nuclear chemistry, radiation chemistry, toxicology and safety evaluation, and corrosion. Requests for additional information, or applications to attend, should be addressed to W. George Parks, Director, Department of Chemistry, University of Rhode Island, Kingston, Rhode Island.

Aeronautical Research

THE Combustion and Propulsion Panel of the Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, will hold its third colloquium in Palermo, Sicily, during March 17–21. The meeting will be largely devoted to consideration of current propulsion problems. Five themes will be developed during the meeting, with one day devoted to each. They are: power plant requirements related to aircraft mission; interaction of the combustion systems with other engine components; noise; combustion; aerophysical chemistry.

The Group's Wind Tunnel and Model Testing Panel will also sponsor a meeting, in Freiburg im Breisgau, Germany, during April 22–25. The subjects which will be discussed during the four-day meeting will include the historical development of ballistics, high-velocity guns, range techniques and long-range missiles.

Lady Tata Memorial Trust Scholarships and Fellowships

THE Trustees of the Lady Tata Memorial Fund invite applications for grants, scholarships or fellowships for research on diseases of the blood, with special reference to leukæmia, in the academic year beginning on October 1. In view of the affinity between leukæmia and other forms of neoplastic disease, candidates with programmes of research on any aspect of malignant disease which may throw incidental light on problems of leukæmia will be eligible for consideration. Grants of variable amount are made for research expenses or to provide scientific or technical assistants for senior workers. Scholarships are awarded for the personal remuneration of workers carrying out approved research under suitable direction; their normal value will be £600 per annum. In addition, the Trustees may award one or more Lady Tata Memorial Research Fellowships to workers with considerable research experience, with stipends of £1,200 per annum. Further particulars and forms of application may be obtained by writing to the Secretary of the (European) Scientific Advisory Committee, Lady Tata Memorial Trust, Chester Beatty Research Institute, Fulham Road, London, S.W.3. Applications must be submitted before March 31, and the awards will be announced by the Trustees in June. The grants, scholarships and fellowships offered by the Trust are open to suitably qualified investigators of any nationality, working in any country in which it will be possible to make payments in the coming academic year.

Oversea Service Division, Colonial Office

THE following appointments have recently been made in the Oversea Service Division, Colonial Office: H. B. Ambrose (agricultural officer, Kenya), research officer, Nyasaland; A. de K. Frampton (agricultural adviser to the controller, Development and Welfare Organizations, Barbados), deputy director of agriculture, Barbados; V. E. Gale (principal agricultural officer, Western Nigeria), assistant director of agriculture, Western Nigeria; L. Green (field officer (agriculture), Uganda), senior field officer (agriculture), Uganda; V. R. James (assistant superintendent of public gardens, Jamaica), superintendent of public gardens, Jamaica; G. S. Scott (provincial tsetse officer, Tanganyika), agricultural officer, Uganda; W. S. Steel (entomologist, Game and Tsetse Control Department, Northern Rhodesia), chief entomologist, Game and Tsetse Control Department, Northern Rhodesia; W. E. Lewis (assistant conservator of forests, Nyasaland), conservator of forests (Division of Afforestation), Nyasaland; J. L. Masson (assistant conservator of forests, Northern Nigeria), senior assistant conservator of forests, Northern Nigeria; C. A. M. Nash (assistant conservator of forests, Northern Nigeria), senior assistant conservator of forests, Northern Nigeria; I. Paul (assistant conservator of forests, Sierra Leone), senior assistant conservator of forests, Sierra Leone; J. D. Todd (assistant conservator of forests, Mauritius), assistant conservator of forests, Northern Rhodesia; L. H. Myers (assistant director of surveys, Jamaica), supernumerary deputy director of surveys, Jamaica; P. D. L. Guilbride (veterinary investigation officer, Jamaica), deputy chief research officer, Uganda; M. A. Petris (veterinary officer, class 2, Cyprus), veterinary officer, class 1, Cyprus; P. J. Sheehy (veterinary officer, Northern Rhodesia), deputy director of veterinary services, Northern Rhodesia; E. Jones, chemist, Agricultural Department, Northern Nigeria; Lieut. Col. C. H. Keenlyside, land settlement officer, Nyasaland; B. H. Kenten, biochemist, West African Cacao Research Institute, Ghana; J. F. Longworth, agronomist, West African Cacao Research Institute, Ghana; W. I. Powell, agronomist, Somaliland; W. Smith, supernumerary agricultural engineer, Mauritius; D. G. Thomas, senior botanist, Uganda; W. J. Evans, assistant conservator of forests, Northern Nigeria; C. S. Feilberg, assistant conservator of forests, Northern Nigeria; B. J. Rushton, chemist, Geological Survey, Tanganyika; R. C. Sansom, assistant geologist, British Guiana; S. S. Brunton, veterinary officer, Northern Rhodesia; P. B. Capstick, veterinary research officer, Kenya; J. Dickson, veterinary research officer, Federation of Nigeria; D. G. Erskine, veterinary research officer, Federation of Nigeria; O. G. H. Karst, veterinary officer, Northern Nigeria; K. A. Ross, veterinary officer, Northern Rhodesia; L. A. Stephens, veterinary officer, Kenya.

University News: Glasgow

PROF. J. MONTEATH ROBERTSON has been granted leave of absence to enable him to hold a visiting professorship in the College of Chemistry at the University of California, Berkeley. He will give a short course of lectures on the chemical significance of recent developments in crystal analysis, and will be away for about one month from the middle of March. Leave of absence has also been granted to Dr. E. Gelles for six months, during which time he will hold a research fellowship at Brandeis University, Waltham, Massachusetts. Dr. G. A. Sim has been appointed to a lectureship in chemistry, and Dr. W. M. Fairbairn has resigned his lectureship in mathematics in order to take up a lectureship at the Manchester College of Science and Technology.

London

DR. H. G. EGGLESTON, lecturer in the University of Cambridge, has been appointed to the University chair of mathematics tenable at Bedford College. Dr. Mary Barber has been appointed to the University readership in clinical bacteriology tenable at the Postgraduate Medical School of London and the title of reader in mathematics in the University of London has been conferred on Dr. M. A. Jaswon, in respect of his post at the Imperial College of Science and Technology.

Announcements

DR. H. R. C. PRATT has recently taken up an appointment as leader of the chemical engineering section in the Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization. Dr. Pratt was formerly chief scientific officer at the U.K. Atomic Energy Research Establishment at Harwell and was senior group leader of the Chemical Engineering Division.

THE Trustees will consider in June applications for a Ramsay Memorial Fellowship for advanced students of chemistry. The value of the Fellowship will be £600 per annum, to which may be added a grant for expenses of research not exceeding £100 per annum. The Fellowship will normally be tenable for two years. Further information can be obtained from the Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College, Gower Street, London, W.C.1. Completed applications must be received not later than April 18.

A SYMPOSIUM on "The Design of Teaching Laboratories in Universities and Colleges of Advanced Technology" will be held at the Royal Institute of British Architects on March 14. The chairman will be Sir Keith Murray. Further information can be obtained from the Secretary, Royal Institute of British Architects, 66 Portland Place, London, W.1.

AN informal discussion on "The Practice of Light Scattering" will be held in the Chemistry Lecture Theatre, Chemistry Department, University of Birmingham, on April 25. The discussion is intended to be entirely informal and to consider the experimental techniques employed in applying the light-scattering method to the study of solutions of both synthetic and biological macromolecules. Further information can be obtained from Dr. F. W. Peaker, Chemistry Department, The University, Birmingham 15.

AN international congress on nuclear physics will be held in Paris, during July 7–12, under the patronage of the International Union of Pure and Applied Physics and of Unesco. The title of the congress is "Low Energy Nuclear Interactions and Nuclear Structure". Its purpose is to gather theoretical and experimental information in the energy range lower than the threshold for meson creation. Further information can be obtained from the Congrès International de Physique Nucléaire, Institut du Radium, rue Pierre Curie, Paris, 5 ème.

THE Linnean Society of London is to hold a symposium on the biological uses of the electron microscope on March 28, with a possible extension to the morning of March 29. The object of the meeting is to enable biological workers (including those engaged in the cognate medical sciences) who are not themselves experts in the use of the electron microscope to learn something of the biological applications of that powerful research tool. Biologists who are not members of the Society should inform the General Secretary, Linnean Society, Burlington House, London, W.1, before February 28 if they desire to attend.

THE Federation of British Industries is to hold a Conference on Nuclear Energy under the chairmanship of Sir Claude Gibb (managing director, C. A. Parsons and Co., Ltd.) at the Grand Hotel, Eastbourne, during April 10–12. The Conference, which aims at conveying an understanding of the industrial potentials and applications of nuclear power to directors of firms in fringe industries, will include a visit to the Atomic Energy Research Establishment at Harwell. Further details can be obtained from the conference secretary, Mr. P. J. C. Perry, Federation of British Industries, 21 Tothill Street, London, S.W.1.

ERRATUM. In the communication entitled "Action of Ethylene Dibromide on Hen Gonadotrophic Hormones" by Dr. Eugenia Olomucki, published in *Nature* (180, 1358; 1957), the daily amount of follicle-stimulating hormone injected into hens was 1·4 mgm. (and not 14 mgm., as printed).

BRITAIN'S COAL AND ITS FUTURE

THE pace at which the material conditions of civilization are changing at the present time is unique in recorded history. Prof. Arnold Toynbee has contended that throughout the 5,000 years up to the past century these conditions, and the human outlook, remained fundamentally the same. But the rapid acceleration that began with the industrial revolution is now so far-reaching that it may herald a change in kind rather than of degree in the affairs of mankind ; accompanied, it is to be hoped, by an increased capacity for understanding and controlling the new environment. Though this general picture is true only of the industrial nations, none can long continue unaffected whether it participates in the process of industrialization or not. Prof. P. M. S. Blackett, in his recent presidential address to the British Association, has suggested that an investment of about £1 per head of population per annum is required initially to enable a society to 'take off' in this sense and gather the necessary momentum.

Nowhere is this acceleration more apparent than in the basic activities of fuel production and consumption. Industry has developed chiefly on energy from coal over some 200 years ; oil has become important during the past forty years and nuclear energy is providing the latest example of rapid growth. Other sources of energy have been, and are likely to remain, relatively unimportant in the broad picture. Oil has natural advantages, such as its convenience in use whether in the mobile internal combustion engine or as furnace fuel ; and, in addition to its energy value, the demand for certain fractions as lubricants is by no means negligible. It is thus the coal industry that may be most affected by the changing relative importance of these three sources of energy.

There is considerable misconception about the likely effects of these changes within the present century ; the quantity of coal used is very great, and nuclear energy, however rapidly developed, seems unlikely to shoulder a major part of Britain's power load before the final decades. Recent authoritative forecasts have predicted that the use of coal in the United States may be at least doubled over the next twenty years, though ultimately there may be some decline in consumption. In Britain, the change is unlikely to be spectacular, but an increase is to be expected in the immediate future. The large uncertainties that necessarily attend even the most careful attempts to foresee the overall trends and the detailed shifts in the modes of coal consumption thus pose many problems, not least to those responsible for both long- and short-term research on coal utilization.

It was in relation to this background that Dr. J. Bronowski, director of the Coal Research Establishment of the National Coal Board, delivered to the Royal Institute of Chemistry the tenth Dalton Lecture, entitled "Coal and Coal Chemicals in the National Economy", at the Manchester Town Hall on October 25. The large audience comprised, as well as scientists, a wide cross-section of the public led by the Lord Mayor ; and a well-designed exhibition relevant to the subject was arranged in the nearby public library by the Institute and the National Coal Board with the support of other organizations.

Dr. Bronowski's lecture consisted of a thoughtful analysis of trends in the material basis of life with special reference to fuel, their extrapolation into the future, and their bearing on current research policy. He demonstrated that the standard of living of a society is related in precise detail to its degree of mechanization ; as measures of mechanization, steel and energy consumption per unit of population, representing respectively indices of material being processed and of energy used in processing it, are both satisfactory. For reasons that are obvious, food consumption as a measure of standard of living tends to rise to a maximum, whereas the rate of increase of income with increase in mechanization shows no slackening. The position of the United Kingdom on the food-graph lies near the maximum, whereas on the income curves it lies well below that of the United States and Canada, though it is high among the European countries. With each additional ton of coal or its equivalent used annually by the individual, the average income rises by approximately £60 a year.

The acceleration in energy consumption is well illustrated by the fact that half the coal used in the history of mankind has been consumed in the past twenty-five years, and half the petroleum in the past ten. Coal had traditionally been used in two ways : to provide energy, and to produce coke for steelmaking—the latter a crude chemical use.

In Great Britain, only two forms of coal consumption are still increasing rapidly : electricity generation by about 80 per cent over the past ten years and metallurgical coke production by about 60 per cent ; other uses are for the most part either falling, stationary, or if still increasing, decelerating rapidly. Coal production is inflexible, the increase over the whole world since 1910 having been only 40 per cent, smaller than the increase in population. Considering the two accelerating demands in this context, electricity production at its present rate of increase cannot for long continue to be based solely on coal ; demand could not be met, and to attempt it would be inimical to the best use of the three main fuels. The nuclear fuels have no other large-scale application, but coal has its considerable chemical value. Moreover, the contribution of fuel to the total cost of manufactured goods is falling. This is due to the general shift from heavy towards light industry in which skill and therefore labour costs are relatively more important. A parallel tendency is from solid fuels towards the more flexible fluid forms, oil and gas. Dr. Bronowski emphasized that, owing to the exhaustion of the older seams and increased mechanization, the trends in the types of coal available are towards the following : coals yielding more volatile matter on heating but of less value in coke making ; an increased proportion of small coal ; and coals of increased ash content. Such lower-grade coals should be regarded progressively, in planning for the future, as raw material for making refined fuels and chemicals rather than as fuels *per se*.

The chemical by-products of coal carbonization now of greatest importance are benzene, naphthalene and phenols; these are linked with gas and coke production. From present tendencies, Dr. Bronowski estimated a need in 1975 for 50 million tons [an estimate perhaps on the high side] of coal to make metallurgical coke, a development that will make available considerably larger amounts of these chemicals. Thus the only use of coal likely to expand considerably will—in opposition to the pattern of production—demand selectively the better classes of coking coal unless the range of coals that can be used for this purpose can be widened—an important research objective. Even with this increase, the production from coal of the three chemicals mentioned will probably be inadequate—barely half the estimated needs of their users. Moreover, the coke oven is a most expensive plant requiring a capital investment of £7·7 for each £1 of value added in the product, as compared with £2·2 average in industry. The remainder of the lecture was therefore concerned with alternative methods of producing chemicals and coke or coke substitutes from a wider range of coals.

The chemical structure of oil is more suited to flexibility in the production of raw materials for chemical industry than that of coal; moreover, research in the past has been pursued more energetically in the oil industry. Nevertheless, the constitution of coal gives it a natural advantage for the production of aromatic chemicals; and though the hydrogen/carbon ratio in coal is low, carbonization leads to disproportionation reactions, yielding volatile products of higher ratio and a carbonaceous residue. Fluid-bed conditions are more favourable to high yields of liquid products than those in the fixed bed of a coke oven, which favour secondary cracking of the products. The former type of process converts coal to a powdered char, with good yields of tar, and a rich gas; these novel tars are less suited to the current market for tar chemicals, though there is a low-price outlet in the expanding market for coal-tar fuels. Dr. Bronowski mentioned the processes, being developed at the National Coal Board's Coal Research Establishment, designed to convert such chars by briquetting to smokeless fuels for domestic use [see also Sir Charles Ellis, *Nature*, **175**, 274; 1955].

Such processes are envisaged only as an interim measure, since the demand for solid smokeless fuels may well prove ephemeral. The next step would be gasification of the char, made as described above by fluidized carbonization with production from the tar of medium oil. The gasification stage could produce alternatively a rich gas for heating or a synthesis gas for production of oil—especially the gas and Diesel oils increasingly in demand as fuels rather than light oil of high octane number, previously the main objective of the Fischer–Tropsch process. Some of the simplest and most flexible chemical raw materials now made from petroleum, such as the olefines, could also then be made as by-products during production of oil from coal. Another potential use for the char is for production of calcium carbide simultaneously with gasification at high temperature using oxygen.

Looking still farther ahead to the end of the century, the possible availability of electricity at very low cost from nuclear reactors might make available cheap electrolytic hydrogen, so that the question of direct hydrogenation of coal to fuel oil, at present uneconomic owing to the high cost of hydrogen and power, might be reopened.

Dr. Bronowski concluded by emphasizing that these were his personal views on the future of coal. In brief, the post-war energy famine is ending; the industrial energy demand will ultimately be carried chiefly by atomic energy; small and high-volatile coal thus set free could be used for making solid smokeless fuels, and later, fluid fuels and chemicals.

In broad perspective, Dr. Bronowski's review of trends and portents corresponds closely with views increasingly coming to be accepted in Britain, and indeed in other European countries (see, for example, D. W. van Krevelen, *Chem. and Indust.*, 546; 1957). It will be conceded that there is likely to be an important shift in the use of coal within a few decades towards gasification and the production of oil. Opinions may differ, however, as to the advantage of a two-stage process, in which fluidized carbonization of coal precedes gasification of the char, over gasification of the coal in a single stage; this will depend partly on the commercial value of the tar produced by the first method. It may also be expected that for many years an appreciable amount of small coal of high ash content will be burnt in boiler plant, increasingly automatic, to provide heat and power for small industries. The extent of this will be affected by the siting of industry: for much of the heat inevitably wasted in a nuclear power station could ultimately be used as process heat in neighbouring factories. A large-scale outlet for higher-grade waste heat might, in fact, be provided by the gasification of coal or char, as suggested especially in the United States; the external source of heat would lead to many economies if it could be provided at not less than 900° C., to maintain an endothermic reaction between carbon and steam. The prospects of success appear, however, to be small (see J. V. Dunworth, "The Future of Nuclear Power", Inst. Gas Eng. Copyright Publ. No. 513; 1957).

One other point should be mentioned: not only is the coke oven, as Dr. Bronowski stated, a most expensive plant; the whole present sequence of steel making, using coke oven, blast furnace and open-hearth furnace, is costly and indirect, since it embodies three major stages and excess carbon introduced in the second has to be removed in the third (though for making special steels retention of this stage in some form would probably be necessary). It is quite possible that a successful single-stage process (see Sir Charles Goodeve, *Advanc. Sci.*, **13**, 23; 1956) might be developed before the end of the century; and if such a process proved effective and economic on an industrial scale it would seem likely that from that time onward only sufficient coke ovens to maintain supplies of foundry coke might be replaced. Their normal life being of the order of twenty years, one must envisage a possibility—no more at present—that the demand for metallurgical coking coals might then fall to a small fraction of its maximum level within some twenty years. Whether this will happen, and when, will determine whether a shortage (other than local) of coking coals is likely to develop, and therefore the importance of research—necessarily in the immediate future—on the production of metallurgical coke from coals at present unsuitable. In the writer's judgment, such research should be continued but regarded as an urgent and possibly short-term activity.

I. G. C. Dryden

SITING OF NUCLEAR POWER STATIONS

IN a debate on the siting of nuclear power stations initiated in the House of Commons on December 19 by Mr. A. Blenkinsop and Mr. T. W. Jones, the Parliamentary Secretary to the Ministry of Power, Mr. D. Renton declined to comment on the project for a nuclear power station in Merioneth because the Minister had already decided to hold an inquiry; but he gave a full account of the procedure for preserving the amenities of the countryside so far as the Ministry of Power is concerned which was distinctly reassuring. Mr. Renton recognized the serious conflict and dilemma which arises, and assured the House that the limited possibilities of using land already developed or waste were not overlooked. In selecting the four sites already chosen and in choosing the remaining eight before the end of 1966, a preliminary general suggestion by the Central Electricity Authority is followed in each case by the search for a particular site by the Authority, and then by application to the Minister of Power, usually with a public inquiry before the Minister gave his decision.

Throughout the three stages there are certain limiting factors. First is the purely economic one, requiring nuclear power stations to be sited where the greatest economic benefit may be secured—in regions where the cost of coal is highest, remote from coalfields. Second are safety considerations, and the Government is adhering to the policy of avoiding built-up areas. Furthermore, such power stations require large quantities of cooling water, as much as 35 million gallons an hour for the stations now contemplated, solid foundations for the very heavy buildings and plant, and an area of about 300 acres.

It is with these considerations in mind that the Central Electricity Board—and from January 1, 1958, the Central Electricity Generating Board—make preliminary studies in each area where a power station appears to be needed. These studies include a thorough consideration of the development plans of local planning authorities, of the maps of the national parks and areas of outstanding natural beauty, both of which must be avoided if possible, and a geographical study of basic physical features, such as water supplies. On the basis of these general studies, the team of technical experts of the Authority proceed to what they call site selection. This may take three to twelve months, involving consideration of every possible site in the area of search and sometimes survey before provisional selection. Besides the local planning authority, the Ministry of Housing and Local Government, the Ministry of Agriculture, the Home Office, the Air Ministry, the Ministry of Transport and Civil Aviation, if necessary the Admiralty and the War Office, the National Parks Commission and the Nature Conservancy are consulted and, after a site has been provisionally selected, the Royal Fine Art Commission. Moreover, Mr. Renton pointed out, under Section 37 of the Electricity Act, the Board, the Electricity Council and the Minister of Power must have regard "to the desirability of preserving natural beauty, of conserving flora, fauna and geological or physiographical features of special interest, and of protecting buildings and other objects of architectural or historical interest".

They must take into account the effect of their proposals on the natural beauty of the countryside and on any such flora, fauna, features, buildings and objects. Furthermore, it is not until these studies and consultations are completed that formal application is made to the Minister for his consent. When the Minister receives such an application he is now obliged to hold a public inquiry whenever a local planning authority objects and he may do so when there is any other objection. In such an inquiry he receives expert advice from his Ministry's inspector, who sometimes sits with an inspector of the Ministry of Housing and Local Government.

Observing that a conflict of public interests could only be resolved by a Minister or Ministers, Mr. Renton said that the aim was to provide a flexible system of planning. Each planning authority had the duty of formulating a county development plan and the Minister of Housing and Local Government has certain statutory duties in respect of development plans. He and other Ministers concerned were consulted by the Minister of Power before he gave his decision on each application, and the Minister's decision, which was that of the Government, could be questioned in Parliament. Mr. Renton said that the Minister of Housing and Local Government had overall responsibility for preserving amenities under the Planning Acts and his Ministry provided the information, maps and detailed plans which helped to prevent any avoidable desecration of the beauties of the countryside. Mr. Renton did not think that the central consultative committee of amenity associations suggested by Mr. Blenkinsop would contribute anything further, and he thought there was already sufficient frequent consultation with the National Parks Commission from the inception of any scheme.

CONCRETE ROADS

AN international congress was held in Rome in October to discuss recent technical progress and achievements in the construction of concrete roads and runways. Seventeen lectures were given by prominent engineers from ten countries and reports on the subjects to be discussed were also received from many others. About 800 delegates from 28 countries attended.

The congress enabled the practice in different countries to be compared, and it was of particular interest to note where there was general agreement and where there were differences. It was generally agreed that motorways and urban expressways were desirable on grounds of economy and safety. Most countries, and in particular Western Germany and Holland which together contain 80 per cent of the motorways existing in Western Europe, have preferred concrete construction for motorways. The slab thicknesses used in most countries were comparable and were based on experience; the thicknesses given were expected to give adequate service; but, when discussing concrete roads other than motorways, there was not complete agreement on the expected life of the road nor on what constituted failure. Probably for this reason there were considerable differences between countries in the change in thickness recommended for different classes of traffic, in the amount of reinforcement and in the spacing of joints. For example, in Belgium reinforcement was not considered necessary for secondary roads, whereas in Britain and Switzerland reinforcement was included in designs for housing estate and rural roads.

Because of the differences in design and in the availability of materials suitable for concrete or for other types of road construction, there were large differences in the views expressed on the economy of concrete construction. In Germany, improvements in bituminous construction resulting in enhanced durability required that there should be qualitative improvements in concrete construction on trunk roads. In Belgium, which has more secondary roads in concrete than elsewhere in Western Europe, this type of construction is claimed to have the advantages of economy in construction and maintenance and of good surface texture. For housing-estate roads in Great Britain concrete roads are considered to be particularly good for carrying builders' traffic, but to require careful supervision during construction if they are to be successful. In Switzerland, concrete roads had proved to be economical for rural roads when maintenance costs were considered as well as the prime cost. The question of the economical design of concrete roads in relation to performance and maintenance costs would obviously repay further study.

Economical design was also considered of major importance for the design of runways capable of carrying the very heavy channelized traffic which was now using heavy-duty airfields. One approach to the problem was to examine the traffic volume on various sections of an airfield and to relate the thickness of the pavement to the load and number of repetitions. If traffic was classified in this way it was possible to make the thickness of mid-sections of runways 25 per cent less than that required at the ends and on the main taxiways. Another approach was to use a prestressed pavement; the construction at Maison Blanche was described and it was estimated that the cost of the 7-in. thick prestressed slab was similar to that of 13 in. of normal concrete. This would correspond to a saving of some 10 per cent since it was considered that for comparable strength a normal pavement would need to be 14½ in. thick.

It seemed to be generally agreed that the subgrade had little effect on the stress in a concrete slab if the soil was uniform and the slab was equally supported over its whole area. In practice, however, uniform support is difficult to obtain, and, compared with twenty years ago, great emphasis is now placed in all countries on the proper compaction of the subgrade and base and, in order to avoid changes in the moisture content of the soil during the life of the road, on the protection of the soil from the weather during construction. In most countries the base thickness considered necessary was greater than that generally recommended in Great Britain; but this difference may be due more to the necessity of providing sufficient thickness of construction to avoid damage by frost than to the requirement for uniform support.

A very valuable summary of the construction practice in different countries was given. There was general agreement on what constituted good practice; but there were differences, many of which were due to the desire for economy. Thus, it was agreed that the concrete should have a high flexural strength and that for this purpose crushed stone aggregates were to be preferred, but gravels were used for reasons of economy. A dense concrete was desirable for durability but plastic concrete was sometimes used for facilitating placing in order to reduce costs. Two-course construction was often employed where cheaper concrete could be used in the lower course. The development of cheaper methods of construction was thus another subject on which a study might be made.

The development of prestressed concrete for roads was discussed. Most experimental work had been done in France and Great Britain but some work had also been carried out in Germany, Switzerland and the United States. It seemed that prestressed slabs of the individual type, that is those stressed by cables, have been preferred in Great Britain and Germany, while prestressed slabs of the continuous type, that is those stressed between abutments, seemed to be preferred in France and Switzerland. It seems probable that where the abutments can be placed a considerable distance apart the continuous method is more likely to be economical, but the problem of maintaining stability against buckling and of dealing with horizontal curves needs more consideration. With the individual type of slab the major problem is concerned with joints. With both types the question of reducing subgrade friction is also of importance. The congress felt, however, that the development of prestressed concrete for roads was of great importance because of the economies it appeared likely to achieve.

Finally, there were two papers on the surface irregularity of concrete roads. The methods of measuring the evenness were different, and a plea was made for agreement on an accepted international method so that comparisons could be made easily. Although a direct comparison could not be made, examination of the two papers suggested that the riding quality of recent Danish and recent British work was of the same order of quality but that considerably more effort was required in Britain to achieve that standard. In this connexion, however, it seems probable that the differences in the methods of construction may have some effect on the ease with which good riding quality may be obtained. For example, the Danish roads are generally unreinforced while reinforcement is generally included in British roads. The rate of progress during construction would therefore normally be slower in Britain, thus making the achievement of an even surface more difficult. It is important to remember, however, that the comparison is generally made between new roads, and it appeared from the discussion that the differences in construction might lead to differences in performance so that after some years under traffic the ultimate riding quality of roads of the two designs might be different. Further information is obviously desirable about the movements of slabs under traffic.

The congress thus enabled the present practice and experience in different countries to be compared. Although there was agreement on many points it was considered that further meetings to exchange experience, with perhaps a more limited field, would be of considerable value, particularly where new developments such as prestressed concrete were concerned.

R. H. H. Kirkham

LIVING CONDITIONS AND HEALTH

A MEDICAL conference on "The Influence of Living and Working Conditions upon Health" was held at Cannes during September 27–29, under the chairmanship of Prof. J. Parisot, former president of the World Health Assembly, and Prof. J. de Castro, formerly president of the United Nations Food and Agriculture Organization. The French Ministry of Health and Atomic Energy Commission were represented.

In the section on nutrition the diverse ways in which food factors operate were discussed on a world level by de Castro, while Cicely Williams laid stress on the social factors that might often exceed the physiological in a given food situation. According to Yang-En-Fu, recent examination of the high cereal diet common in China had shown evidence of reasonable adequacy of its vegetable protein with consequently less necessity for substitution by meat; local vegetable foods, fortified by vitamins and minerals, could be expected to correct the main deficiencies of this diet.

D'Arcy Hart considered that the highly efficient chemotherapy now available against tuberculosis imposes some re-thinking on nutritional policy in relation to this disease in under-developed countries. It is imperative to discover whether such chemotherapy is effective in the malnourished, so that mass chemotherapy can be integrated with general social and nutritional improvements; probably host resistance to infection remains important for healing, however potent the drugs may be in the initial stages of treatment. Techniques and factors, particularly psychological, in the study of fatigue in industry were discussed by Desoille and Le Guillant in the section on work factors, while problems of industrial disease in various occupations were presented by other speakers. These include Reysek, who told of some apparently new types of pulmonary exercises being tried in Czechoslovakia for silicotics, which were suggested by observations on glass blowers.

The third main topic on late effects of ionic radiations was introduced by Lacassagne, who concluded that collective measures, which would restrict the almost inevitable increase in the chance of the total population being exposed to a supplementary dose of such radiations, should not be delayed. The results of a follow-up in 1956 on the changes in blood and bone marrow in survivors of Hiroshima were given by Kono, who said that, apart from leukæmia, significant abnormalities were found on close examination of some apparently normal persons. Peacock pointed out the possible future carcinogenic dangers from radioactive isotopes. The general view of the speakers seemed to be that practice had outrun experiment and safety tests.

The conference concluded by forming an "International Medical Association for the Study of Health and Living Conditions"*, which, it is assumed, will sponsor the recently published journal *Living Conditions and Health*, the first two numbers of which have appeared in no less than six languages.

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* Secretariat: Helferstorferstrasse 4/12/III, Vienna 1.

IMMUNITY IN PARASITISM

"THE Nature of Immune Responses in Parasitism" was the subject discussed at a meeting of the Parasitology Group, Institute of Biology, on October 18, at 41 Queen's Gate, London, S.W.7. Three speakers were invited to read papers.

Dr. M. Robertson (Lister Institute) summarized the results of the investigation into the antibody response of cows and heifers to infection with *Trichomonas foetus*. This work was carried out in collaboration with Dr. W. R. Kerr, of the Ministry of Agriculture, Northern Ireland.

The parasite develops in the uterus, and antigen, probably from the breakdown of the trichomonads, passes into the lymph glands and blood stream, resulting in the production of circulating agglutinins. The antibody in the blood stream has no protective value as it does not come into contact with the trichomonads at the site of infection.

The presence of *T. foetus* in the uterus stimulates the local production of antibody, which in acute cases of the disease appears to have a brief protective value in early re-exposure to infection.

Antigen passes out from the uterus, and antibody is produced in the circulating blood; but antibody does not pass back from the blood into the uterus. Trichomonads from the uterus appear in the vagina, sometimes in great numbers. Their presence stimulates the appearance of antibody in the vaginal mucin which causes the temporary disappearance of the trichomonads from the vagina, but does not have any value in protecting the animal from re-infection.

The vaginal antibody is probably produced locally. It is of great diagnostic value.

The antibody reactions of the rat to infection with *Trypanosoma lewisi* were briefly described. The trypanocidal antibody and the growth- and division-controlling antibody, or ablastin, studied by Taliaferro were referred to, and further work on the nature of ablastin was mentioned.

Dr. E. J. L. Soulsby (Cambridge) presented work concerned with immunological responses of the host to helminth infestations.

The way in which immune mechanisms may modify naturally ocurring helminth infestations was briefly indicated, with particular references to gastro-intestinal nematodes of sheep. It was shown that the degree of immunity of the host, as measured by antibody-levels, was inversely proportional to the intensity of infestation and to the level of egg production. An almost complete elimination of previously high infestations occurred in early summer, and this was associated with a marked immunological response by the host. Following the elimination of the helminths, a period of protection was established in the sheep despite persistent reinfestation.

More detailed work with *Ascaris lumbricoides* in the guinea pig showed that a marked immunity to re-infestation can be induced by administering infective stages orally or by alternative routes. With the exception of the 'metabolic products' of third-stage larvæ, non-viable worm material induced no protective immunity in the guinea pig. The critical period for the release of helminth antigen, which ultimately induces protective immunity, appears to be from four to six days after infestation. The earlier larval stages appear to be unimportant in stimulating immunity. During the period of four to six days after infection the second-stage larvæ moult, but in an immune host the growth of the larvæ is inhibited and they do not reach the size at which moulting normally occurs. Using a natural marker antibody (Forssman antibody), it was found that the period between the fourth and fifth days after infection was the earliest time at which a marked release of antigen could be expected. Since this period coincides with the commencement of moulting, the moulting process is strongly suspected as an important mechanism for the release of antigens which stimulate protective immunity in the host.

Dr. K. Mellanby (Rothamsted Experimental Station) spoke at short notice, in place of Prof. R. M. Gordon, on reactions to insect bites and infestation by mites and ticks.

Individual animals respond differently to the bites of particular insects, and the responses change with the period and intensity of the attack. Two and possibly three antigens may be involved. The first evokes a weal 5–10 min. after exposure. The second antigen produces the delayed, tuberculin-type reaction some hours after exposure. Thirdly, there may be a more serious, generalized reaction, distinct from the delayed reaction and possibly related to a third antigen. The antigens are injected with the saliva of the biting insects, but also occur in their tissues. Thus, extracts of larval, pupal and male mosquitoes may give similar reactions to the bites of adult females. Reactions to non-biting insects (for example, sensitization to locusts) are essentially similar to reactions to bites.

A previously unexposed person may not react to a first bite. However, after exposure he shows the immediate reaction to a bite, and on further exposure shows the delayed reaction as well. Generally, further exposure causes the delayed reaction to disappear, and prolonged exposure may eliminate the immediate reaction also.

The reaction of the host does not affect the feeding of most blood-sucking insects, but the feeding of mites and ticks, which may take some days to engorge, may be interrupted in sensitized hosts by the infiltration of leucocytes around the mouth-parts. Sensitization to the scabies mite *Sarcoptes* causes local œdema and the mites tend to leave their burrows; the sensitized individual may be virtually immune to scabies.

Other workers have reported differences in the reaction to bites of clean insects and those infected with parasitic diseases. In the rickettsial disease, scrub typhus, infecting bites may give characteristic local lesions not caused by uninfected mites.

June Mahon

INTERNATIONAL SCIENTIFIC RADIO UNION

The twelfth general assembly of the International Scientific Radio Union was held at Boulder, Colorado, during August 22–September 5 and was attended by more than 550 delegates and observers from twenty-seven countries. The meetings of the full assembly and of the executive and organization committees were held under the chairmanship of Father P. Lejoy, who was serving a second term as president of the Union. This was the first assembly since the recently constituted national committees in Austria, Greece and the U.S.S.R. had been formed; delegates from these countries were warmly welcomed, and they took an active part in the scientific work of all the meetings in Boulder.

As is probably now well known, the main functions of the Union are to promote and organize radio research requiring international co-operation and to encourage the setting-up of such common methods of measurement as may be required for the study of any radio phenomena, whether or not these be directly associated with the Earth and its atmosphere. The work is carried out by seven commissions, each of which is concerned with specific aspects of radio research, and ranging from measurements and standards, and the use of circuits and electronics techniques to all aspects of wave propagation, and terrestrial or atmospheric noise and the important new developments in radio astronomy.

Detailed accounts of the work of each commission will be published in due course in the "Proceedings of the General Assembly". In the meantime, the results of this work are crystallized in the resolutions which each commission made and presented to the assembly for adoption. These resolutions are being printed in the Information Bulletin of the Union, which is published by the Secretary-General at 7, place Emile Danco, Uccle-Brussels (Belgium). The most recently issued Bulletin—No. 105—contains the recommendations and resolutions of Commissions 1, 2, 5 and 6, and those of the remainder will presumably be in a later issue. A list of the commissions, with their officers and the national official members, is also given in the same Bulletin.

Prior to the general assembly in Boulder, meetings were held in New York of the Mixed Commission on the Ionosphere under the chairmanship of Sir Edward Appleton, and of the Joint Commission on Radio-meteorology with Dr. W. E. Gordon as chairman. The work of these groups is conducted in close co-operation with the corresponding commissions of the International Scientific Radio Union, namely 3, "Ionospheric Radio" and "Radio and Troposphere", of which Drs. D. F. Martyn and R. L. Smith-Rose, respectively, were re-elected chairmen.

At the closing meeting, Dr. L. V. Berkner was elected president, and it was decided that the next general assembly would be held in the United Kingdom in 1960. A revised scale of national subscriptions was introduced, and provision was made for the organization between general assemblies of international symposia on specialized subjects relating to radio scientific matters.

PHYTOCHEMISTRY

SPONSORED jointly by the Government of the Federation of Malaya and Unesco, a symposium on phytochemistry was held in the new Government chemical laboratories at Petaling Jaya, Kuala Lumpur, during December 4–8. The symposium, under the chairmanship of Prof. R. A. Robinson, was attended by sixteen overseas visitors, together with eighteen scientists representing the University, Government departments and research institutions in Malaya and Singapore.

The symposium was opened on Wednesday morning by the Hon. the Minister of Health, Mr. V. T. Sambanthan, and by the Unesco representative, Mr. Lennart Mattsson, both of whom emphasized that this was the first occasion since Malaya had achieved independence that a meeting of scientists including overseas delegates had been held in this territory and that in view of this region's dependence on plant products it was particularly appropriate that the first symposium should concern itself with phytochemistry.

Twelve original papers were presented to the symposium: "Avicennin, a new coumarin from *Zanthoxylum avicennae*", by Dr. H. R. Arthur (Hong Kong); "Constituents of *Phebalium nudum*", by Prof. L. H. Briggs (New Zealand); "Alkaloids of Apocynaceous Plants", by Dr. A. Chatterjee (India); "Preliminary Investigations on the C.N.S. Action of Indonesian *Rauwolfia* spp.", by Prof. A. J. Darman (Indonesia); "The Occurrence of some Optically Active Compounds in Anacardiaceous Exudates", by Dr. H. H. Hatt (Australia); "Testing for Anti-Arrhythmic Action of New Compounds in Dogs with Ventricular Tachycardia", by Prof. A. S. Harris (United States); "Chemical Constituents of the Plants of Coniferae and Allied Orders", by Prof. T. Kariyone (Japan); "The Isolation and Separation of Alkaloids of *Kopsia singapurensis*", by Dr. Kiang and Mr. R. D. Amarasingham (Singapore); "Recent Advances in Tea Chemistry in Japan", by Dr. Y. Sakato (Japan); "Bis-coclaurine Alkaloids from *Phaeanthus ebracteolatus*, with special reference to Phaeantharine", by Prof. A. C. Santos (Philippines); "Experimental Research on the Toxicity of Rice infected by *Penicillium citrinum*", by MM. Tran-Vy, Truong-Van-Chom and Bui-Duy-Tam (Vietnam); and "Preliminary Investigations on the Separation of Alkaloids of *Rauwolfia perakensis*", by Mr. Wan Sai Cheong and Dr. A. K. Kiang.

Surveys were presented by delegates from Australia, Hong Kong, India, Indonesia, Japan, Malaya, New Zealand, the Philippines and Vietnam describing the phytochemical work already done in their areas and outlining their future programmes. These surveys were integrated with round-table discussions of the problems associated with the collection of plants and their dispatch from field to laboratory, the chemical and biological methods used in the screening of plants for useful products and the exchange of further information between delegates on return to their own countries. The desirability of depositing specimens in recognized herbaria was stressed and the meeting expressed the opinion that in all publications from this region the herbarium number should be quoted. Unesco was asked to publish the proceedings and also to issue from its regional office in Djakarta a periodical newsletter containing items of phytochemical interest.

R. A. ROBINSON

THE SHIRLEY INSTITUTE

THE thirty-eighth annual general meeting of the British Cotton Industry Research Association was held at the Shirley Institute, Manchester, on October 10, with the chairman of the Association presiding. In his address, Mr. N. G. McCulloch said that he believed that the Institute could be of immense service to higher management in the field of operational, as well as technological, research. The chairman was also convinced that some kind of common policy among the directors of the 2,000 firms in the industry was essential if it were to be in a position to compete successfully in the European Free Trade area. He was very happy to be able to report considerable progress in the matter of the co-ordination of research with the British Rayon Research Association, and also to announce a generous offer by the British Man-made Fibres Producers' Committee which, subject to equal support being obtained from the industrial rayon users, would assist materially in financing the Association's work. Mr. J. Lindley, honorary treasurer, in reviewing the statement of accounts for the year, reported that although the new terms of the Government's grant-in-aid were potentially more generous, there would have to be a considerable increase in the industrial income, if the Association's funds were to achieve the full benefit.

Dr. D. W. Hill, director of research, then presented his report on the year's work which once again had shown intense activity in all branches of the Institute's activities. In selecting a few of the recent developments for comment, Dr. Hill mentioned the great success of the dust hood, now re-named the Shirley pressure point system for dust extraction, in ridding the industry of byssinosis, an occupational disease of the card room for more than 100 years. The director also referred to the complete success in prolonged mill trials of the Shirley separator for hard waste breaking-up machines, a simple and inexpensive device which could be fitted to existing machines to separate out the harder waste which could then afterwards be reprocessed. The dry feed system for the automatic size box had been further developed to give precision and accuracy, and a new automatic size box was also being developed to deal with all types of continuous filament yarns. The Shirley loom for high quality fabrics, the prototype of which had been undergoing prolonged mill trials, was now working satisfactorily. The comprehensive programme of fibre blending was yielding results which were becoming rapidly available to members. Dr. Hill also made special mention of the work on flame-proofing, the new rapid ager for colloresine printing, the intensive survey of industrial mangling, and the bulked yarn programme. He pointed out further that in spite of petrol rationing, the Institute had had almost 11,500 technical transactions with its members (against 12,000 in the previous year) including 2,999 special visits, figures which, he thought, would be of interest to those who suggested that the industry was not sufficiently interested in technical advance.

As in previous years, the Institute's laboratories were open for inspection for two days with senior members of staff available for consultation. For condenser spinners the hard waste breaking-up machine was displayed. Much of the emphasis in the spinning section was on a number of simple devices for improving quality control in the mill. Much of the fundamental work on spinning has been devoted to the preliminary stage of a programme of research with the immediate emphasis on automatic regularity control at several stages of the process.

Weavers were shown a new dobby which has been incorporated in the Shirley loom. Two sizing innovations which attracted interest were the recent developments of the automatic size box, the principle of which has now found application outside textiles.

The work on raising carried out in the Finishing Department provided a display of important information on power consumption and on the effect on the rate of raising of variations in the cloth speed. The exhibition which attracted most attention from finishers, however, was the new flash-ager, for accelerating, and in some instances improving, the development of colloresine printing. Work on industrial mangles, which is almost complete, has led to the production of an improved liquid removal process, in addition to providing data from which target figures at which to aim in plant operation can be given.

Fundamental chemical work was represented by four exhibits. Infra-red spectroscopic equipment was being utilized for investigating chemically modified cellulose; the results were shown of a critical examination of the effects of cyanoethylation on cotton; the interactions of formaldehyde with cellulose and of formaldehyde with urea are being investigated and some results were illustrated which, in addition to being of considerable chemical interest, will advance the understanding of the increasingly varied resin-treatment of textiles; and the partition chromatographic techniques which have considerably advanced knowledge of the structure of silk fibroin were demonstrated.

The Institute continues its fundamental investigations of the effect on yarn properties of blends of fibres (particularly of man-made with natural fibres) in various proportions in the yarn; work in three departments was displayed including the results of chemical treatment of various blends; another working exhibit was of the equipment for producing tailor-made synthetic filaments, the physical properties of which can be related to the chemical properties of the parent polymer.

There is a newly constituted department concerned solely with members' problems either of quality control or arising from the introduction of new fibres and processes in the mill and works. The department is staffed with physicists and chemists and textile technologists, and examples were shown of the use of spectroscopy in diagnosing biological damage, of the photochemical properties of certain new dyes and of the solution of some of the difficulties most frequently posed by members.

It is not the concern of the Institute to search for new textile products, but inevitably there are occasions when such materials are discovered during some broader research. On this occasion two such discoveries were displayed, namely, an elastic yarn made by a new process and a metallized fabric with novel optical properties. These aroused considerable interest.

Lastly, mention must be made of the continuing work on instruments for quality control which has had so great an impact on the industry in recent years, particularly since the setting-up of Shirley Developments Limited. The Company had its own display of instruments which it handles, and, in addition, there were four new instruments developed at the Institute which will shortly be handed over for exploitation.

The occasion of the annual general meeting and its two associated members' days was successful in attracting a total attendance of 800, representing 217 firms.

INFLUENCE OF ORGANIC VAPOURS ON THE CRYSTAL HABIT OF ICE

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ICE crystals grown from the vapour, both in atmospheric and in laboratory supercooled clouds, show the following remarkable variation of habit with temperature[1]: 0° C. to − 3° C., thin hexagonal plates; − 3° C. to − 8° C., needles and hollow hexagonal prisms; − 8° C. to − 25° C., plates; stellar dendrites around − 15° C.; < − 25° C., prisms.

Experiments by Shaw and Mason[2], in which crystals were grown on a metal surface under conditions in which the temperature and supersaturation of the surrounding atmosphere could be varied independently, showed that the crystal habit was determined by the temperature according to the above scheme and that variation of the supersaturation produced no systematic effects. More recent experiments[3] in which crystals are grown on a fibre suspended in the centre of a water-vapour diffusion chamber confirm this result. The habit of crystals growing along the length of the fibre, over which the temperature varies from 0° C. to − 50° C., again changes in accordance with the above scheme with dendritic crystals being limited to the temperature-range − 12° C. to − 16° C. and appearing only if the supersaturation exceeds about 10 per cent. Variation of the supersaturation over very wide limits (0–300 per cent) does not induce changes as between the essential prism and plate-like habits, but such transitions may be induced by varying the temperature by only one degree centigrade.

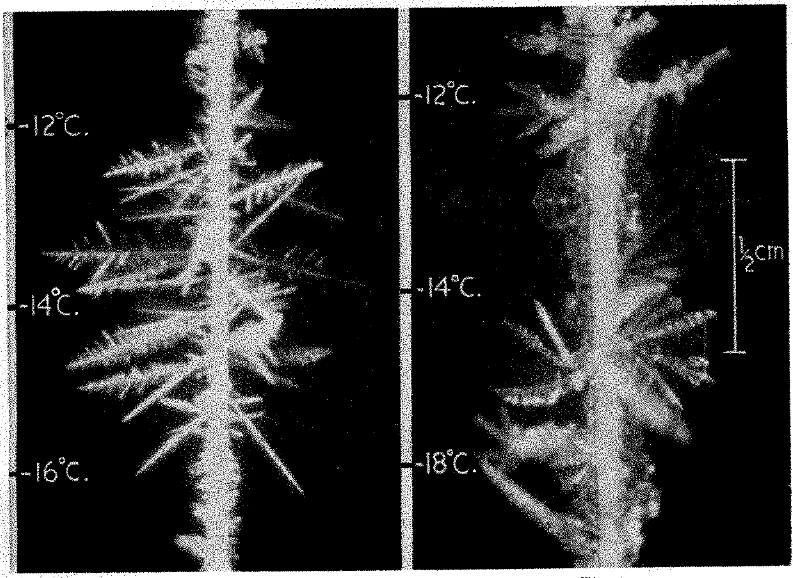

Fig. 1 Fig. 2

The variation, at about − 14° C., of ice-crystal habit with increasing concentrations of *iso*-butyl alcohol. Fig. 1. Dendritic growth; no alcohol present. Fig. 2. Plate-like growth; vapour pressure of alcohol 10^{-3} mb.

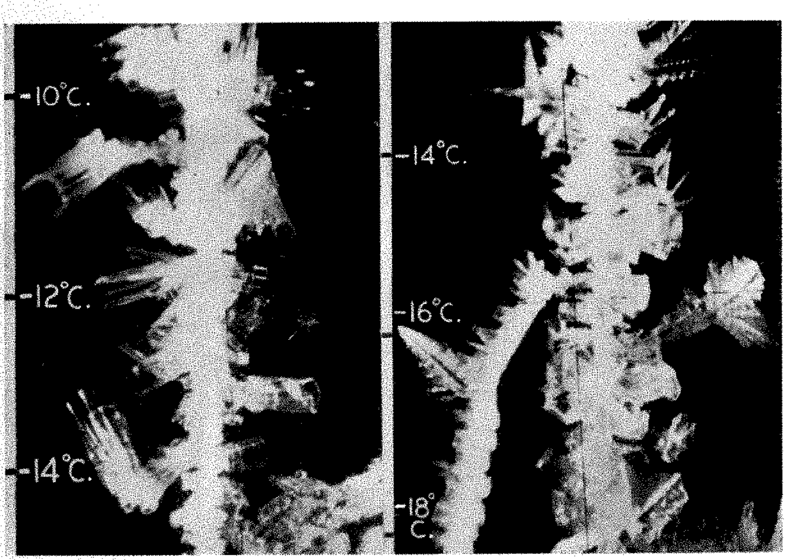

Fig. 3 Fig. 4

The variation, at about − 14° C., of ice-crystal habit with increasing concentrations of *iso*-butyl alcohol. Fig. 3. Hollow prisms; alcohol pressure 10^{-2} mb. Fig. 4. Reversion to dendritic growth; alcohol pressure 1 mb.

Nakaya[4] has reported that the growth forms of ice crystals may be modified by the presence of atmospheric aerosols. For example, he states that when the air is filtered to remove the suspended particles, the plate and dendritic crystals which normally occur at about − 15° C. are replaced by hollow prisms. We are unable to confirm this result. Crystals growing in our diffusion chamber show exactly the same variation of habit with respect to temperature irrespective of whether they grow in the presence of a water cloud formed by condensation on atmospheric aerosol particles or in very clean air from which all the particles have been removed by sedimentation.

However, it has been found that the presence of traces of organic vapours may profoundly influence the growth habit of ice crystals. For example, crystals grown in a diffusion chamber in which *iso*-butyl alcohol has been added to the water source show remarkable changes of shape as the concentration of alcohol vapour is varied from 0 to 1 mb. partial pressure. The vapour density of the alcohol, which diffuses downwards into the colder regions of the chamber in much the same way as the water vapour, can be estimated at each level by specifying its values at the source and sink and assuming a linear gradient in between. The concentration of alcohol vapour at the top of the chamber (the source), which is varied by changing the alcohol–water ratio of the mixture by successive factors of ten, is determined in terms of the partial pressures of the two component liquids. The vapour pressure of the alcohol at the sink, which is at − 50° C., is assumed to be practically zero. Although, in view of the simplifying assumptions, the calculated values for the absolute concentration of alcohol at each level may be slightly in error, the relative concentrations at different levels are probably reliable.

The most striking variations of crystal habit with increasing concentrations of alcohol occur between − 12° C. and − 16° C.; these are shown in Table 1 and illustrated in Figs. 1–4. When the partial pressure of the alcohol exceeds about 10^{-3} mb. the normal dendritic growth (Fig. 1) is suppressed and replaced by plate-like crystals (Fig. 2). A further rather small increase in alcohol concentration causes these to be replaced, either by hollow prisms or by needles (Fig. 3), which persist until the concentration is raised beyond 0·1 mb., above which there is a further transition to plates, and finally, at higher concentrations still, a reversion to a rather stunted form of dendritic growth (Fig. 4).

An earlier observation by Vonnegut[5], that a cloud of tiny hexagonal plate-like crystals, growing at

Table 1

Partial pressure of alcohol (mb.) 10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1} 10^{0}
Dendrites				
	Plates			
		Hollow prisms and needles		
				Dendrites

– 20° C., was transformed into hexagonal prisms by the addition of butyl alcohol at a partial pressure of about 10^{-2} mb. is confirmed. A reversion to plates occurs if the concentration of butyl alcohol exceeds about 0·2 mb. Similar transitions are also observed in the temperature-range – 8° C. to – 12° C.

The mechanism by which such sharp changes in crystal habit are produced either by small changes of temperature or by the adsorption of small quantities of certain organic vapours is not fully understood. However, experiments suggest that the habit changes, which reflect changes in the relative growth-rates of the basal and prism faces of the crystals, are due primarily to changes in surface structure, which is likely to be profoundly affected by the adsorption of foreign polar molecules, possibly by the poisoning of dislocation sites.

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ESTIMATION OF ELECTRON AFFINITIES OF OXYGEN BY EXTRAPOLATIONS OF IONIZATION POTENTIALS

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EXPERIMENTAL determinations of the first electron affinity of atomic oxygen, $E(O \rightarrow O^-)$, have given results in unresolved conflict. A relatively short time ago a value in the range 2·0–2·33 eV. was suggested by studies of electron attachment at a hot filament and from dissociative attachment in a mass spectrometer[1]. (Data expressed in eV. should be multiplied by the factor 23·05 to obtain corresponding values in kcal./gm.-atom.) More recently, Smith and Branscomb[2] obtained the value 1·48 eV. by observing the threshold and measuring the cross-section for photo-detachment of an electron from the O^- ion. Also, Schüler and Bingel[3] have derived the values 0·98 and 1·05 eV. from spectroscopic studies. There is thus considerable uncertainty as to the correct value of the electron affinity.

In addition to experimental methods, various theoretical and semi-empirical procedures have been employed to derive electron affinities[4], and the whole problem has been reviewed by Pritchard[5]. One of the most widely used of the various extrapolation methods for the estimation of electron affinities of atoms depends on a knowledge of the ionization potentials of a series of isoelectronic ions. This type of method is considered here in connexion with the estimation of the first and second electron affinities of atomic oxygen. An indication of the consistency of the results may be obtained by comparing the sum of these electron affinities with the affinity of oxygen for two electrons, which may be evaluated by employing the theoretically calculated lattice energies of oxides in conjunction with known thermodynamic data[6,7].

Table 1. IONIZATION POTENTIALS OF IONS ISOELECTRONIC WITH O^- AND THE FIRST ELECTRON AFFINITY OF OXYGEN

Z	Ion	Ionization potential I			
		Moore	Finkelnburg and Humbach	This work	Selected value
9	F	17·42	17·418		17·418
10	Ne^+	41·07	41·07		41·07
11	Na^{2+}	71·65	71·8 ± 0·1*	71·715*	71·715
12	Mg^{3+}	109·29	109·3		109·29
13	Al^{4+}	153·77	153·8		153·77
14	Si^{5+}	205·11	205·1		205·11
15	P^{6+}	263·31	263·3		263·31
16	S^{7+}	328·80	328·4 ± 0·1*	328·6*	328·6

Extrapolation to $Z = 8$ gives $E(O \rightarrow O^-) = 1·044$ eV.
* Interpolated values.

Table 2. IONIZATION POTENTIALS OF IONS ISOELECTRONIC WITH O^{2-} AND THE SECOND ELECTRON AFFINITY OF OXYGEN

Z	Ion	Ionization potential I			
		Moore	Finkelnburg and Humbach	This work	Selected value
9	F^-				3·577*
10	Ne	21·559	21·559		21·559
11	Na^+	47·29	47·29		47·29
12	Mg^{2+}	80·12	78·2 ± 0·1†	80·14†	80·18‡
13	Al^{3+}	119·96	119·96		119·96
14	Si^{4+}	166·73	166·73		166·73
15	P^{5+}	220·414	220·41		220·41
16	S^{6+}	280·99	280·99		280·99

Extrapolation to $Z = 8$ gives $E(O^- \rightarrow O^{2-})$ equals – 7·754 eV.
* Value selected by Pritchard (ref. 5).
† Interpolated values.
‡ If this term were omitted, and extrapolation carried out, the same result would be obtained for $E(O^- \rightarrow O^{2-})$, namely, – 7·754 eV.

Although the ionization potentials, I, of isoelectronic ions are the eigenvalues of a discontinuous function of the atomic number Z, the present work is based on the premise that they satisfy a continuous well-behaved function.

The best way of finding whether the table of a function is reliable is to form a table of successive differences. The onset of 'noise' in the table indicates to how many significant figures the tabulated function is reliable. The most recent set of ionization potential data for ions isoelectronic with O^- and O^{2-} appears to be that of Finkelnburg and Humbach[8]; the values together with those given by Moore[9] are listed in Tables 1 and 2. The data of Finkelnburg and Humbach in Table 1 fit a well-behaved function quite reasonably. Their data in Table 2, however, do not represent a well-behaved function, as is indicated by the early onset of 'noise' in a difference table.

Following the initial premise that the ionization potentials should satisfy a well-behaved function, the interpolated values of Finkelnburg and Humbach have been recomputed by means of the Lagrange formula:

$$f(x) = \sum \frac{\prod\limits_{i \neq j}^{n} (x - x_i)}{\prod\limits_{i \neq j}^{n} (x_j - x_i)} . f(x_j) \qquad (1)$$

This may be rewritten as

$$f(x) = \sum_j L_j f(x_j) \qquad (2)$$

L being referred to as the Lagrange coefficient of the *j*th term. The results of the interpolations are given in column 5 of Tables 1 and 2. Although the best fit would be obtained by the use of Tchebychev coefficients, it was decided that the reliability of the data did not merit the extra work involved. (An extrapolation using weighted data may therefore be merited, but this was not done since it is uncertain which of the higher terms are most reliable.) The calculations have been performed on an electronic digital computer, the Lagrange programme being used for performing the final extrapolation to $Z = 8$.

The extrapolated value corresponding to the first electron affinity of oxygen was found to be 1·044 eV. This agrees well with the experimental results of Schüler and Bingel[3], namely, 1·05 and 0·98 eV.

The extrapolation required to obtain the second electron affinity of oxygen $E(\mathrm{O}^- \rightarrow \mathrm{O}^{2-})$ provides more difficulty. Morris[7] has recently derived the value − 6·63 eV. for the double electron affinity of oxygen $E(\mathrm{O} \rightarrow \mathrm{O}^{2-})$ from lattice-energy calculations, and it appears reasonable to regard this value as correct to within ± 0·3 eV. It follows that $E(\mathrm{O}^- \rightarrow \mathrm{O}^{2-})$ should be about − 7·67 eV. This may be compared with the value − 7·754 eV. obtained by extrapolating the selected values in Table 2. To assess the variation of $E(\mathrm{O} \rightarrow \mathrm{O}^{2-})$ on altering I_{12} in Table 2, it is necessary merely to evaluate L_{12}. This is − 17·5. Hence, if values for I_{12} of 80·12 or 80·14 eV. are adopted, I_8 is increased by 1·05 or 0·7 eV., respectively, and $E(\mathrm{O} \rightarrow \mathrm{O}^{2-})$ equals − 5·66 or − 6·01 eV. On the other hand, if the value of $I_{12} = 80{\cdot}2$ eV., quoted in Landolt-Börnstein[10], is taken, $E(\mathrm{O} \rightarrow \mathrm{O}^{2-})$ equals − 7·06 eV. The introduction of the value 80·12, 80·18 or 80·20 eV. into the difference table gives rise to considerable noise. It follows, if our major premise is to hold, that at least one *other* of the selected values in Table 2 is suspect. However, in view of the fact that the Lagrange coefficients of the middle terms are quite large, only small adjustments to these terms, about 0·02 eV., would be required to make the data satisfy a continuous function consistent with $E(\mathrm{O}^- \rightarrow \mathrm{O}^{2-})$ equal to −7·754 eV.

From the preceding argument it follows that the value for $E(\mathrm{O} \rightarrow \mathrm{O}^{2-})$ obtained by extrapolations of ionization potential values of present known accuracy, − 6·71 eV., is consistent with the value, − 6·63 eV., obtained from lattice energy calculations.

Our thanks are due to Dr. P. N. Daykin and Dr. A. J. Carr for helpful and stimulating discussion.

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MAMMALIAN CELLULOSE

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IT has been shown recently that following treatment with alkaline buffers collagenous tissue contains domains in which masses of 'elastica staining material' can be observed[1,2]. Further work has shown that numerous fibres or lamellæ with a high degree of birefringence may be associated with these domains, and their presence is more clearly seen after alkali treatment of the collagen and ground substance. Such fibrous systems have now been identified as minor components of many adult human tissues, but from present observations appear rarely in infant tissue. There is also evidence that they may constitute a significant component of certain pathological tissues, for example, dermis from cases of scleroderma. Hence it is felt that the presence of these adventitious fibre species in quantity may indicate aberrant developments in the metabolism of connective tissue. Thus a study of these fibres has been made using both chemical and physical methods.

The fibres are of two types, illustrated in Figs. 1 and 2. (These illustrations show two fibres obtained from fresh bovine skin by treatment with alkali, followed by digestion with collagenase and elastase, boiling with 2 per cent acetic acid and treatment with saturated lithium bromide solution to remove residues of keratin. Dried, unfixed preparations.) The first demonstrates uniform anisotropy in all directions. Hence there is no extinction of birefringence, whether the fibre is arranged parallel or at right angles to the plane of polarization. Extinction does occur, however, if the fibre is rotated about its axis (Fig. 1). The other group of fibres (Fig. 2) is

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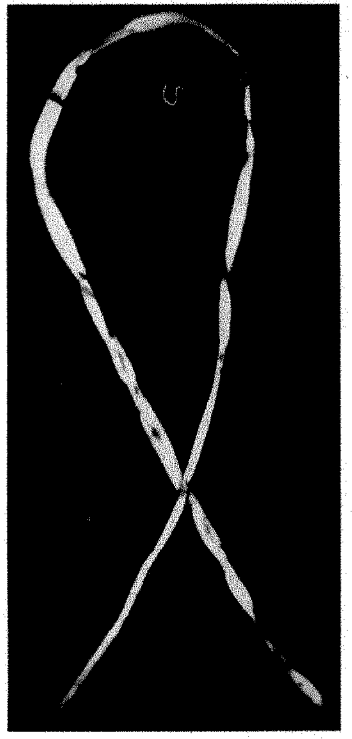

Fig. 1. Anisotropic fibre photographed in monochromatic sodium light. The birefringence is not associated with the orientation of smaller anisotropic rods, since it is not extinguished where the fibre is curved. Examined in white light the fibre shows very little dichroism in some regions. With a first-order red plate it is negatively birefringent like cellulose, and the refractive index is also of the same order as cellulose. (× 141)

characterized by the presence of either one or two anisotropic helices wound around a core, which shows little or no birefringence.

Preparations of small quantities of fibres in a relatively pure state have been obtained by the removal of the surrounding tissue by reaction with collagenase, elastase, boiling 2 per cent acetic acid and treatment with reagents specific for the fission of hydrogen bonds, such as lithium bromide. There was no evidence that these reagents had any effect on the completely anisotropic fibres, but lithium bromide treatment of those which consisted of two clearly observable phases (the polysaccharide did not form a complete pellicle around the ground substance) caused a certain amount of swelling, accompanied by the uncoiling of part of the outer helical layer (Fig. 2).

Hydrolysates of fibre preparations showed the presence of both amino-acids and sugars. Chromatography of the hydrolysates indicated that the protein portion of the fibres had an amino-acid composition intermediate between that of collagen and elastin. The polysaccharide portion, on the other hand, consisted in the main of glucose, associated with small amounts of pentoses and amino-sugars which could be derived from mucopolysaccharides. This high concentration of glucose coupled with the solubility properties of the intact fibres suggested that the polysaccharide might well be cellulose, or some related polymer.

Optical measurements on the fibres between crossed nicols gave the refractive indices with the fibre axis parallel and at right angles to the plane of polarization of 1·586 and 1·525, respectively. The

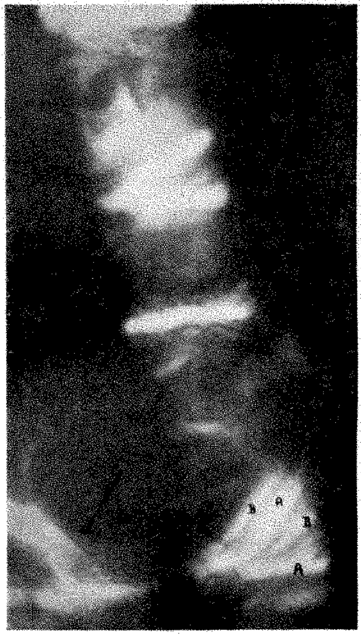

Fig. 2. Fibre composed of two phases: a core oriented in one direction only, and an outer layer having helical orientation. Observations in white light indicated dichroism of the core in some regions but none in the helix, and on examination with a first-order red plate only the helix had a yellow coloration and thereby the two phases could be separated. The outer helix is much more highly oriented, being of the same order as cellulose. Some of its layers have been stripped off (shown by arrow) and two superimposed layers of the anisotropic helices (*AA*, outer layer; *BB*, inner layer) can be seen. Photographed in white light. (× 1215)

sign of this birefringence is negative, and its value, 0·061, lies close to that of ramie. X-ray examination of the fibres confirmed the presence of native cellulose (Fig. 3). Finally, infra-red spectra, although rather complex and difficult to interpret due to the simultaneous presence of both polysaccharide and protein, were not inconsistent with the above conclusions.

Microscopic examination of the angles of the helices of those fibres with a partially developed polysaccharide phase (as in Fig. 2) showed a spread about

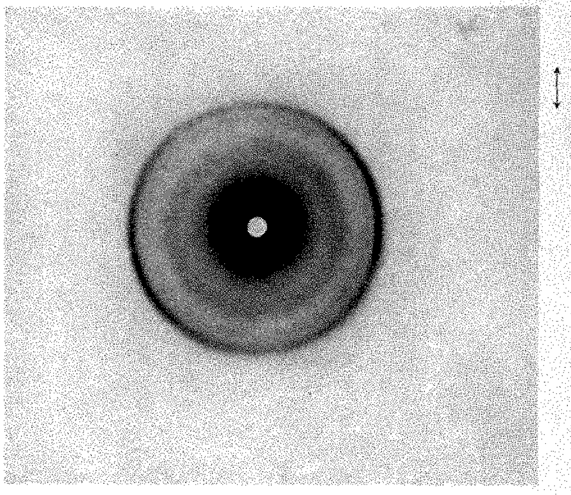

Fig. 3. X-ray diagram of aligned fibres showing a clearly defined X-ray diagram of native cellulose with an angular dispersion of ~ 75°. (Copper $K\alpha$ radiation, D = 4 cm. (on original diagram).) The direction of the fibre axis is marked on the diagram with an arrow

a mean value of 72° with a small distribution peak at about 58°. The angular dispersion of the arcs in the X-ray diagram would also appear to indicate that the cellulose was oriented at an angle in the region of about 75°, thereby showing marked correlation with the optical observations. Where extensive development of the cellulose component has occurred (Fig. 1) these helical angles cannot be measured.

Hitherto, cellulose has only been reported in the plant kingdom, and in certain lower animals such as the Tunicata. Examination of the cellulose fibres present in the tunics of the sea squirt, *Ascidiella aspersa*, has shown that, in common with the highly anisotropic fibres found in mammalian tissue, the cellulose is associated with a protein fraction which is resistant to attack by the same enzymes and chemical reagents, and which has an amino-acid analysis between that of collagen and elastin.

On the basis of these observations it may be suggested that under certain conditions cellulose may be laid down on the surface of collagen fibres. This deposition occurs initially in helical form and afterwards in a similar fashion in successive layers (Fig. 2) resulting finally in a fibre, the protein core of which is completely covered with anisotropic cellulose. Electron microscope studies of such fibres have also shown the presence of finer fibrils arranged in layers. All the fibrils in any one layer lie parallel to one another, but they lie at an angle to those in adjacent layers.

From the point of view of collagen morphology, this phenomenon is of considerable interest since it would appear to indicate that collagen degradation products are capable of bringing about the orientation of highly anisotropic elements in a helical form. This may suggest the existence of an underlying helical structure in the collagen fibre itself. A helical structure has been used for explaining the molecular organization of collagen[3,4] and has also been observed at electron-microscope level in the early stages of thermal denaturation[5]. It is interesting to postulate that a helical structure persists at all levels of organization. Cruise[6] has reported the presence in a number of animal tissues of fibres having a brittle nature. Their properties appear similar in many respects to those of the fibres reported here.

As a first indication of the presence of cellulose in mammalian tissue these observations are of fundamental biological importance, especially in view of the fact that there is a marked similarity between the protein matrix to which the cellulose is attached, in both mammalian fibres and in those obtained from the Tunicata. The existence of cellulose as a component of mammalian tissue may, therefore, have considerable significance from an evolutionary point of view, but it may also have an equally profound impact on theories of tissue ageing.

A further account of these observations will be published elsewhere.

We wish to thank Prof. R. D. Preston for electron-microscope studies and Dr. W. Horton for assistance in the X-ray examination.

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ADENOSINE TRIPHOSPHATASE AND CONTRACTION IN DEHYDRATED MUSCLE FIBRES

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WHEN raw meat or fish is dehydrated it tends to become rather tougher and less juicy after reconstitution and cooking than is the starting material. It was thought that this might be due to denaturation of actomyosin, the major protein of muscle in rigor. To investigate changes in the actomyosin, three of its properties were measured, namely, solubility in salt solutions of ionic strength 0·5 or greater, adenosine triphosphatase activity, and contractility in presence of adenosine triphosphate.

The meat and fish examined were dehydrated either by freeze drying in a vacuum desiccator or by the vacuum contact plate drying process[1,2]. In the former case strips of muscle (about 1 × 1 × 10 mm.) were put on a microscope slide with a few drops of water. The water was frozen solid in 5–10 min. The slides were transferred to a desiccator and dried *in vacuo* over sulphuric acid. The method used in the latter case has been described by Rolfe[3]. Here the foodstuff is freeze-dried for a few hours; its temperature is then slowly raised until it reaches 60° C., by which time the material is dry.

The effect of dehydration by both processes on the solubility of cod (*Gadus callarias*) muscle proteins has been investigated by Connell[4]. He found that extensive denaturation had occurred and that none of the structural proteins had remained in the undenatured state. It was also found in this work that the actomyosin of vacuum-contact plate-dried cod muscle was not soluble in 0·5 *M* potassium chloride or in 5 per cent sodium chloride if the extraction were done by allowing the ground fibres to stand overnight in the salt solution, or by blending them at half speed in an 'Atomix' with a close-fitting baffle to prevent foaming. On the other hand, when an 'Atomix' blender was used at full speed, the 'soluble' protein rose to 85–95 per cent of the total protein. This additional 'soluble' protein, however, was sedimented as the centrifugal force was increased in the range 800–16,000 *g*. It could also be removed completely by filtration through a fine paper (Whatman 42). No solubility measurements were done on meat since those on fish were so inconclusive.

The adenosine triphosphatase activity of both cod and beef was measured before and after dehydration

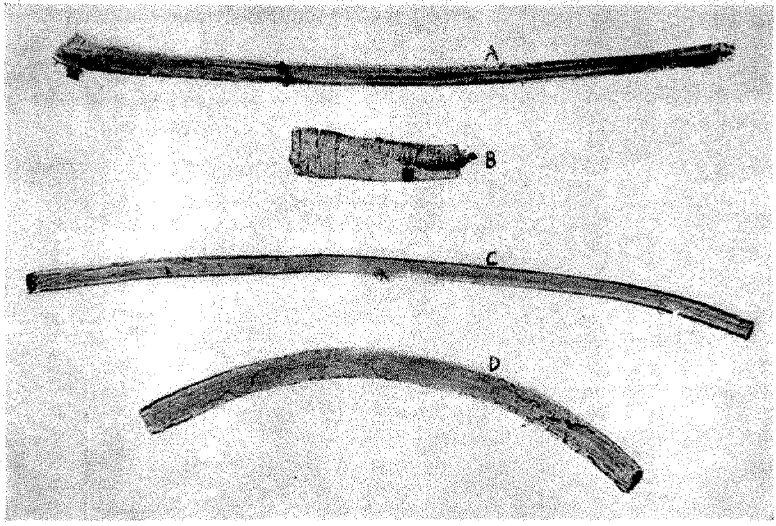

Fig. 1. Contractility of fresh and reconstituted, dehydrated, beef fibres on addition of adenosine triphosphate. *A*, fresh beef muscle fibre before addition of adenosine triphosphate; *B*, 5 min. after addition of adenosine triphosphate; *C*, dehydrated reconstituted beef muscle fibre before addition of adenosine triphosphate; *D*, 5 min. after addition of adenosine triphosphate. (× 50)

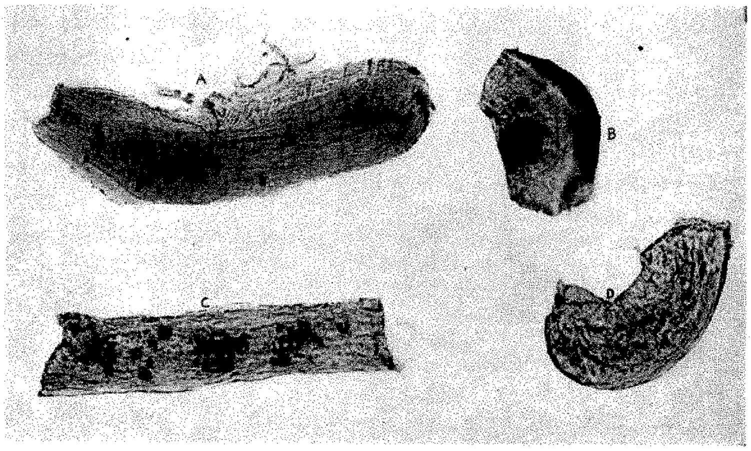

Fig. 2. Contractility of fresh and reconstituted, dehydrated cod muscle fibres on addition of adenosine triphosphate. *A*, fresh cod muscle fibre before addition of adenosine triphosphate; *B*, 15 min. after addition of adenosine triphosphate; *C*, dehydrated reconstituted cod muscle fibre before addition of adenosine triphosphate; *D*, 15 min. after addition of adenosine triphosphate. (× 30)

by the vacuum contact plate drying process. In these determinations the rate of liberation of inorganic phosphate from adenosine triphosphate by washed muscle preparations was measured with calcium as an activator. Calcium is probably not the physiological activator but it does promote actomyosin–adenosine triphosphatase without activating that of other tissue or apyrases. In every case examined, a proportion of the adenosine triphosphatase survived dehydration. In beef, the amount left varied from 40–80 per cent; in fish, about 50–75 per cent remained active. Loss of solubility and of enzyme activity are commonly used to show protein denaturation, but these results indicate that actomyosin could become insoluble in 0·5 *M* potassium chloride without losing its adenosine triphosphatase activity.

To obtain more evidence on the changes which occur in dehydration, beef and fish muscle were examined before and after dehydration for contractility in the presence of adenosine triphosphate. For this purpose, single fibres were removed by dissection with fine needles under the × 30 power of a stereoscopic microscope. These were then reconstituted in veronal buffer containing magnesium ions, and observed under the microscope while adenosine triphosphate was added. Beef fibres so treated always contracted whether they had been dehydrated by freeze-drying in a vacuum desiccator, or by the vacuum contact plate drying process. The dried, reconstituted fibres contracted to a smaller extent than the fresh and at a slightly slower rate. Like them they increased in cross-section as they shortened (Fig. 1). The contractility of dried beef fibres was not very easily destroyed by heat. Samples dried in a desiccator and heated in open dishes for 1 hr. at 22°, 37° and 55° were still contractile. At 70°, the power to contract was much reduced and at 100° it was completely absent.

The actomyosin in cod muscle fibres was much more labile. Fibres from cod fillets or steaks dried by the vacuum contact plate process never contracted in presence of adenosine triphosphate. Fibres from materials freeze-dried in a desiccator were sometimes contractile and sometimes not. The reason for this is not yet apparent though it is probably connected with the rate of freezing. Even when the fibres were contractile, they shortened less than similar fresh fibres and at a very much slower rate (Fig. 2).

From the above results it appears that cod actomyosin can be rendered insoluble by dehydration, but a large part of its adenosine triphosphatase activity, and sometimes even of its contractility, remains. Robinson had similar results with chicken actomyosin[5]. Solubility measurements are therefore not reliable criteria of denaturation though they do seem to measure some change which has occurred in actomyosin during drying.

Beef actomyosin is much more stable than that of cod. A large proportion of it is undamaged as measured by adenosine triphosphatase activity and contractility, after dehydration by freeze-drying or the vacuum contact plate process.

A detailed account of this work will be published elsewhere.

We wish to thank Mr. J. R. Bendall, of the Low Temperature Research Station, Cambridge, for his suggestion that contractility might be a useful method for studying the behaviour of actomyosin in dehydration.

[1] Hay, J. M., *J. Sci. Food Agric.*, **6**, 433 (1955).
[2] Gooding, E. G. B., and Rolfe, E. J., *J. Sci. Food Agric.*, **6**, 427 (1955).
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[5] Robinson, D. S., *Biochem. J.*, **52**, 621 (1952).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Assay of Isotopic Nitrogen by Mass-Spectrometer

In a recent communication, Capindale and Tomlin[1] have pointed out some of the difficulties in measuring accurately the abundance of isotopic nitrogen (nitrogen-15), a measurement which is generally required when this isotope is used as a tracer in biological experiments.

One of the chief difficulties in estimating the abundance of isotopic nitrogen in small samples (20–300 μgm.) is the correction for contamination by air. Two methods are commonly used, each of them suffering from some drawbacks. One is based upon a measurement of the oxygen peak at mass number 32 and, by means of a predetermined nitrogen/oxygen ratio (28/32) for air ($\approx 5 \cdot 5$), correcting for contamination by atmospheric nitrogen. This method is accurate provided that all the oxygen in the sample comes from air, but is invalidated if any oxygen is formed by decomposition of hypobromite, when this is used for oxidizing the ammonia to gaseous nitrogen. The other method of correction is more specific in that it depends on measurement of the nitrogen/argon ratio (28/40); but it has the disadvantage that argon is present only in traces and experimental errors are magnified by the high nitrogen/argon ratio (≈ 73) in air.

Both methods have been tested in these laboratories during the course of work carried out by Yemm and Willis[2] and by Cocking[3]. More recently, it has been possible to apply corrections, based on measurements of the oxygen peak, with greater confidence by virtually eliminating the release of oxygen from hypobromite. As shown by Fleury[4], the decomposition, $2NaBrO \rightarrow 2NaBr + O_2$, is catalysed by traces of copper (Cu^{++}), but the decomposition is prevented by adding potassium iodide, which presumably forms a complex with the catalyst. Many tests have shown that no detectable release of oxygen occurs when 0·1 per cent potassium iodide is added to the hypobromite reagent. Moreover, by immersing the reaction vessel in liquid air after completion of the oxidation, it is possible to freeze out other by-products, such as nitrous oxide and carbon dioxide, which may interfere with measurements of nitrogen at mass numbers 28, 29, 30.

For routine analyses Rittenberg tubes[5], which can be fitted directly to the gas inlet system of a mass spectrometer, are convenient. By evacuating the tubes in two stages, first to about 10^{-2} mm. mercury by a mechanical pump (warming the solution to dispel dissolved gases) and then to about 5×10^{-5} mm. mercury by a backed mercury diffusion pump, nearly all the air can be removed prior to oxidation of ammonia by hypobromite. After the oxidation, the Rittenberg tube is attached to the mass spectrometer and immersed in liquid air to freeze out impurities. The gas is then expanded into a highly evacuated vessel of suitable volume (usually 50 ml.) for measurement of the peaks at mass numbers 28, 29, 30 and 32. In this way it is possible to obtain consistent measurements in samples containing as little as 30 μgm. nitrogen with very small or negligible corrections for contamination by air. Some typical examples of the estimates of nitrogen-15 abundance in amino-acids, separated chromatographically during the course of tracer experiments on yeast, are given in Table 1.

Table 1. Nitrogen-15 Abundance in Amino-Acids

Amino-acids	Nitrogen (μgm.)	Relative peak heights				Isotope abundance (atom per cent nitrogen-15)	
		Mass 28	Mass 29	Mass 30	Mass 32	28 : 29	28 : 29 : 30
Aspartic acid	92	280	28·25	0·700	0·600	4·86	4·85
Threonine	49	100	17·75	0·825	0·215	8·24	8·25
Serine	29	150	19·0	0·630	0·125	5·98	6·00
Glutamine	91	347·5	66·6	3·26	0·340	8·76	8·78
Glycine	30	189	23·6	0·775	0·125	5·93	5·96

In samples of gas containing about 5 atom per cent nitrogen-15 or above, it is possible to calculate the abundance either from the ratio of mass numbers 28 : 29 or from the measurements of the three peaks 28, 29, 30 (Rittenberg[6]). Close agreement between the two estimates is obtained, thus indicating the validity of the small correction for contamination by air, based on the measurement of the peak for oxygen at mass 32.

With the precautions outlined above, measurements have been made over a period of several months on replicate samples containing 30 μgm. nitrogen of a standard solution of an enriched ammonium salt; fifteen measurements had a mean of 31·67 atom per cent nitrogen-15 with a standard deviation of ±0·17.

We are indebted to Mr. B. Davis for measurements on the mass spectrometer, which were carried out in the Department of Chemistry in the University.

The work was supported by research studentships awarded by the Agricultural Research Council.

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[2] Yemm, E. W., and Willis, A. J., *New Phytol.*, **55**, 229 (1956).
[3] Cocking, E. C., Ph.D. thesis, University of Bristol (1956).
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Mass-spectrometric Observations of Ions in Flames

As an extension of our studies of ionization in flames, previously based largely on conductivity measurements[1], an apparatus has been constructed for direct mass-spectrometric analysis of ions drawn from a flame. Whereas previously information about the nature and relative amounts of positive ions could only be obtained by inference from the electron concentration, it is now in principle possible to obtain directly the concentration of ions of any given mass number. It is the purpose of this communication to give preliminary qualitative results obtained with this apparatus, which prove to be of considerable interest.

In brief, the flame, burning at atmospheric pressure, is directed against a thin (0·002 in.) window in which is a small hole of about 0·002 in. diameter, which samples about 1/4 c.c./sec. from the flame into a chamber, evacuated to $\sim 10^{-3}$ mm. by means of a fast pumping system. Using a series of ion lenses, it is found possible to direct a beam of ions into the slit of a conventional sector-type mass spectrometer, and thus to obtain a mass analysis. Ion concentrations down to 10^7 ions/c.c. in the flame are readily detectable.

So far, premixed hydrogen–air and acetylene–air flames have been studied (temperatures ~2,200° K.) and sprays of salts of the alkali and alkaline earth metals have been added, and the resulting ions investigated.

A feature common to all the simple ions found is an apparent facility of attachment of one or two, or even, to a small extent, three water molecules to the parent ion. It is not yet established whether these hydrated ions occur in the flames, or are formed at some stage of the sampling process, but the latter seems more probable.

In hydrogen flames with no additive, the main ion in the gases above the reaction zone appears to be H_3O+, with a smaller peak corresponding to the attachment to this of a water molecule. There is also a fairly large peak at mass 18, which is thought to be due to H_2O+. There are also traces of Na+ and K+, which seem to be inevitable, at least when using compressed air to run the flame.

On spraying salts of alkali metals into the flame, the expected peaks of the simple ions Li+, Na+, K+, Cs+ appear strongly, and also those of the hydrated ions, increasingly weaker as one, two and possibly three molecules of water are attached. On spraying a solution of strontium chloride into the flame, the ion peaks of Sr+ appear, but somewhat stronger peaks appear seventeen mass numbers higher, which correlate with the ion SrOH+, previously postulated by Sugden and Wheeler[2] on the basis of electron concentration measurements. A small peak at mass number 106 confirms the presence of some of the first hydrate of Sr+, and likewise the second may be detected. Ion peaks corresponding to $SrOH+nH_2O$ may be detected up to $n = 3$. Similar results are found with calcium and barium, except that Ba+, if present, is below the limit of detection, and the hydroxide ion is predominant.

The flames of acetylene provide a more complicated system, and on sampling the primary reaction zone of an acetylene–air flame (near-stoichiometric mixture), ion peaks of varying sizes were found at almost every mass number up to 100. No analysis of this has yet been attempted. In the gases above the reaction zone, the ions are fewer both in number and in type. The peaks observed in hydrogen flames appear also in these, and the only additional prominent peak appears at mass number 30 (with its first hydrate at 48). The most likely formula for this is CH_2O+ or NO+. Further, it may be said, in the former case, that this is probably ionized formaldehyde rather than hydrated carbon, since no indication of the presence of C+ was found. The appearance of this ion in the upper parts of the flame, and the disappearance of other ions just above the reaction zone, merit much further study.

It is our aim to extend this work as both a qualitative and quantitative study with various types of flame and metallic elements, and to publish details of the apparatus and further results in due course.

We wish to express our gratitude to the Research Laboratory of the General Electric Company of Schenectady, New York, for a grant in support of this work.

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[2] Sugden, T. M., and Wheeler, R. C., *Disc. Farad. Soc.*, 19, 76 (1955).

Burning Voltage of Arcs in High Vacuum

In the course of an investigation of high-current arcs between solid electrodes in vacuum, an empirical relationship between arcing voltage and physical properties of the cathode material has been found. Certain exceptions are significant because, except for carbon, they are all ferromagnetic metals or alloys containing a ferromagnetic metal.

The burning voltage of an arc between two electrodes in vacuum is almost constant, increasing only very slightly with increase of current and depending in the main only on the nature of the cathode material. This applies provided that the anode subtends a large solid angle at the cathode, so that electrons and metal vapour ejected from the cathode spot or spots may follow line of sight paths to the anode. It is from the metal vapour ejected from the cathode spot or spots that the positive ions (which serve to neutralize the electronic space charge) are derived. The loss of positive ions from the discharge is small, so that the voltage gradient at any point in the discharge clear of the immediate neighbourhood of the cathode spot is negligible.

Although the arcing voltage of any particular metal is not steady, but contains high-frequency components, its average value is remarkably constant. The anode material does not normally affect the burning voltage, because the anode rapidly becomes coated with a thin film of material ejected from the cathode spot.

In Fig. 1, burning voltage is shown plotted against the product of boiling point and thermal conductivity of the cathode material. Normal temperature thermal conductivities have been used, because few data exist on thermal conductivities at elevated temperatures.

It is apparent that, with the exception of carbon and non-magnetic stainless steel, the arcing voltages of the non-ferromagnetic metals lie on or very near to a smooth curve, while the voltages of arcs on the ferromagnetic materials lie above the curve by an

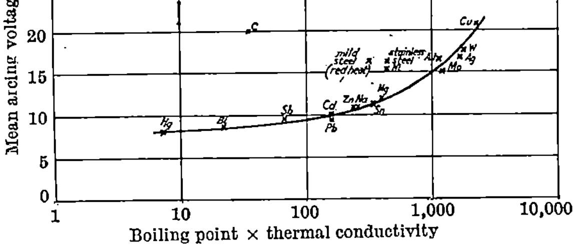

Fig. 1. Empirical relationship between arcing voltage in vacuum and physical properties for some common metals

amount that increases with the Curie point of the metal.

For steel the arcing voltage of 33 V. drops to 16·2 V. when the bulk of the metal is raised to a temperature at which it is a bright red, above the Curie point.

These results, which will be described fully elsewhere, give very considerable support to a new theory of electron emission from non-thermionic cathode spots, outlined in the following communication.

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The Arc Cathode

IT is generally agreed that none of the theories that has been suggested gives a complete and convincing account of the mechanism of the non-thermionic arc cathode. Combinations of, say, thermal and field emission do not fare much better, particularly for cases like the mercury arc cathode[1]. What follows is a new approach which goes some way, if not all the way, towards a satisfactory theory.

In the pinch effect in a plasma the inward radial force is balanced by an increase in gas pressure which is, of course, unbalanced axially. The plasma maintains its state of electrical neutrality under the pinch forces. If, however, we consider what occurs in the metal, the fact that the positive charge centres—the crystal lattice points—are not free to move means that the pinch-effect forces are not balanced by an electron gas pressure but by space-charge forces: that is, the pinch effect sets up a negative space charge in the region of high current density near the cathode spot. The density of this space charge is easily shown to be:

$$\rho = \mu\varepsilon J\bar{v} \qquad (1)$$

where μ and ε have their usual meanings, J is the current density, and $\bar{v}$ is the mean velocity of the electrons carrying the current just inside the metal surface. But the electrons that can escape across the potential boundary must have energies greater than $W + \varphi$, where W is the Fermi energy and φ the work function, and so the appropriate value of $\bar{v}$ in equation (1) is of the order of

$$[(2/m)(W + \varphi)]^{1/2} \qquad (2)$$

Near the surface, therefore, the Fermi equilibrium is disturbed; there is a deficit of high p_z electrons, and to restore equilibrium a corresponding number of $-p_z$ electrons would require to be injected. These high $-p_z$ electrons would gradually degenerate to mean p_z as we move in from the surface and simultaneously the current would be transferred to the normal drift velocity appropriate to the centre of the metal. It is this 'slowing-down' length that determines the fall-off in space charge density as we move inwards from the surface.

The effect of the negative space charge is to lower the potential barrier and therefore the effective work function φ by an amount $\Delta\varphi$ which is of the order of $\mu\varepsilon J\bar{v}\Lambda^2 e$, where Λ is the slowing-down length. Characteristic values show this to be about 2–3 eV. in the case of, say, copper. Note that the value of φ in (2) must now be replaced by $\varphi - \Delta\varphi$. At high temperatures, where the simplified form of the Fermi distribution can be used, we then get an expression for the current density given by (Richardson formula):

$$J = AT^2\exp(-\varphi/kT)\exp(\Delta\varphi/kT) \qquad (3)$$

where $\Delta\varphi$ is the solution of:

$$\Delta\varphi \sim \mu\varepsilon J\Lambda^2 e[(2/m)(W + \varphi - \Delta\varphi)]^{1/2} \qquad (4)$$

that is to say, (3) is an implicit equation for J.

The space charge produced by the pinch effect is thus responsible for lowering φ sufficiently to account for the electron emission.

This changes much of the usual picture. The current density in the metal produced in this way, together with the increased resistivity $(\propto p^2)$ is responsible for the heating and evaporation of the metal at the cathode spot, which is therefore a purely secondary effect. The molten metal will itself have higher resistivity, and the depth of liquid below the surface is therefore involved. The result is that there is a considerable ohmic voltage drop *within* the metal. This has been pointed out by Reece (previous communication), who has shown, in the case of vacuum arcs, that the arc voltage is a function of the boiling point of the metal multiplied by the thermal conductivity of the metal and that a large part of the cathode fall is accounted for in this way. An unusual feature of the theory is the dependence on μ, which will have the effect of increasing the current density and therefore the cathode fall in the ferromagnetic metals. This is strikingly corroborated in Reece's experiments. Again, since there is always a parallel path of lower resistance through cold metal, the position of the arc is inherently unstable and hence must be in continual random movement.

Another consequence of this theory is that the time of disappearance of the cathode mechanism is just that of the dispersal of the electron space charge in the metal. It is in fact of exactly the same order as that observed for mercury arcs, namely, 10^{-9} sec.

There are several other consequences of the theory which, together with a more complete theoretical treatment and numerical verification, will shortly be published elsewhere.

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Preliminary Investigations of the Silicon Boride, SiB_6

ALTHOUGH there has been a good deal of experimental work on the borides of silicon dating back to Moissan[1], current reports (ref. 2 and Parthe, E., M.I.T., private communication) have been somewhat confusing as to the exact phases present in the boron–silicon system. We now wish to report that we have prepared single crystals of silicon boride (SiB_6) by fusion of the elements. The wet chemical analysis after removal of excess silicon agrees with stoichiometric values for the compound SiB_6 as are shown by the following determinations:

B—69·05, 70·16, 69·3
Si—29·43, 29·48, 30·4

The density as determined by pycnometer methods is 2·45 gm./c.c.

Preliminary investigations of the compound by Laue and rotation photographs have indicated an orthorhombic unit cell with approximate lattice parameters of $a = 14{\cdot}60$ A., $b = 18{\cdot}40$ A., $c = 10{\cdot}02$ A. Based on the pycnometer density of 2·45 gm./c.c. the unit cell contains 42·7 molecules. These values confirm facial indices and axial ratios found from optical goniometer measurements. The structure appears to be quite complex, and further work using Weissenberg camera measurements will be necessary before an exact structure can be reported.

Electrical, hardness, and melting-point determinations indicate that the compound has interesting physical properties which are being investigated.

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[1] Moissan, H., and Stock, A., *C.R. Acad. Sci., Paris*, **131** (1900).

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Permeability and the Size Distribution of Pores

A RECENT communication by T. J. Marshall[1] directs attention to a formula for calculating the permeability of a porous medium from its pore-size distribution. This appears to be derived from an implicit model for a porous structure which is very similar to a model which we have found useful at the Gulf Laboratories. However, the formulæ which we derive are somewhat different from Dr. Marshall's.

The physical model, which we believe can be used advantageously to represent actual porous rocks, may be conceived in the following way. Consider a cylindrical bundle of straight capillary tubes the radii of which have a suitable range. Cut this bundle into thin slices, of equal thickness, perpendicular to its axis. Re-arrange randomly the pieces of tube in each slice and then reassemble the slices to form a cylindrical core. This structure of randomly interconnected capillary tubes of various radii forms the model which we have used for studying linear flow.

In any homogeneous porous body a plane section exposes a pore distribution the total area of which is a fraction φ of the area of the section, where φ is also equal to the volumetric measure of porosity. Hence, in any slice of the model the total area available for flow is φ times the area of the slice. Because of the random interconnexion between adjacent slices, however, the total area available for flow at the junctions is reduced to φ^2 times the area of a slice.

Based essentially on this idea, we have worked out formulæ relating capillary pressure, absolute and relative permeabilities, electrical resistivity index and formation factor. We have also set up a theory for the displacement of a fluid from a porous medium by a miscible fluid. Details will be published elsewhere.

It is noteworthy that the expressions we get for permeabilities are essentially the same as those derived empirically by Burdine[2]. A comparison with some of the available experimental work can be found in his paper. In view of the simplicity of the model, the general agreement between predicted and observed results is surprisingly good. It cannot be said, however, that an unequivocal conclusion has been reached.

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[1] Marshall, T. J., *Nature*, **180**, 664 (1957).

[2] Burdine, N. T., *Trans. Amer. Inst. Mech. Eng.*, **198**, 71 (1953).

FROM the preliminary information and the reference given by Dr. Wyllie and Dr. Gardner, it appears that the difference in their permeability equations may arise from their use of a term for tortuosity. I have avoided this mainly by allowing for the effect of imperfect fit and dead ends and the effect of the smaller pore in a sequence on the average size of the necks connecting the pores. Further details are given in a paper[1] which is to appear shortly.

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Effect of Plastic Deformation on the Electrical Resistivity of Chromium

THE presence of a transition in the electrical resistivity and temperature coefficient of resistance of chromium in the region of 40° C. has been reported by several investigators[1]. In studying the influence of plastic deformation (at 150° C.) on high-purity chromium an anomaly has been found, in that below the transition temperature the deformed material had a lower resistivity than the annealed. Curves of resistivity versus temperature are shown in Fig. 1, together with the respective temperature coefficients of resistance. No hysteresis was observed in these measurements. A positive deviation in the temperature coefficient of resistance of the deformed material is observed both below and above the transition temperature. A minimum in the curve of resistivity versus temperature for the annealed material (Fig. 1) occurs at 41° C. and is in close agreement with other workers. Particulars of the specimen material are recorded in Table 1. As shown in Fig. 2, a change in the sign occurs, from negative to positive, in the value of $\Delta\rho$ (the difference in resistivity between the deformed and the annealed material) on increasing temperature through the transition region, namely, $-40°$ C. to $+40°$ C.

Table 1. RELEVANT HISTORY OF THE SPECIMEN

Analysis of chromium* (per cent)		Analysis of chromium* (per cent)	
Mg	< 0·0002	Ag	0·0001
Pb	0·0002	Ti	trace
Si	< 0·0005	C	< 0·0015
Al	0·0005	O_2	< 0·013
Fe	< 0·0005	N	< 0·0005
Cu	0·0002	H_2	< 3·0 ml./100 gm.

* All metallic elements determined spectrographically. (*a*) Specimen dimensions: 0·027 in. (0·073 cm.) diameter, 8·3 in. (20·7 cm.) length. (*b*) Specimen history: arc melted electrolytic chromium ingot (1·5 in. diameter) → extruded bar (0·5 in. diameter) → swaged rod (0·2 in.) diameter) → wire drawn to 0·027 in. diameter at 300° C. final 3 per cent reduction at 150° C. Total reduction in area 98 per cent. (*c*) Annealing treatment: 700° C. for 15 min. *in vacuo* (2×10^{-4} mm. of mercury); specimen completely recrystallized after this treatment.

Previous investigators[2] have reported changes in other physical properties of chromium in this temperature region although no satisfactory explanation for this transition has so far been given. It has been suggested[3,4] that the transition may be associated with a magnetic change at about 40° C. in residual chromic oxide (Cr_2O_3).

From the generally similar shape of the curves of temperature versus resistance for specimens annealed or plastically deformed, it seems reasonable to assume that the factors influencing the transition are similar in both states. Above the transition temperature the normal increased resistance in deformed material is observed; this is due to the scattering of conduction electrons by the lattice defects introduced during the deformation process. However, below the transition temperature, after deformation a modification must occur to that part of the resistance dependent on temperature, which in this particular case more than compensates for the scattering produced by lattice defects and leads to an overall decrease in the resistance relative to the annealed material. This modification is manifested as a 5 per cent decrease in resistivity on superimposing the positive value of $\Delta\rho$ at 70° C., on the $\Delta\rho$ value at $-60°$ C. (Fig. 2) and suggests a deviation from the normal electronic structure for chromium below the transition temperature, the normal structure being taken as that state which is essentially consistent with Matthiessen's rule.

Both Thomas[5] and Linde[6] have reported a decrease in resistivity in gold/chromium alloys with cold work and Linde[7] has postulated a change in the dynamic equilibrium between the electrons in the 3*d*- and 4*s*-shells in certain chromium atoms after cold work. The net result of this exchange is a reduction in the capture of conduction electrons by the *d*-shells by virtue of the more stable electron configuration attained by certain atoms, probably those displaced most from their lattice positions. This explanation has been supported by magnetic measurements on cold worked alloys of gold and chromium[8] which have shown a change in magnetic susceptibility corresponding to an increase in the number of electrons bound to the 3*d*-shell.

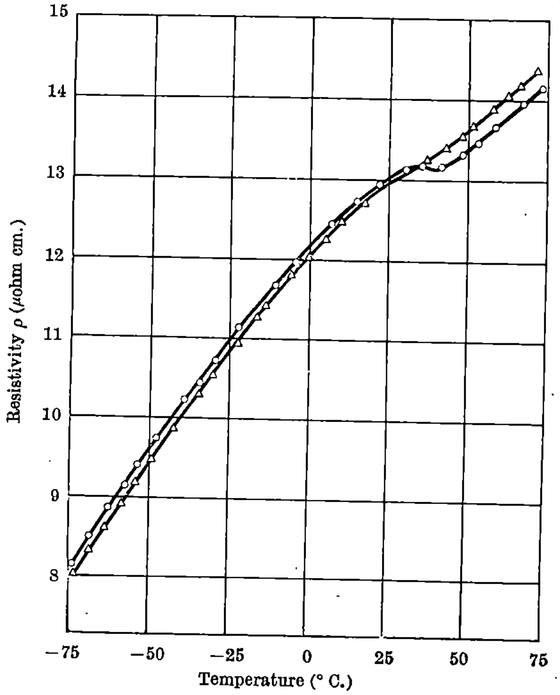

Fig. 1. Resistivity of annealed (○) and deformed (△) chromium as a function of temperature

Temperature range (° C.)	Temperature coefficient of resistance × 10^3	
	Annealed	Deformed
− 70 to − 45	7·16	7·40
45 to 70	2·50	2·58

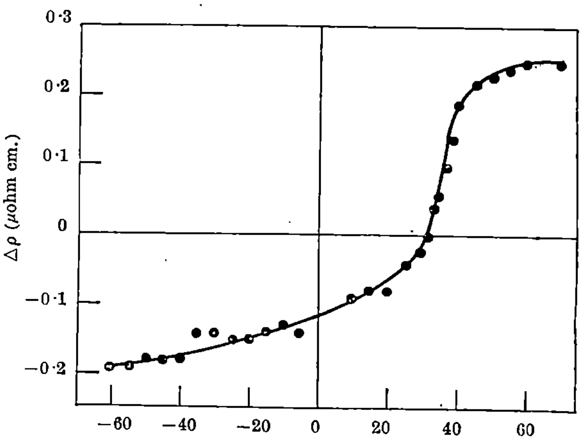

Fig. 2. Variation of $\Delta\rho$ with temperature

Electrolytic chromium is characterized by an increase in magnetic susceptibility with increasing temperature[3,9]. No irregularities have been observed in the susceptibility near the transition region. An antiferromagnetic superlattice has been detected by neutron diffraction experiments[10] at very low temperature with a Néel temperature of 200° C. Unfortunately no magnetic measurements are available for chromium in the worked condition to check the Linde hypothesis with respect to very pure chromium. It would seem, however, that the fundamental reason underlying the decrease in resistance is the abnormal electronic state present below the transition temperature and that the effect of deformation will not be fully understood until this state is defined and the reason for the transition determined.

A detailed report on the resistance measurements of chromium will be published elsewhere. Acknowledgment is made to Mr. J. I. Nish for his encouragement throughout this work and to the Chief Scientist, Department of Supply, Australia, for permission to publish it.

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Oxygen-cutting of Vanadium

The mechanism controlling the oxygen-cutting of iron and steel has been investigated by this Association, primarily along the lines of previous work by Wells[1], whereby attention was focused on the iron/oxygen combustion process. Recently this work has been extended to the study of the general conditions governing the progress of flame cuts through elementary materials, propagated by combustion with a pure gaseous element. The situation has been analysed in some detail for oxygen and chlorine. With the halogen gases, melting points of the elements most likely to be cut appear to be below the ignition temperature in the gas; no cuts were obtained in the cases of zinc and magnesium, which were otherwise thought to be likely to respond. Other halogen gases have not been tested experimentally, though it is known that fluorine may be used for flame-cutting copper[2].

In the field of oxygen-cutting, probable natural flame-cutting elements are iron, titanium, vanadium and antimony. Experimentally, the latter element does not ignite below its melting point, but the first three are readily cut. Iron and steel cutting by oxyacetylene, hydrogen, propane, coal-gas or oxy-arc processes, has, of course, been in use for many years. Flame-cutting of titanium by the oxyacetylene process has formed the subject of a detailed report[3], as it was not realized that the process was known in the United States[4], though investigations by this Association were conducted independently.

Vanadium was selected as a trial element, since no previous tests were known, and, owing to the high cost of the material and its scarcity in massive form, it would be unlikely to be attempted outside a research laboratory. Because of the extremely poisonous nature of the vanadium oxides, it is necessary to conduct the cutting operation in a closed chamber, progress being viewed through a glass window. Two successful cuts have been made in a vanadium plate 11 cm. × 5 cm. × 0·6 cm. obtained through the courtesy of the United Kingdom Atomic Energy Authority. The first cut was made manually and the second with a motor-driven oxyacetylene torch at 32 in./min. traverse speed. The surfaces near the pre-heat initiation point were contaminated with condensed vanadium metal and oxide, but away from the pre-heat area contamination was limited to a temper-coloured zone about $\frac{3}{8}$ in. on either side of the cut edge. There was no appreciable hardening on the surface of the plate to within $\frac{1}{32}$ in. of the cut. As in titanium, the major deleterious effect would be expected to be oxygen pick-up by the edge. Owing to the high reactivity of vanadium, its flame-cutting properties would be expected to be more akin to titanium than to mild steel.

Apart from confirming previous conceptions of the process, the successful test on vanadium makes it likely that alloys of the iron–titanium–vanadium system would be 'cuttable' by oxygen methods.

A more detailed account of this work will appear elsewhere.

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Structure of Cupric Salts with Mono-, Di- and Tri-chloroacetic Acids

In former communications[1], we reported that the cupric salts, anhydrous or hydrated, with *n*- and *iso*-monocarboxylic acids might consist of the dimeric molecules having a sort of copper-to-copper linkage. In continuation of these researches, we have recently examined the structure of cupric salts with mono-, di- and tri-chloroacetic acids, using the criteria previously derived: (1) the cupric alkanoates involving the dimeric molecules show, in addition to a band at about 43 × 10^{13} c./s., an absorption band of a special kind at about 80 × 10^{13} c./s., which was regarded as due possibly to the presence of the copper-to-copper linkage; (2) the polarization of the latter band is the reverse of the polarization of the former.

The present measurements indicate that cupric monochloroacetate and dichloroacetate in dioxane show absorption spectra which are closely similar to those of the cupric alkanoates in solution, showing an absorption band of the special kind at about 80 × 10^{13} c./s. The dichroism in the visible and ultra-violet of the two compounds has been determined quantitatively by Tsuchida–Kobayashi's microscopic method[2]. The crystals of cupric monochloroacetate tetrahydrate and anhydrate, and of anhydrous cupric dichloroacetate all show absorption bands at about 41 and 80 × 10^{13} c./s. besides strong absorption in the shorter wave-length regions. The polarization of the band at about 80 × 10^{13} c./s. is found to be the reverse of the polarization of the band at about 41 × 10^{13} c./s. These relationships bear a close resemblance to those with the cupric alkanoates, suggesting the existence of dimeric molecules similar to those of the alkanoates. Thus it may be concluded that cupric monochloroacetate and dichloroacetate have the dimeric molecules in dioxane and in the crystalline state. The dimeric molecules may be represented by $Cu(R.COO)_4$ or $Cu(R.COO)_4.(OH_2)_2$.

In contrast to the above mentioned compounds, cupric trichloroacetate in dioxane shows only one absorption band at about 40 × 10^{13} c./s. in the corresponding wave-length range. Furthermore, cupric trichloroacetate tetrahydrate in the crystalline state displays polarized absorption spectra having only the absorption band at about 40 × 10^{13} c./s. Thus the spectra of the compound are found to be quite different from those of the other two compounds. It is concluded, therefore, that the trichloroacetate does not involve the dimeric molecules in the crystalline state or in dioxane.

Cupric dichloroacetate is known to exist in a tetrahydrate as well. The dichroism of this form is not quite identical with that of the anhydrous form, which is shown to consist of the dimeric molecules. The structure of the tetrahydrate in the crystalline state is under investigation.

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Time Variation of Chemical Affinity

In two previous communications[1,2] we have shown that an accelerated chemical reaction is always characterized by the variation of the chemical affinity of the system with time. For a reaction with constant velocity this time derivative would, of course, be zero. In this communication we shall consider further the properties of the function $\dot{A} \equiv (\mathrm{d}A/\mathrm{d}t)$. A is the instantaneous chemical affinity defined by

$$A = -\sum_i \nu_i \mu_i \tag{1}$$

In this equation, ν_i is the stoichiometric coefficient, and μ_i is the instantaneous chemical potential of the ith component. Since this potential is a function of the activity of the particular substance, it will vary with concentration, and hence with time. Bearing this in mind, we can now differentiate equation (1) with respect to time :

$$\dot{A} = -\sum_i \nu_i \mu_i \tag{2}$$

Throughout this discussion the pressure and temperature will be assumed constant.

Utilizing the definition of μ_i in terms of the activity coefficient[3]

$$\mu_i = \mu_i^0 + RT \ln a_i$$

where a_i is the activity of the component i and μ_i^0 is the chemical potential of this substance in the arbitrary standard state, we obtain

$$\mu_i = RT\, \mathrm{d}/\mathrm{d}t(\ln a_i).$$

By substitution in equation (2) we have

$$\dot{A} = -RT \sum_i \nu_i\, \mathrm{d}/\mathrm{d}t(\ln a_i) \tag{3}$$

This equation can alternatively be established from the relation[3] between the affinity and the equilibrium constant K :

$$A = RT \ln K - RT \ln \prod_i a_i^{\nu_i}$$

Differentiating this relation with respect to time, we get

$$\begin{aligned} \dot{A} &= -RT\, \mathrm{d}/\mathrm{d}t\, (\ln \prod_i a_i^{\nu_i}) \\ &= -RT\, \mathrm{d}/\mathrm{d}t(\sum_i \nu_i \ln a_i) \\ &= -RT \sum_i \nu_i\, \mathrm{d}/\mathrm{d}t(\ln a_i) \end{aligned} \tag{3a}$$

If the behaviour of the substances participating in the reaction tends to ideality, we may replace activities by concentrations (that is, the activity coefficient can be regarded as unity for our purposes). Thus,

$$\dot{A} = -RT \sum_i \nu_i\, \mathrm{d}/\mathrm{d}t(\ln c_i)$$

where c_i is the concentration of the ith component at any instant. As an approximation, therefore, we arrive at $\dot{A}$ from the experimental observation of the change of ($\ln c_i$) with time. We should note, of course, that the rate of change of concentration with time is related to the reaction velocity, but in the case of the accelerated reaction under consideration the velocity has different values with successive instants of time.

For the sake of completeness we can show how the acceleration of a chemical reaction may be related to the time variation of the chemical affinity.

We can define the acceleration and velocity of a chemical reaction by

$$v = \mathrm{d}\xi/\mathrm{d}t \text{ and } \dot{v} = \mathrm{d}^2\xi/\mathrm{d}t^2$$

where $\mathrm{d}\xi = \mathrm{d}n_i/\nu_i$ (n_i is the mole number of the ith component). Previously[1] we formulated the relation

$$\dot{v} = (\dot{A}/A)v$$

which, in terms of equation (3), becomes

$$\begin{aligned} \dot{v} &= \frac{-RT \sum_i \nu_i\, \mathrm{d}/\mathrm{d}t(\ln a_i)}{RT \ln K - RT \ln (\prod_i a_i^{\nu_i})} v \\ &= \frac{-\sum_i \nu_i\, \mathrm{d}/\mathrm{d}t(\ln a_i)}{\ln K - \ln(\prod_i a_i^{\nu_i})} v \end{aligned}$$

or approximately,

$$\dot{v} = \frac{-\sum_i \nu_i\, \mathrm{d}/\mathrm{d}t(\ln c_i)}{\ln K - \ln(\prod_i c_i^{\nu_i})} v \tag{4}$$

However, from the experimental point of view it is much simpler to obtain the acceleration directly from the definition

$$\dot{v} = \frac{\mathrm{d}^2\xi}{\mathrm{d}t^2} = \frac{1}{\nu_i} \frac{\mathrm{d}^2 n_i}{\mathrm{d}t^2} = \frac{1}{\nu_i} \frac{\mathrm{d}^2(Vc_i)}{\mathrm{d}t^2} \tag{5}$$

where V is the volume. Equation (5) implies that data for only one reactant are required to compute the acceleration. Equation (4) can thus claim no heuristic value, but is relevant to our discussion as a merely theoretical deduction.

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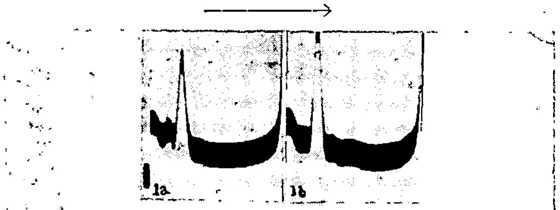
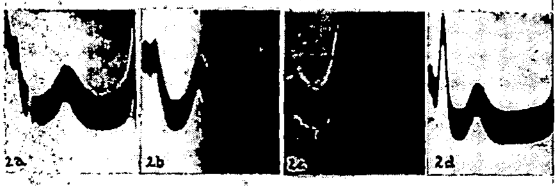
Complex Formation between Groundnut Skin Pigments and Conarachin II

When defatted groundnut meal containing a portion of the red skins of the nut was extracted with 10 per cent (w/v) sodium chloride solution and the extract dialysed against phosphate-sodium chloride buffer, ionic strength I 0·5, *p*H 8, the sedimentation-velocity diagram (Fig. 1*a*) revealed the presence of three components : arachin, the major component (sedimentation constant, $s^\circ_{20} = 13{\cdot}3$ S., conarachin II ($s^\circ_{20} = 8{\cdot}4$ S.) and conarachin I ($s^\circ_{20} \approx 2$ S.)[1]. When the extraction was carried out at *p*H 8–9 with sodium hydroxide, the solution was considerably more red in colour, the conarachin II component was less apparent, and the presence of a fourth, very fast sedimenting component ($s^\circ_{20} = 32$ S.) was observed (Fig. 1*b*). This fast component was absent, however, in extracts of blanched nuts or white skinned nuts. It would therefore appear to be connected with the presence of the red skin pigments in the meal.

The addition of calcium chloride (4 gm./l.) was found to precipitate most of the protein from a *p*H 8–9 extraction liquor leaving the colour in the supernatant liquor. When the latter was saturated with ammonium sulphate, the remaining protein precipitated along with the red pigment leaving an





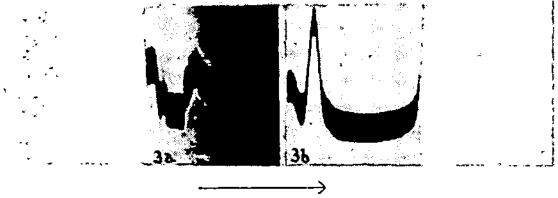


Fig. 1. Sedimentation diagram of: *a*, 10 per cent sodium chloride extract; *b*, (*p*H 8)-extract of groundnut meal containing some of the red skins. Both extracts dialysed to *I* 0·5, *p*H 8. Protein concentration, 1 gm./100 ml.

Fig. 2. Sedimentation diagrams in (*I* 0·5, *p*H 8)-buffer of: *a*, protein in supernatant of a (*p*H 8)-extract of groundnut meal after addition of calcium chloride: (4 gm./l.); *b*, 65/85 ammonium sulphate fraction of the supernatant; *c*, sediment after solution-*b* was spun in ultracentrifuge at 150,000*g* for 3 hr.; *d*, protein left in supernatant after (*p*H 8)-extract of meal was saturated to 65 per cent with ammonium sulphate. Protein concentration, 1 gm./100 ml.

Fig. 3. Sedimentation diagrams of: *a*, conarachin II (*I* 0·5, *p*H 8) + dark coloured (*p*H 9)-extract of red skins of the groundnut; *b*, conarachin II at *I* 0·5, *p*H 8

almost colourless supernatant. The precipitate in (*I* 0·5, *p*H 8)-buffer gave a dark red solution and the sedimentation diagram of Fig. 2*a*. If the supernatant, after the calcium chloride precipitation, was first 65 per cent saturated with ammonium sulphate, the protein which precipitated was not coloured. Further saturation from 65 to 100 per cent with ammonium sulphate produced a dark precipitate, giving in (*I* 0·5, *p*H 8)-buffer the sedimentation diagram of Fig. 2*b*. This diagram shows the presence of a higher proportion of the s_{32} component. The solution giving Fig. 2*b* was then centrifuged at 40,000 r.p.m. (150,000*g*) in the preparative head of the 'Spinco' Model *E* ultracentrifuge for 3 hr., and the sediment, when dissolved in (*I* 0·5, *p*H 8)-buffer, gave an extremely dark coloured solution and the sedimentation diagram of Fig. 2*c*. It will be observed that the proportion of s_{32}-component in this diagram is greater than that in Fig. 2*b*. This fast component was also observed in the supernatant after an extract of *p*H 8–9 of groundnut meal was 65 per cent saturated with ammonium sulphate (Fig. 2*d*). Its presence was only observed in highly coloured solutions.

When the solution giving Fig. 2*c* was dialysed against buffers at *I* 0·5 in the *p*H range 5–11 no change in the sedimentation diagram was observed. The addition of 5 *M* urea caused no change in the sedimentation diagram. When, however, the solution giving Fig. 2*c* was extracted with methyl ethyl ketone, a known solvent for vegetable tannins[2], the colour was removed from the solution, and the s_{32}-component was replaced by a component of sedimentation constant close to that of conarachin II. It thus appeared that the s_{32}-component was a complex between conarachin II and the groundnut skin pigments.

In order to confirm this, it was decided to attempt a synthesis of the complex from the protein and the pigments. The red skins of groundnuts were extracted at *p*H 9 with sodium hydroxide. Some of the very dark extract was then added to each of the three groundnut–protein fractions, arachin, conarachin I and conarachin II dissolved in (*I* 0·5, *p*H 8)-buffer. With arachin and conarachin I orange precipitates were formed. With conarachin II, however, no precipitation occurred, and the solution in the ultracentrifuge gave the sedimentation–velocity diagram of Fig. 3*a*, which shows the presence of a fast sedimenting component ($s^{\circ}_{20} \approx 32$ S.) but more polydisperse than the s_{32} component of Fig. 2. The diagram for conarachin II itself is shown in Fig. 3*b*.

The presence of four pigments in groundnut testa (tannin, phlobaphene, leuco-anthocyanin and flavone) has been reported[3]. Since the red tannin is the water-soluble pigment it seems probable that the complex is formed between conarachin II and the tannin. In view of the considerable increase in the sedimentation constant of conarachin II (8·4 → 32 S.) it would appear that some cross-linking of the protein by the tannin occurs to form the complex.

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Isolation of 2-Nitro-phenol from the Mixture of Mono-nitro-phenols

2-Nitro-phenol is usually prepared from the mixture of mono-nitro-phenols obtained by nitration of phenol. According to the classical methods[1] the isomers can be separated by steam distillation, as the steam volatility of the 2-nitro product is higher than that of the 3-nitro- or 4-nitro-phenol. The 2-nitro-phenol obtained by these methods, however, is usually contaminated by more or less of the 3-nitro- and 4-nitro-isomers. A number of interesting publications have appeared on the preparation of the pure products[2].

A convenient method of isolating practically pure 2-nitro-phenol has been devised, which may be used for avoiding the adoption of the steam distillation in certain cases, and is also suitable for further purification of the steam distillate. Apart from its use in the laboratory, the procedure has potential industrial application in working up mixtures of nitro-phenols obtained either by nitration of phenol or by hydrolysis of nitro-chloro-benzenes.

The method is based on the different solubilities of the sodium salts of mono-nitro-phenols in dry ethanol. As the sodium salt of 2-nitro-phenol[3] has the lowest solubility among them, it can be separated from an adequately concentrated alcoholic solution of mono-nitro-phenols by adding sodium ethylate. Having a mixture of sodium salts of the nitro-phenols, the sodium 3-nitro-phenoxide and 4-nitro-phenoxide can be dissolved with a suitable quantity of dry ethanol, while the sodium salt of the 2-nitro-phenol remains undissolved. In choosing the appropriate quantity of the solvent it must be taken into consideration that 3·9–4·0 gm. of sodium 4-nitrophenoxide and 0·4–0·5 gm. of sodium 2-nitrophenoxide, respectively, can be dissolved in 100 ml. of dry ethanol at 20° C.

Isolation of 2-nitro-phenol from the solution of mono-nitro-phenols. 2·5 gm. of 4-nitro-phenol and 7·5 gm. of 2-nitro-phenol (melting point, 43·5–44·5° C.) are dissolved in 45 ml. of dry ethanol, then 27 ml. of a solution of sodium ethylate (1·35 gm. of sodium metal dissolved in 27 ml. of dry ethanol) is added, and allowed to stand for an hour at room temperature. The sodium salt of 4-nitro-phenol remains dissolved, while the red-coloured sodium salt of 2-nitro-phenol separates. After filtration it is washed successively three times with 20 ml. and once with 7 ml. of dry ethanol cooled in ice, finally with two 15-ml. portions of benzene, and dried at 105° C. The sodium-2-nitro-phenoxide thus obtained (7·6 gm., 87 per cent yield) is converted into the phenol by treatment with 28 ml. of 5 *N* sulphuric acid on a steam-bath, and then allowed to stand overnight in a refrigerator. The crystallized 2-nitro-phenol is filtered, crushed and rubbed with ice-cooled water in a mortar, filtered again, rewashed with ice-cooled water, and dried at room temperature (6·4 gm., 85 per cent yield. Melting point, 43·5–44·5° C.).

Isolation of 2-nitro-phenol from the mixture of the sodium salts of mono-nitro-phenols. 4·95 gm. of sodium-4-nitro-phenoxide and 10·05 gm. of sodium-2-nitro-phenoxide are dissolved in water, and the solvent evaporated. The dry residual mixture of the sodium salts is extracted with 150 ml. of dry ethanol, stirring for 40 min. at 70° C. It is then cooled to room temperature; filtered, washed successively five times with 20 ml. of ice-cooled dry ethanol and three times with 20 ml. of benzene, and finally with two 10-ml. portions of ethanol. The sodium salt of 2-nitro-phenol dried at 105° C. weighs 8·0 gm. (80 per cent yield). The salt is converted into 2-nitro-phenol by acidification as above. (Melting point, 43·5–45·0° C.)

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Electrophoretic Removal of Protein from Hyaluronic Acid

EVIDENCE has been presented[1-3] to show that the hyaluronic acid of ox synovial fluid exists as a complex with a specific protein[4], the latter constituting 25–30 per cent of the total complex. This evidence is, in brief, that hyaluronic acid isolated from synovial fluid by a sufficiently mild means (differential filtration) cannot be obtained free from this amount of protein, and that removal of the protein (as by proteolytic action) from the material so isolated profoundly alters the physicochemical properties of the remaining hyaluronic acid.

It has been claimed, however, by Blix[5] and by Hesselvik[6] using U-tube electrophoresis and by Roseman, Watson, Duft and Robinson[7] using electrodeposition that hyaluronic acid containing substantially less than 25 per cent protein can be isolated; since electrophoresis should be as mild a procedure as filtration, these claims constitute an apparent contradiction of the evidence obtained from filtration experiments. Ogston and Stanier[2], in attempts to repeat Blix's procedure, were unable to obtain hyaluronic acid containing less than 25 per cent protein. Although it has not yet been shown that the products obtained by Roseman, Watson, Duft and Robinson have unchanged physicochemical properties, we have thought it well ourselves to investigate further the removal of protein from hyaluronic acid by electrophoresis.

We were not satisfied that the design of the electrodeposition apparatus[8] was such as to prevent the access of electrode products to the hyaluronic acid. We therefore used an electrodialysis apparatus designed and constructed by Dr. O. Smithies[9]. This apparatus consists of three cylindrical chambers of diameter 3 cm. The end-chambers contain circular platinum electrodes of large area, and the transfer of electrode products to the central compartment (10 ml. capacity) is entirely prevented by a carefully directed flow of fresh buffer through the electrode compartments. The maximum current employed in the apparatus was 40 m.amp., about 5·6 m.amp./cm.². 'Millipore' (Millipore Filter Corporation, Watertown, Mass.) *HA* membranes of pore diameter 0·4μ were used for separating the central compartment from the electrode chambers. The buffer used was 0·025 *M* phosphate, *p*H 7·0. The entire apparatus was used in the cold room at about 2° C.

Preliminary experiments indicated that the 'Millipore' membranes do not permit hyaluronic acid from ox synovial fluid to pass, even under considerable pressure, but do allow the passage of protein. Albumin and γ-globulin were found to migrate freely out of the central compartment with the application of an electric current.

Electrodialysis of ox synovial fluid at about 37 m.amp. caused a rapid loss of protein through the membranes. Colour was almost completely gone at the end of 11 hr. At 14 hr. ultra-violet absorption measurements revealed about 66 mgm. of protein per 100 ml.; at 18 hr., 38 mgm.; and at 22 hr., 23 mgm. At 26 hr. and 30 hr., however, the protein remained at 23 mgm./100 ml. This and another sample of ox synovial fluid, electrodialysed for 36 hr. at 37 m.amp., showed protein contents of 30 per cent of the hyaluronic acid complex.

To confirm this finding, a sample of hyaluronic acid complex prepared by filtration and containing initially 30 per cent protein was electrodialysed for 12 hr. at 37 m.amp. This period was sufficient to remove about 90 per cent of the total protein from synovial fluid, and assuming an exponential loss of protein, approximately the same proportion should have been removed from this material. At the end of the 12 hr., however, the protein content was unaltered. The viscosity and the non-Newtonian variation of viscosity with velocity gradient also remained unchanged.

Since there is reason to think that the protein present in the complex is of normal molecular size[4], and hence that it would, if free, be readily removed through the 'Millipore' membrane (as are all the other proteins of ox synovial fluid, as well as the two serum proteins tested), this evidence suggests that this protein cannot be removed from the complex by simple electrophoresis. Its removal by electrodeposition may have been the result of oxidation or change of *p*H caused by electrode products.

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Dextrorotatory Urobilin-IXα and Racemic *d*-Urobilin

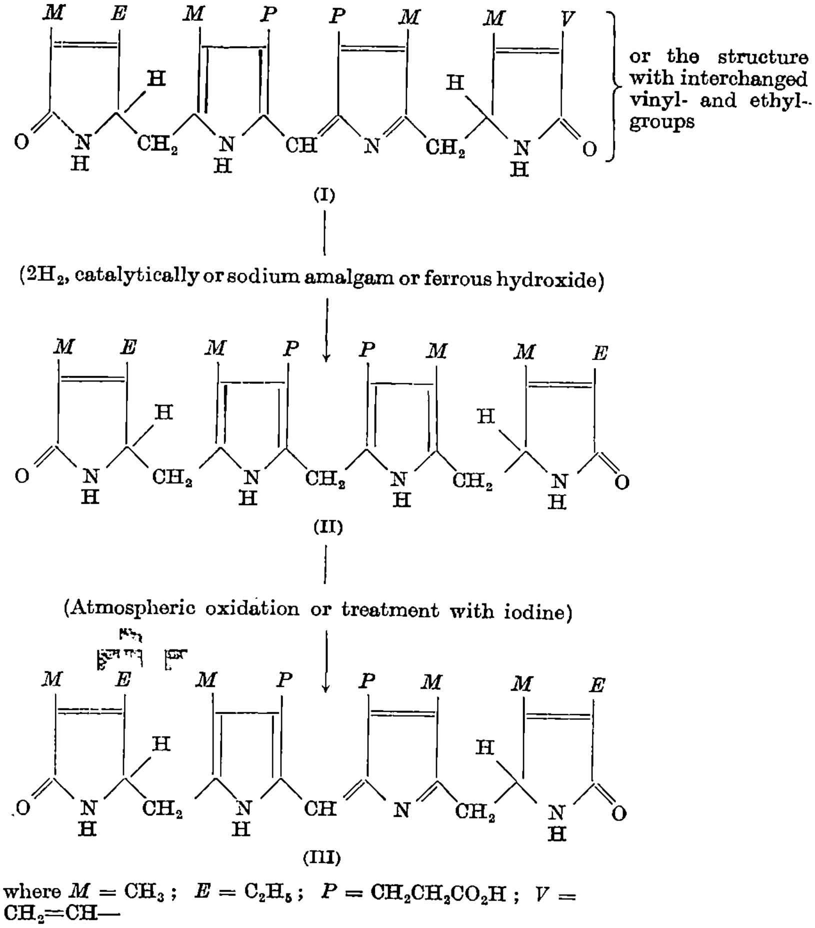
Of the three hitherto known bilene-*b* pigments only *l*-stercobilin and *d*-urobilin are optically active; *i*-urobilin has never been obtained in an optically active form. We now report the isolation of a dextrorotatory urobilin IXα and a racemic form of *d*-urobilin.

d-Urobilin appears to be formally derived from *i*-urobilin by replacement of an ethyl group by a vinyl group[1]. This is in agreement with Watson's earlier observation[2] that sodium amalgam or ferrous hydroxide reduction of *d*-urobilin gives a mesobilirubinogen (II) evidently identical with the compound obtained by total reduction of bilirubin since both afford *i*-urobilin (III) on oxidation. In the presence of colloidal platinum, *d*-urobilin hydrochloride ($[\alpha]_D^{CHCl_3} = +4,390$) in methanol or acetic acid absorbs a maximum quantity of two molecular proportions of hydrogen. However, the leuco-compound thus produced differs from the mesobilirubinogen obtained in Watson's experiments in providing, on oxidation, not *i*-urobilin but a dextrorotatory urobilin of $[\alpha]_D^{CHCl_3}$ = about $+ 4,950$. Quantitative hydrogenation of this pigment shows the presence of only one reducible double bond per molecule (as in *i*-urobilin) and not two (as in *d*-urobilin).

If the structure of *d*-urobilin is that shown in I the new dextrorotatory pigment can only be an optically active isomer of *i*-urobilin. We have recently shown[3] that the order of the β side-chains in *d*-urobilin is that of the IXα pigments; this must also be true of the new dextrorotatory pigment, which we will therefore call '*d*-urobilin IXα'. This accords with the term 'urobilin IXα' which has been given by many workers to *i*-urobilin, although all naturally occurring bile pigments have the IXα structure.

It is difficult to prevent the isomerization of *d*-urobilin to other pigments when the substance is in alkaline solution; but treatment, under hydrogen, with 1·25 *N* sodium hydroxide at laboratory temperature, causes complete racemization in 45 min., about 60 per cent of the pigment remaining as a urobilin. It has been possible to isolate sufficient of the crystalline, racemic urobilin hydrochloride for quantitative hydrogenation; the compound resembles *d*-urobilin but differs from *i*-urobilin in containing two reducible double bonds per molecule.

The existence of an optically active urobilin IXα is of some significance in relation to the structure of the end rings in such pigments. The classical hydroxypyrrole formulæ for *i*-urobilin (IV) and other bile pigments imply the absence of any element of asymmetry apart from that conferred by the asymmetric IXα order of the β side-chains; the substances would not, therefore, be expected to show any significant optical activity. On the other hand, structure III contains two asymmetric carbon atoms so that this structure is more in keeping with the observed optical activity of *d*-urobilin IXα. Doubtless the conditions prevailing in amalgam- or alkaline



(I)

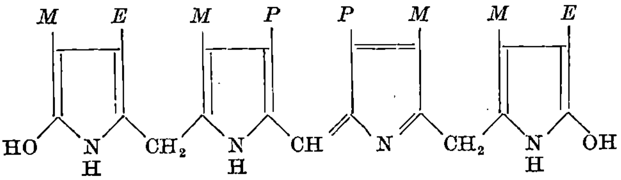
(2H₂, catalytically or sodium amalgam or ferrous hydroxide)

(II)

(Atmospheric oxidation or treatment with iodine)

(III)

where $M = CH_3$; $E = C_2H_5$; $P = CH_2CH_2CO_2H$; $V = CH_2{=}CH{-}$



(IV)

ferrous hydroxide reduction of *d*-urobilin are suitable for the racemization of the pigment, and this would explain the formation of *i*-urobilin in Watson's experiments.

d-Urobilin IXα also undergoes racemization in alkali. It is possible that *i*-urobilin, prepared from mesobilirubinogen formed by amalgam reduction of bilirubin, is a true meso compound, but the racemized pigment must contain equal quantities of enantiomorphs. It should therefore be possible to obtain, in addition to the above pigments, a lævorotatory urobilin IXα which is not identical with stercobilin as well as an *l*-dehydro-urobilin IXα which is enantiomorphous with *d*-urobilin.

The quantitative hydrogenations were kindly carried out by Miss J. Cuckney, of the Micro-analytical Department of the Imperial College of Science and Technology.

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Excretion of 17-Ketogenic Steroids in Subjects with Complete Transverse Lesions of the Spinal Cord

Elevation of the blood adrenaline-level, whether by intravenous infusion or in response to stress stimuli, leads to an increase in the concentration of adrenocortical hormones in blood[1-4]. It is believed that this increase is mediated by the anterior hypophysis, which responds to the increased blood adrenaline levels by releasing adrenocorticotrophic hormone.

The peripheral blood contains adrenaline, though in very low concentrations, even in the resting state. It has been shown that subjects with complete transverse lesions of the cervical cord have blood adrenaline-levels which are significantly lower than those of normal subjects[5]. More recent work in this Centre has shown that subjects with complete transverse lesions above fifth thoracic vertebra (*T*.5), that is, subjects whose adrenal medullæ are isolated from the control of the higher nervous centres, also show low blood adrenaline-levels.

It was of some interest, therefore, to determine the rate of excretion of adrenocortical hormones in the urine of subjects with complete transverse lesions of the spinal cord above *T*.5. The adrenocortical hormones determined were the 17-ketogenic steroids.

The 24-hr. excretion of 17-ketogenic steroids was determined on 16 male subjects with complete transverse lesions of the spinal cord above *T*.5, and on a comparable group of 17 male subjects with transverse spinal cord lesions complete below *T*.5.

The results are summarized in Table 1.

Table 1. 24-hr. 17-ketogenic Steroid Excretions

Subjects	No. of determinations	Mgm. 17-ketogenic steroids excreted/day (mean ± *S.D.*)
Normals (from Norymberski *et al.* (ref. 6))	8	13·15 ± 3·48
Subjects with lesions below *T*.5	17	14·0 ± 3·19
Subjects with lesions above *T*.5	16	5·8 ± 2·26

For the purpose of statistical analysis, the results of excretion of 17-ketogenic steroids by normal men obtained by Norymberski *et al.*[6] have been used. The results obtained from subjects with lesions complete above *T*.5 are significantly lower ($P < 0{\cdot}01$) than results from subjects with lesions complete below *T*.5 and than from results from normal subjects; there is no significant difference between the results from normal subjects and those from subjects with lesions below *T*.5.

The results are in harmony with the view that adrenaline is concerned in the release of adrenocortical steroids not only in stress conditions but also under resting conditions.

Studies are at present in progress on the plasma 17α-hydroxycorticosterone-levels in subjects with spinal cord lesions. The results of these studies, together with those reported above, will be published *in extenso* at a later date.

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Isolation of a New Flavin produced by an Actinomycete

Since the discovery that riboflavin is produced by *Eremothecium ashbyii* and *Ashbya gossypii*[1], a great number of bacteria and fungi have been found capable of producing this and other closely related substances[2]. Among the *Actinomycetales* only a few species of *Mycobacterium*[3] have been reported capable of producing riboflavin, while no true Actinomycete has ever been found to possess such a capacity.

During the isolation of an antibiotic produced by *Streptomyces* 476, a still unidentified species probably belonging to the *griseus* group, a considerable yellow-green fluorescence of the metabolic liquids was noted. The riboflavin potency of such liquids was assayed with mutant strains of *Lactobacillus casei* and *Leuconostoc mesenteroids*, giving an activity corresponding to a riboflavin content of 0·9–1·2 μgm./ml.

The fluorescent pigments could be easily extracted with *n*-butanol and purified by absorption on charcoal and elution with aqueous pyridine. Paper chromatography of such preparations and of the original brews were then run in a *n*-butanol/acetic acid/water system according to Crammer's technique[4]. The

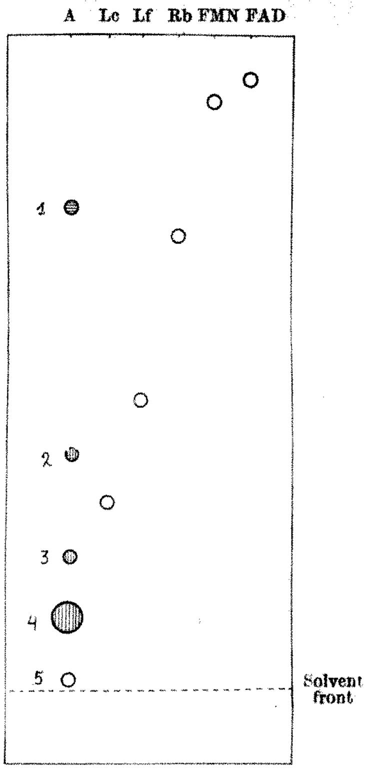

Fig. 1. Paper chromatogram developed with *n*-butanol/acetic acid/water (3 : 1 : 1, v/v). *A*, Sample; Lc, lumichrome; Lf, lumiflavine; Rb, Riboflavin; FMN, flavin-mononucleotide; FAD, flavin-dinucleotide. Areas shaded with vertical lines indicate yellow fluorescence, horizontal lines blue fluorescence and unshaded areas yellow colour without fluorescence

chromatograms showed at least four spots characterized by fluorescence under Wood's light but none could be identified either with riboflavin or its nucleotides or decomposition products (Fig. 1). Only spot 2 reacted with ninhydrin. When the spots were cut off the chromatograms and tested individually, only spot 1, characterized by a blue fluorescence, proved capable of sustaining the growth of *L. casei*.

Further work on the identification of the new flavin is proceeding, and will be reported in detail elsewhere.

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Junction of the Epidermis and Dermis

At the surface of the dermis, fine fibres form a continuous subepithelial network[1]. These fibres, unlike the underlying coarser fibres, are argyrophilic and also stain red with periodic acid–Schiff technique[2] (Hotchkiss's method[3]). Into this network, processes from the basal epidermal cells project, and it has been reported that the interlocking of these processes with the dermal fibre is a means by which the epidermis adheres to the dermis[4].

New observations have been made on this junction of epidermis and dermis in the skin of the ox. The skin from the leg of an ox was freeze-dried about 5 hr. after death. Sections (3–5μ) were stained, without preliminary fixation by Foot's silver method[5] (to demonstrate the surface dermal fibres), followed either by Mallory's phosphotungstic acid hæmatoxylin (to demonstrate the tonofibrils of the epidermis) or by periodic acid–Schiff technique (Hotchkiss's method for the presence of mucopolysaccharide).

In the basal layer cells of the epidermis the tonofibrils ran mainly parallel with the long axis of the cell. These tonofibrils were found to project beyond the base of the cell and to pass between the argyrophilic dermal fibres. In Fig. 1*a* the tonofibrils can be seen to pass between the silver-stained dermal fibres.

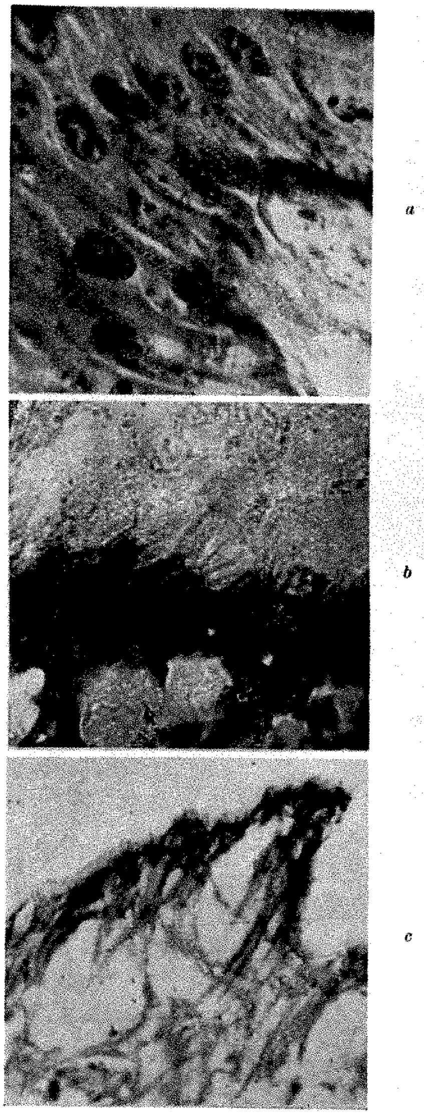

Fig. 1. *a*, Tonofibrils of the basal layer cells of the epidermis interlocking with the silver-stained dermal fibres (× 700); *b*, periodic acid–Schiff-positive fibrils projecting beyond the silver-stained dermal fibres (× 900); *c*, periodic acid–Schiff-positive fibrils as a fringe above the silver-stained dermal fibres (× 530)

From this observation we may conclude that there is also an interlocking of the tonofibrils of the basal cells, and dermal fibres, as part of the system by which the epidermis adheres to the dermis.

Examining the silver-stained sections counter-stained with periodic acid–Schiff reagent, no homogeneous periodic acid–Schiff-positive layer, as reported by Gersh and Catchpole[6], was observed between the dermis and epidermis. However, fine periodic acid–Schiff-positive fibrils were observed to extend from the silver-stained dermal fibres and to project into the epidermis. These fibrils appeared to be continuous with the dermal fibres and to be free ending. They varied in length, the longer fibrils at the tips and base of the papillæ. No epidermal structures were stained in these preparations. Fig. 1*b* shows these fine fibrils projecting beyond the silver stained dermal fibres. Fig. 1*c* shows at a lower magnification the fibrils forming a fringe above the dermal fibres.

Such free-ending periodic acid–Schiff-positive fibrils extending from the subepithelial argyrophilic network have not previously been described. As the fibrils stained intensely with periodic acid–Schiff reagent we may conclude that they are closely associated with mucopolysaccharides, and so it is unexpected that the silver failed to deposit on them. The relationship of these fibrils with the epidermal cells remains to be established.

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Enzyme Changes in the Ageing Periosteum

ACID and alkaline phosphatase, cytochrome oxidase and succinic dehydrogenase activities of the periosteum of the femora of 100 normal and 100 traumatized animals were studied histochemically. The animals ranged from newborn to more than one year of age. Trauma was induced by drilling a hole in the midfemoral region.

A steady state of phosphatase activity was revealed in the osteogenic layer of the periosteum of normal animals except for a slight rise at a time comparable to the period of maximum bone formation and a reduction at about the time of sexual maturity. Animals exhibited a rise in dephosphorylating activity throughout the different age groups at the trauma site (Fig. 1, top).

The respiratory enzyme activity of the periosteum of normal animals was high at birth and increased at five weeks; a drastic reduction, however, was observed in all the older animals. At the site of trauma an increase in respiratory enzyme activity occurred but to a lesser degree with increasing age of the animal (Fig. 1, bottom).

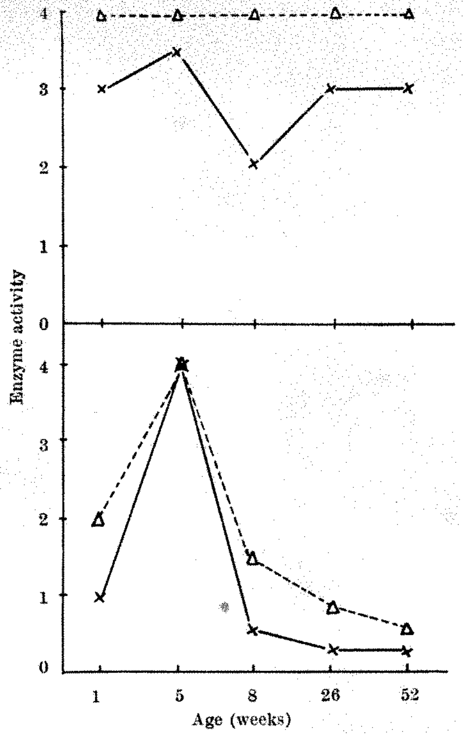

Fig. 1. Enzyme activity based on intensity of precipitate and colour in the osteogenic layer of the periosteum of rat femora taken at different ages. ×, Normal periosteum; Δ, traumatized periosteum. Top, phosphatase activity; bottom, respiratory enzyme activity

Zorzoli[1] has reported an increase in acid phosphatase activity in the cells of old animals. Weinbach and Garbus[2] have shown that in the liver and brain of old animals the respiratory level was maintained. This was supported by Bourne[3]. Bourne[4] further indicated that there was evidence of some increase in cytochrome oxidase and succinic dehydrogenase activity in the tissues of older animals.

It appears that, at least in the periosteum of rats, phosphatases do not increase with ageing, and the respiratory enzyme activity decreases to a low level. This is further supported in the observation that the cells of the periosteum of traumatized animals are less able to increase their respiratory enzyme activity with increasing age to levels seen in younger animals.

Bourne[3] states that the consequence of dephosphorylation of metabolically important substances may be behind the fundamental processes involved in cellular senescence. Trauma to bone at any age leads to increased dephosphorylation which is essential for bone repair mechanisms. This brings renewed life to an injured area. The respiratory enzymes, however, are associated with the reactions which make energy available to cells for various activities. The reduction in the activity of these enzymes is believed to be involved with cellular changes which bring about the gradual disappearance and death of the osteoblasts, which in turn reflect a reduction in bone repair rate and growth with increasing age.

The present results will be published elsewhere in greater detail.

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Ovaries of Some Fœtal and Prepubertal Giraffes (*Giraffa camelopardalis* (Linnæus))

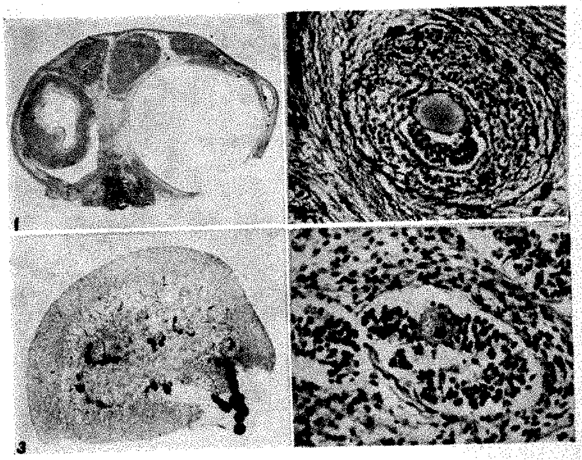

Fig. 1. (1) Section of a late gestation giraffe fœtal ovary showing luteinization, and advanced follicular development (× *c.* 1·5); (2) reticular fibres and capillary vessels penetrating a mass of granulosa-like cells which surround a centrally placed ovum (× *c.* 85); (3) section of a mid-gestation giraffe fœtal ovary showing a wide cortical region separated from the central medullary core by a zone of connective tissue which contains relatively few sex cells (× *c.* 4); (4) rete ovarii with contained ovum from a mid-gestation giraffe fœtal ovary (× *c.* 160)

In several species of mammals the ovaries of near-term fœtuses show a departure from the typical pattern of development as known in the laboratory rodents, the cat, the dog, etc. Deviations from this normal have been described in the fœtal gonads of the horse[1], the seal[2] and the African elephant[3], in which species an enormous development of interstitial cells is a characteristic feature. A premature development of large ovarian follicles, with antrum formation and luteinization, has been described in the human full-term fœtus[4-9]. Follicle development up to antrum formation appears to be a constant occurrence in the ovaries of near-term fœtal sheep (personal observations), and can occur in the cow[8]. The morphogenesis of the giraffe fœtal gonads provides yet another example of a departure from the normal pattern.

We have examined three stages in the development of the gonads of the female giraffe. So far as we can ascertain, these represent the mid-gestation, late-gestation and new-born periods. In many respects the histological structure of the ovaries of the late-gestation specimen *C.R.* = 1,040 mm. (at birth approximately *C.R.* = 1,162 mm.), Fig. 1,1, recalls that of an adult mammal. The germinal epithelium is cuboidal, there is a well-developed definitive tunica albuginea containing an abundance of both collagen and reticular fibres, the primary follicles are relatively few in number, and many appear shrunken and degenerate. In the medulla there are a number of apparently normal follicles, some of which have a large antrum and a well-developed discus proligerus; the largest is illustrated in Fig. 1,1. Hæmorrhagic follicles of various sizes are present in both ovaries as well as a number of corpus luteum-like structures (Fig. 1,1). These latter are solid, spherical bodies well vascularized and surrounded by a theca externa. The luteinized cells are of two types easily distinguished by their staining affinities, in sections stained in hæmatoxylin and eosin, and also by their size. It is of interest, therefore, to find that in all the adult giraffe ovaries so far examined by us the luteal cells of the corpora lutea of pregnancy show a similar dimorphism. Moreover, in the corpora lutea of pregnancy the proportion of large to small luteal cells appears to reflect the age of the structure. The impression is gained that in the fœtus the luteal bodies are of two forms, one in which the small cell type is prominent and a second in which it is less conspicuous. Besides these solid structures, there is what appears to be a luteinized follicle with a large central cavity (Fig. 1,1).

In the medullary stroma of the fœtal ovary of late gestation, a few discrete, spherical masses of granulosa-like cells surrounding a centrally or eccentrically placed oocyte are also present. These structures are penetrated by large sinusoidal capillary vessels, and contain a conspicuous network of reticular fibres (Fig. 1,2). In the ovaries of two mid-term fœtuses (*C.R.* = 485 mm. and *C.R.* = 620 mm., respectively), these last-mentioned structures, together with what appear to be normally developing follicles, are prominent features in the medulla, and in some of the follicles antrum formation has begun. In the older of the two specimens there is one exceedingly large hæmorrhagic follicle and several smaller ones. No such structures are present in the younger specimen. Surrounding the centrally placed follicles in both specimens and separating them from the cortex is a prominent zone of connective tissue (Fig. 1,3). The cortex of both ovaries is wide, and consists largely of closely packed primary follicles embedded in a small amount of connective tissue. The germinal epithelium, in the few places where it is undamaged, is simple and cuboidal. Lying immediately below, and penetrated in most places by connective tissue elements, are epithelial cells and a small number of sex cells not yet in the primary follicle stage. A few of the innermost of the cortical primary follicles appear to have penetrated into the subadjacent connective tissue zone, and even into the more centrally placed medullary core. There are signs of degeneration in many of the oocytes both in the primary follicles of the cortex and in the primary and more advanced follicles of the medulla.

Whether the spherical masses of granulosa-like cells penetrated by capillaries and surrounding an oocyte, which are so striking a feature of the medulla in the mid-term ovaries, are derived from a current cortical proliferation or are medullary derivatives is not yet clear. In places these structures occur in the neighbourhood of, and are closely associated with, the rete ovarii, the cells of which are separated, in places, by the occurrence of germ cells of various sizes (Fig. 1,4).

The ovaries of the two new-born giraffe specimens in our collection both contain large apparently healthy follicles with antra, large luteinized follicles, and numerous corpus luteum-like structures. These findings, together with the observations of a broadly similar picture in the ovaries of older prepubertal specimens, suggest that the developmental stages we have outlined above are a normal feature of ovarian development in this species.

The endocrinological implications of some of these findings, particularly as they are related to the fœtal gonads of late gestation, have been discussed by Amoroso[10-12]. From the foregoing observations on the giraffe fœtal gonads, and others we have made on the fœtal reproductive tracts, it seems clear that both are sensitive to hormonal stimulation for some time before birth, and, as gauged by the histological appearances, the fœtal ovary of the giraffe may be capable of adult secretory functions in addition to gametogenic functions. In view of the similar character of the ovarian changes in the human and giraffe ovary at birth, the occurrence of gonadotrophins in the urine of pregnant giraffe[13] becomes a matter of special interest. On the other hand, it is possible to envisage an endocrine picture in which maternal (or placental) œstrogen acting directly, or indirectly through the fœtal pituitary, plays a dominant part.

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Avoidance of 'Secondary Disease' in Radiation Chimæras

In the experience of this laboratory the radiation chimæras[1], produced by irradiating *CBA* mice with 950 rads of X-rays and then injecting them intravenously with bone marrow from $C_{57}BL$ mice, invariably die within 4 months from 'secondary disease'. Congdon *et al.*[2] have worked on the lines that this condition might be due to recovery of the host animals' capacity to eliminate the foreign graft. We[3] and Uphoff[4] have favoured the idea that it was due to reaction by the graft against the host.

To test the latter hypothesis with its corollary that material from immature donors may be less reactive, similar irradiated *CBA* mice (950 rads of X-rays ; 250 kV. constant potential, 15 m.amp., half-value layer 1·2 mm. copper, 43 rads/min. at 70 cm.) have been given myeloid tissue from fœtal and newborn $C_{57}BL$ mice with the following results (Table 1).

Table 1. Survivors of Irradiated *CBA* Mice (950 rad X-Rays) given Myeloid Tissue from $C_{57}BL$ Mice

Myeloid tissue given	Survivors at 120 days
(*a*) Adult bone marrow	0/30
(*b*) Newborn spleen	11/20
(*c*) Embryo spleen	9/15
(*d*) Embryo liver	4/10

Two of the survivors in group (*b*) and seven of those in group (*c*), when they had survived more than three months and were in good condition, were grafted with skin from $C_{57}BL$ mice of the same stock. One animal died (? pylephlebitis) during the procedure of deplastering, one skin graft was shed after ten days ; the other seven grafts were intact after 2 months.

These results are in accord with our original hypothesis.

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Transformation of Megaloblasts to Normoblasts by cultivating Human Bone Marrow in Presence of Vitamin B_{12} and Vitamin B_{12}-binding Protein

Callender and Lajtha[1] observed that little or no conversion of megaloblasts to normoblasts occurred when pernicious anæmia marrow was cultivated in pernicious anæmia serum by itself or together with vitamin B_{12}. However, if bone marrow is cultivated in pernicious anæmia serum containing vitamin B_{12} and normal gastric juice or in normal serum with vitamin B_{12} megaloblasts are partly converted into normoblasts within twenty-four hours. Swan *et al.*[2] did not find this influence of vitamin B_{12} and gastric juice, but Astaldi and Cardinali[3] have recently confirmed the findings of Callender and Lajtha[1].

We cultivated human megaloblastic marrow in suspension in pernicious anæmia serum or in normal human serum as described by Osgood[4] and Lajtha[5], and were able to confirm the findings of Callender and Lajtha[1] and Astaldi and Cardinali[3].

It seems that the effective principle in gastric juice and normal human serum necessary for the activity of vitamin B_{12} in the conversion of megaloblastic marrow to normoblastic marrow is the vitamin B_{12}-binding protein. By zone electrophoresis or fractionation with ammonium sulphate we prepared vitamin B_{12}-binding protein from normal gastric juice. When this was added to the bone-marrow cultures together with vitamin B_{12}, the conversion of megaloblastic marrow to normoblastic marrow showed decisive improvement. In some of these cultures we found 50 per cent of the nucleated red cells as normoblasts after twenty-four hours. In the same cultures containing only vitamin B_{12} there were no normoblasts at all. Bone marrow cultivated in normal human serum with vitamin B_{12} contained about 10 per cent of the nucleated red cells as normoblasts after twenty-four hours. The effect was not achieved when some other protein of gastric juice, having no binding capacity for vitamin B_{12}, was added to the cultures. Due to its binding capacity for vitamin B_{12} the α-globulin fraction of normal human serum also showed a marked effect on the conversion.

These investigations were performed on bone-marrow cultures of nine patients with pernicious anæmia in relapse and all yielded the same results.

Further particulars of this work will be published elsewhere.

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Occurrence of Foldings of Plasma Membrane (β-Cytomembrane) in Cells of Pig's Carpal Organ as revealed by Electron Microscopy

THE carpal organ of the pig is a conglomerated sweat gland, and histologically it is known to be similar to the usual small sweat gland (eccrine gland)[1]. This organ is useful for investigating the fine structure of sweat glands with the electron microscope, since the conglomerated body of the gland is easily seen with the naked eye and most of the glandular tissue is found within the small field of the electron microscope. The tissue was fixed in 1 per cent osmic acid and buffered at *p*H 7·4 with acetate–veronal or phosphate buffer, washed for a short time and then dehydrated with ethanol in a graded series of concentrations. The specimens were embedded in a mixture of *n*-butyl and methyl methacrylate (7 : 3), and were cut into sections less than 0·05μ thick with a thermal expansion microtome (*JUM*-4) fitted with a glass knife. Embedded sections were examined in a *JEM*-3 electron microscope.

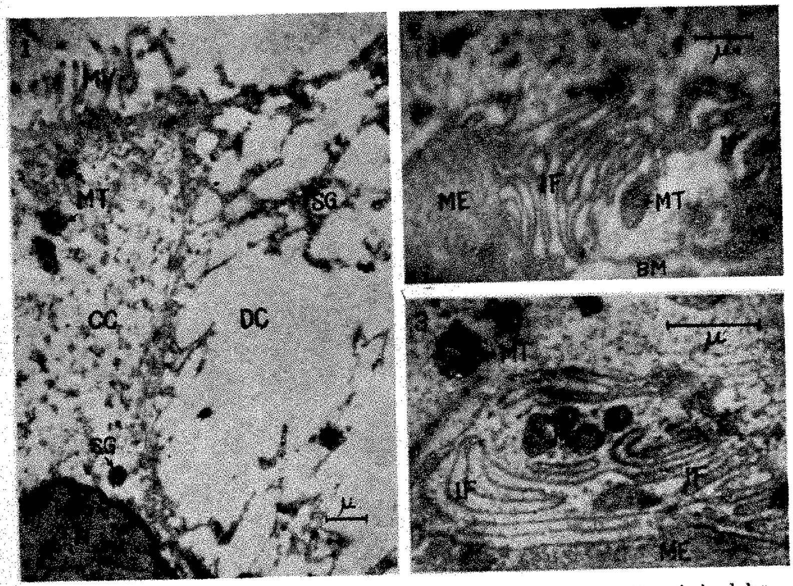

Fig. 1. An electron micrograph of apical and intermediate zone of two adjacent glandular cells (*CC*, clear cell; *DC*, dark cell). *MV*, microvilli; *MT*, mitochondria; *SG*, secretory granules; *N*, nucleus. Figs. 2 and 3. Electron micrographs of nasal portion of the glandular cell, showing the elaborated infolding (*IF*) of basal plasma membrane. *MT*, mitochondria; *ME*, myo-epithelial cells; *BM*, basement membrane

The presence of two kinds of glandular cells in the secretory portion of eccrine sweat glands has already been demonstrated by light microscopy in both human and certain mammalian skins, as well as in the carpal organ of the pig[1–3]. Dark cells, which are observed with the light microscope to contain a number of secretory granules stainable with iron-hæmatoxylin and are periodic acid–Schiff positive, show a number of large electron-lucent vacuoles, which may correspond to the dark-stained granules seen with the optical microscope. While the cells which are clear in light microscopy are rather dark under the electron microscope, secretory granules of this cell type were seen as relatively small, extremely dense granules (Fig. 1).

The free surface of both types of cell is covered by microvilli which are rather irregular in shape when compared with those of the brush or striated border seen in the proximal convoluted tubule of the kidney or intestinal epithelium. The development of microvilli is less marked on the dark cells than on the clear cells (Fig. 1). This was also observed with the light microscope[1].

In the basal cell zone and the lateral boundaries of both cell types, complicated foldings of the plasma membrane were observed (Figs. 1, 2 and 3); this is analogous to the structure called the "β-cytol membrane" by Sjöstrand[4]. The folding at the lateral cell margin is less developed than that of the basal one. The folding in the basal cell zone facing the myoepithelial cell or the basement membrane is similar to the basal infoldings observed in the proximal convoluted tubule of the kidney, the epithelium of the duct of some salivary glands, ependymal cells of the choroid plexus, and in the ciliary body of the eye, all of which are thought to be closely associated with water transport[5]. This suggests that these cells are also associated with the active transport of water from the surrounding connective tissue and blood capillaries into the lumen of the gland producing the sweat, that is, the dilution of the secretory product.

The α- and γ-cytomembranes[4] (called the rough and smooth surfaced varieties of endoplasmic reticulum by Palade[6]; the latter is also identical to the Golgi complex of Dalton[7]) as well as mitochondria are also contained in both glandular cell types. The features corresponding to the various states of the secretion cycle will be described elsewhere.

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Physical Release of Acetylcholine from the Thoracic Nerve Cord of *Periplaneta americana* L.

Recently, suggestions have been made that acetylcholine in nerve tissue is associated with structural entities termed 'vesicles'[1]. The ideas are compatible with a quantum concept of nerve transmission[2]. The evidence that acetylcholine is released from mammalian nerve tissue by physical means[3] lends further support to the structural inclusion of acetylcholine within the nerve cell and casts doubt on the hypothesis that it is held in chemical combination. The following results on the release of acetylcholine from cockroach thoracic cord by osmotic pressure and homogenization makes the existence of a chemical combination in insects doubtful.

Table 1. Effect of Osmotic Pressure on Amounts of Acetylcholine in Supernatant and Residues of Homogenates of Cockroach Thoracic Cord

Extraction molarity with medium homogenization (17 sec.)	Acetylcholine			
	Total (μgm.) (15 cords)	Supernatant (μgm.)	Residue (μgm.)	Supernatant (per cent)
Distilled water	5·75	4·75	1·0	82·6
0·244 *M* Ringer	4·57	3·18	1·39	69·5
0·314 *M* Ringer	4·68	2·85	1·83	60·8

The results in Table 1 show the effect of extraction media of different osmotic pressures on the amounts of acetylcholine recovered from supernatants and residues of homogenates of thoracic cords of cockroaches. The cords were homogenized for 17 sec. in ice-cold medium and centrifuged at 50,000*g* for one hour. Assays for acetylcholine were carried out on frog rectus abdominus muscle, and the values are expressed as chloride. It is clear that both the supernatant and residue values for acetylcholine depend upon the tonicity of the extraction medium. The relatively hypertonic medium, 0·314 *M*, which gave the lowest supernatant value, has the equivalent osmotic pressure of Hoyle's insect Ringer. Furthermore, desheathed cockroach ganglia do not swell at this osmotic pressure. Having established an extraction medium apparently suitable to this insect nerve tissue a combination of homogenization and osmotic pressure was employed to release acetylcholine. The results are shown in Table 2. It is striking that the hypotonic medium, distilled water, released a high proportion of acetylcholine into the supernatant, whatever the severity of homogenization. In the instance of the hypertonic medium more acetylcholine was released into the supernatant with increasingly severe homogenization, until the value for acetylcholine in the supernatant approximated that of distilled water. It should be noted that in either medium it was not possible to obtain all the acetylcholine in the supernatant at severe homogenization.

Table 2. Effect of Homogenization and Osmotic Pressure on Amounts of Acetylcholine in Supernatants and Residues of Homogenates of Cockroach Thoracic Cord

Degree of homogenization	Acetylcholine							
	Distilled water				Insect Ringer 0·314 *M*			
	Total (μgm.) (15 cords)	Supernatant (μgm.)	Residue (μgm.)	Supernatant (per cent)	Total (μgm.) (15 cords)	Supernatant (μgm.)	Residue (μgm.)	Supernatant (per cent)
Light (5 sec.)	5·85	4·35	1·5	74·3	5·43	2·9	2·53	53·4
Medium (17 sec.)	5·75	4·75	1·0	82·6	4·68	2·85	1·83	60·8
Waring blendor (1 min. at 16,000 r.p.m.)	5·5	4·5	1·0	81·8	5·05	3·3	1·75	65·3
Medium + Waring blendor	4·65	4·28	0·37	92·0	4·52	3·86	0·66	85·4

It is concluded from these results that acetylcholine in cockroach thoracic cord can be released by both osmotic pressure and mechanical disruption. The ease with which acetylcholine can be released in insects supports the suggestion that in insects it can be released more easily than in mammals (Pal, R., unpublished). The evidence favours the hypothesis that acetylcholine is not in chemical combination in insects but located in the nerve cell within a 'structural compartment'.

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Method of isolating the β_1-Metal-combining Globulin from Human Blood Plasma

Surgenor, Koechlin and Strong[1,2] have described the isolation of the β_1-metal-combining globulin (siderophilin, transferrin) from Cohn's plasma fraction IV–4 by alcohol fractionation. The crystallization, described by Koechlin[2], could not easily be reproduced by other investigators. Improved conditions for the purification and the crystallization starting from fraction IV–7 have recently been published by Inman[3]. Already the preparation of fraction IV–7 requires many steps and much time, which may be one of the reasons why only very few clinical experiments with this iron-transmitting globulin have been reported.

We have found that an electrophoretically almost pure preparation of the metal-binding globulin can be obtained by a much shorter procedure using rivanol (2-ethoxy-6,9-diaminacridinelactate).

Hořejši and Smetana[4] have shown recently that rivanol precipitates from serum or plasma at *p*H 7·3 almost all the proteins except the γ-globulin (2 parts of plasma + 7 parts of 0·4 per cent rivanol solution at room temperature). After adsorption of the rivanol by charcoal, the γ-globulin can be precipitated from the supernatant in very good yield under conventional conditions.

We have found that the supernatant of the rivanol precipitation contains significant amounts of albumin and a highly soluble β-globulin besides γ-globulin. The higher the *p*H during the rivanol precipitation, the smaller are the amounts of albumin found in the supernatant. Between *p*H 8 and 10 albumin is precipitated almost quantitatively, while the supernatant still contains γ-globulin and the soluble

β-globulin. From the rivanol-free solution the γ-globulin is precipitated in the presence of 25 per cent ethanol at pH 6·8 ($-6°$ C.), whereafter the β-globulin is carried down by 40 per cent ethanol at pH 5·8. Further purification of the β-globulin can be achieved by dissolving it at pH 9·4 (4–6 per cent protein) and repeating the rivanol procedure. From 100 gm. plasma proteins about 2 gm. of β-globulin almost pure paper-electrophoretically were obtained.

The deep red-brown colour of the solutions of this β-globulin fraction is characteristic of the iron-combining protein. Normally it is only partly saturated with iron. By dialysis against versene (ethylenediaminetetraacetate) it can be freed from iron and thereby becomes colourless. Quantitative determinations of the iron-binding capacity have shown that the preparations obtained in this simple manner consist to about 90 per cent of metal-combining globulin. So far as their purity is concerned, these preparations therefore correspond to fraction IV–7–2.

We think that the high solubility of the β_1-metal-combining globulin in the presence of rivanol above pH 7 makes this reagent a very suitable tool to prepare larger amounts of this interesting protein for clinical experiments.

Details of our studies, which are being continued, will be published later.

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Soluble Antigens in Microsomes and Other Cell-Fractions of Rat Liver

It has been known for some time that particulate material sedimentable by high speed from tissue cells has characteristic immunological properties, and the antigenic specificity of isolated cell fractions has been studied in a variety of normal and tumour tissues[1]. These investigations not unexpectedly revealed a high degree of antigenic complexity of the different cell fractions, making further analysis difficult by the methods at hand. However, the results seemed encouraging enough to warrant an extension of the immunological work to the various soluble antigens characterizing different parts of the cell. An investigation of this sort has been carried out in our laboratory, and a detailed report of it will be published later.

The work was carried out on mitochondria, submicroscopic particles and supernatant prepared from liver cells of adult normal rats. For immunization, perfused livers were homogenized in 0·25 M sucrose and fractionated by differential centrifugation. Some microsome samples were prepared by the method of Palade and Siekevitz[2]. For control purposes, antisera were prepared also against total homogenate made in 0·9 per cent saline and against rat serum. The concentrated samples were injected as soon as possible after isolation. The antisera were obtained in rabbits using adjuvant techniques for injection.

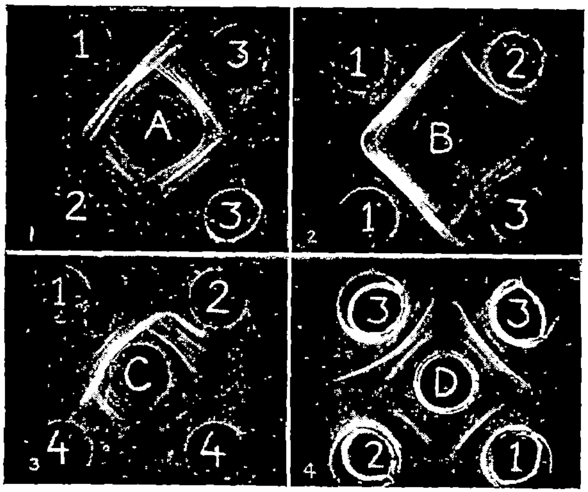
For testing, the cell fractions were prepared similarly, but variations in the conditions of fractionation were studied as separate variables. Mitochondria and microsomes were extracted with 0·4 per cent deoxycholate[2] and the microsomes were further fractionated by means of additional extractions with versene. Since the deoxycholate did not affect the reactivity of the antigens, the extracts could be used for testing without further treatment. The supernatants were tested directly in sucrose or after pressure dialysis against 0·9 per cent saline. Protein and ribonucleic acid determinations were always carried out in order to test the efficacy of the fractionations.

The double diffusion agar-techniques according to Korngold[3] were used in the immunological experiments. Instead of penicillin-cups, small plastic cups with a closed base and with narrow openings close to the base were used as containers for the reagents. The agar layers were poured into Petri dishes on the top of a thin glass slide. The experiments were run at 37° or at 4° C.; one or two fillings were sufficient to ensure strong reactions. After completion of the reactions in the refrigerator, the plates were washed, dehydrated with ethanol, stained and finally dried[4]. The glass slides with the thin agar film on top were removed from the dishes, and the preparations were mounted with liquid plastics under a second slide of the same dimensions[5].

The precipitation patterns obtained in the experiments were often complex and difficult to interpret. The criteria used for identification of the antigens and antibodies were those commonly applied in the Ouchterlony procedure[6]. Our conclusions are based on only those results which could be confirmed by means of independent experimental procedures, including, for example, reciprocal testing, tests at different antigen/antiserum ratios and chemical fractionations of the antigen solutions.

The antisera against both total homogenate and the cell fractions contained only small amounts of antibodies reacting with the proteins of rat serum. Correspondingly, the amount of these antigens in the cell fractions was mostly negligible. In fact the reactions showed an unexpectedly high degree of 'cell-fraction'-specificity. As a general rule, supernatant and deoxycholate extracts of mitochondria and microsomes gave the strongest and most complex precipitation patterns with their homologous antisera (Figs. 2–4). Entirely confirmative results were obtained with the anti-total homogenate sera (Fig. 1). The microsomes were 'strongest antigenic', probably due to lesser stability of both the mitochondrial preparations and the supernatants. This report deals mainly with the immunological properties of the microsome preparations.

The deoxycholate extracts of the microsomes were characterized by a group of antigens, occurring abundantly and predominating also as antibody producers (Fig. 2). The minimum number of detectable antigenically different molecules within this group was five. There are reasons for believing that these antigens, which we may call 'D-antigens', constitute an important part of the proteins extractable with deoxycholate from the endoplasmic reticulum of the hepatic cells[2].



Figs. 1–4. Antisera: *A*, anti-total homogenate; *B*, anti-microsomal; *C*, anti-mitochondrial; *D*, anti-supernatant. Antigen solutions: 1, deoxycholate extract of microsomes; 2, deoxycholate extract of mitochondria; 3, supernatant; 4, rat serum

Whereas the supernatants were essentially free from these D-antigens, the situation was more complicated for the mitochondria. Thus, the anti-mitochondrial sera contained a certain amount of antibodies reacting with the D-antigens in the microsomal extracts, but the concentration of the antibodies was lower here than in the anti-microsomal sera. Apart from antigens characteristic of mitochondria only, deoxycholate extracts of the mitochondria contained D-antigens in relatively small amounts (Fig. 3), varying from preparation to preparation. This might indicate that the presence of the D-antigens in the mitochondrial preparations was due to contamination with endoplasmic reticulum[7], although thus far other explanations cannot be excluded.

Apart from these D-antigens, the deoxycholate extracts of the microsomes contained an additional number of antigens in common with supernatant, and reacting with antibodies in both anti-microsomal and anti-supernatant sera (Fig. 4). In contrast to what has been found for the D-antigens, the distribution of these antigens between the microsome fraction and the supernatant was highly dependent on such variables in preparation as time and speed of centrifugation, sucrose concentration, washing, etc.

Versene extracts of the microsomes contained relatively little in common with the deoxycholate extracts. A certain number of distinguishable antigens, occurring in small amounts and generally not detectable in the deoxycholate extracts, could be found when these extracts were allowed to react with anti-supernatant serum. It cannot yet be stated whether these antigens represented contaminating proteins derived from the supernatant or whether they were common to both fractions in a more functional sense.

Naturally, a considerable amount of work remains to be done for a complete characterization of the main soluble antigens of the liver cell. However, the results reported here are sufficient to show that the striking differences between the antigens make it possible to analyse the cell fractions by the methods described above. Hence, in combination with common biochemical techniques, these methods should offer a valuable tool for testing the efficacy of a cell-fractionation procedure. Furthermore, they seem particularly well suited for a study of the genetic relationship between different elements of the liver cell. Finally, it should be pointed out that a combination of the immunological techniques with work on the incorporation of isotopes should be particularly suited for an investigation of such problems as protein synthesis *in vitro* in isolated cell fractions. Studies along these lines are in progress.

We are indebted to Dr. T. Hultin for valuable discussions and advice.

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Variations in the Erythrocyte Potassium and Sodium in the Possum, *Trichosurus vulpecula*

The ratio of the concentration of sodium ions to that of potassium ions in erythrocytes has been recorded for numerous animal species. In most cases, the relation between the concentrations of sodium and potassium is of the same order for individuals of any one species[1]. This uniformity between individuals, however, does not exist in sheep. Evans[2] has summarized the previous work on sheep, and his own results show three distinct types of sheep, according to the concentrations of potassium and sodium in the erythrocytes, in the various breeds he examined. Evans and King[3] had already shown that variations in concentrations of these ions in sheep erythrocytes were determined by a single-gene substitution.

There has so far been no demonstration of similar variations in any wild population of animals. The results presented here show marked variations in the erythrocyte concentrations of sodium and potassium between individuals of a marsupial, the brush-tail possum, *Trichosurus vulpecula*.

The animals used were trapped in the suburbs of Perth, Western Australia, and of Adelaide, South Australia. (Samples from Adelaide were kindly sent by Mr. J. Eadie, Department of Zoology, University of Adelaide, South Australia.) Blood was collected by heart puncture into heparinized syringes. The Perth samples were treated as follows: for indirect estimation of ionic concentrations in the erythrocytes from whole blood and for plasma values, a portion of the whole blood was separated soon after collection, the remainder was centrifuged and the plasma decanted immediately; the cells separated by

Table 1. COMPARISON OF DIRECT AND INDIRECT METHODS FOR EVALUATION OF CONCENTRATIONS OF SODIUM AND POTASSIUM IONS IN ERYTHROCYTES FOR TWENTY-SEVEN PERTH POSSUMS

Group	No. of animals	Sodium (m.equiv./l.)			Potassium (m.equiv./l.)		
		Cells		Plasma	Cells		Plasma
		Direct method	Indirect method		Direct method	Indirect method	
High $[K^+]$	7	36·3	36·8	157·2	103·8	101·2	5·9
Low $[K^+]$	20	129·6	124·7*	160·7	10·3	10·9*	5·7

* Mean value for sixteen animals only.

centrifugation were prepared for direct estimation of the concentrations of sodium and potassium ions by three washes with isotonic glucose and then resuspended in isotonic glucose for hæmatocrit estimation. Cell samples sent from Adelaide were prepared by two washes with isotonic sucrose after preliminary separation of plasma, followed by 1 : 1 dilution of cells with distilled water. Hæmatocrit estimations were made in duplicate or triplicate using metal-sheathed micro-tubes spun at 3,000 r.p.m. for 30 min. ; concentrations of sodium and potassium ions were determined with an EEL flame photometer.

The concentrations of sodium and potassium ions in the erythrocytes of 42 possums (27 from Perth, 15 from Adelaide) determined by the direct method are plotted in Fig. 1. There is a clear-cut division of the animals into two groups, one with a high concentration of potassium and a low concentration of sodium in the erythrocytes (21 animals) and the other with a low concentration of potassium and a high concentration of sodium in the erythrocytes (21 animals). Some of the Western Australian possums were sampled repeatedly over periods up to three months. The variations between samples from the same animal were small compared with differences between the two groups. The mean sum of the concentrations of the two ions for individuals is approximately 30 m.equiv./l. lower in the Adelaide sample than in the Perth sample. This can probably be accounted for by differences in the preparation of the cell samples from the two areas.

Table 1 records the mean concentrations of sodium and potassium ions for the two groups of the Perth sample, determined by the direct and indirect methods, which give results in close agreement.

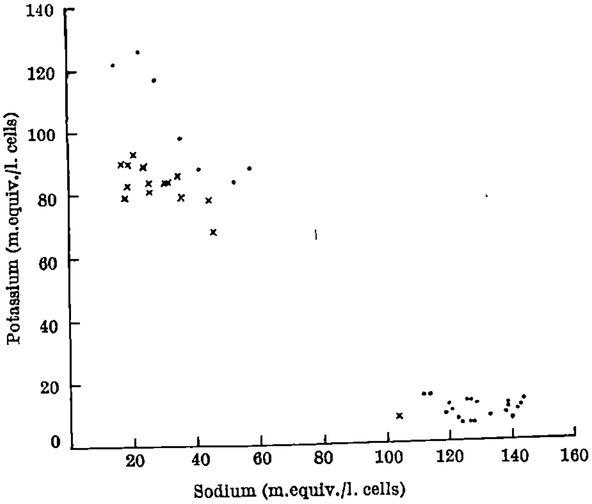

Fig. 1. Erythrocyte concentrations of sodium and potassium ions for 27 Perth possums (●) and 15 Adelaide possums (×), each point representing one animal

The animals from Perth and Adelaide constitute samples of two geographically isolated populations. The ratio of animals exhibiting a high concentration of potassium to animals exhibiting a low concentration of potassium is quite different in the samples from the two areas, being roughly 1 : 3 in the Perth sample and 14 : 1 in the Adelaide sample. The frequency of the different types of sheep varies with breed and geographical distribution[2], and it will be of interest to see what frequencies of cell types occur in possum populations in areas of Australia not so far sampled.

The two cell types reported here for the possum correspond most closely to the Evans α- and γ-types in sheep. Breeding experiments are in progress to determine whether genetic differences are responsible for the different types of erythrocyte in the possum.

The possibility of there being different types of hæmoglobin in the possum, as in the sheep[4], was suggested by Mr. R. L. Kirk (Department of Zoology, University of Western Australia), who has so far tested samples from fourteen of the Perth possums. No differences in type of hæmoglobin have been observed in this preliminary investigation.

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Reproduction of Fused Larvæ in the Boring Sponge, *Cliona celata* Grant

LARVÆ of the sponge *Lissodendoryx carolinensis* fuse with each other if brought together in culture dishes, and some of the compound larvæ metamorphose[1]. Nevertheless, one would rarely expect such an event in Nature, as most sponge larvæ are released a few at a time, and disperse rapidly. In *Cliona celata*, however, I have observed successful reproduction by fused larvæ in a much more natural environment than a culture dish.

Throughout the summer of 1955, I kept several oyster shells containing boring sponges in an asphalt-lined wooden aquarium through which seawater constantly flowed. The water was pumped from the bottom of the Bideford River, Prince Edward Island, an estuary in which *Cliona* was growing, and did not change appreciably in temperature or lose suspended matter during its passage to the aquarium. *Microciona prolifera*, a sponge much more sensitive to stale water than *Cliona*, lived indefinitely and reproduced freely in a similar tank.

Under these conditions, *C. celata* (which is oviparous) may discharge tens of thousands of eggs from a large osculum in a few hours. The eggs are sticky, and adhere to each other and to the substratum in an irregular flattened mass. Diatoms, the shells of larval molluscs, silt and other debris rapidly accumulate on and in the mass, so that on hatching many of the larvæ are temporarily trapped, able to wander among the interstices of the egg mass but delayed in their escape to open water. In their wanderings, the larvæ sometimes come together in twos or threes and fuse. Fusion is without apparent regard for polarity, so the swimming movements of compound larvæ are often merely ineffective gyrations and many perish within the tangle of debris. A few escape, however, since two such compound larvæ metamorphosed successfully into single sponges, with single oscula, and began boring in crystals of calcite placed near an egg mass.

It seems quite possible, then, that *Cliona* larvæ occasionally metamorphose after fusion, in their normal environment. The natural occurrence of larval fusion, previously dismissed as a purely experimental phenomenon, emphasizes its interest to students of individuation and related problems of theoretical morphology.

This observation is part of a study of *Cliona* conducted at the Fisheries Research Board of Canada's Biological Sub-Station at Ellerslie, Prince Edward Island, which will be more completely reported elsewhere. I thank other members of the Sub-Station staff for their help.

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Pressure developed within the Reticular Compartment of the Ruminant Stomach

In order to investigate the mechanical aspects of digestion in the ruminant stomach, pressure variations occurring within the reticulo-rumen have been measured on many occasions[1–3], using balloons connected to liquid-filled manometers or to recording tambours. Wester[1] reported that the intra-ruminal pressure in the cow showed phasic fluctuations of 2·5 cm. mercury, while Quin, Van der Wath and Myburgh[2] recorded a maximal rise of 10·0 cm. water in the sheep; in both instances the basal intra-ruminal pressure was close to atmospheric pressure. Balch, Kelly and Heim[3], using a balloon connected to a writing tambour, recorded pressure-changes from within the reticulum of the cow and showed a basic level of 2·5–3·5 cm. mercury above atmospheric pressure rising by 1–2 cm. mercury with contraction of the reticulum. It is probable that in the latter case the higher resting pressure is due to the hydrostatic effect of the liquid contents of the reticulum.

Brody and Quigley[4] have examined the balloon–water manometer technique for measuring intra-lumen pressure in the digestive tract and have demonstrated that inflated balloons and water manometers produce a number of artefacts in the pressure records which become unreliable and inaccurate. Such criticisms could be applied with even greater force to recordings made in this way from the very capacious reticulo-rumen where differential contraction and relaxation of the various subsidiary sacs occurs[5]. Brody and Quigley advocate the use of open-ended small-bore tubes connected to electromanometers as the technique of choice for the accurate measurement of pressure within the gut.

This method has been used for measuring the pressure within the reticulum of the goat using a 'Polythene' tube (2·0 mm. int. diam.) passed into the œsophagus intra-nasally. Pressure variations were registered by means of a Hansen capacitance manometer and d.c. amplifier and displayed by means of an Ediswan pen oscillograph. It was easy to make pressure records while the tube was being manipulated within the alimentary tract, so that entry of the tube into the antrum of the reticulum was indicated precisely by the replacement of the rapid respiratory pressure changes with the slow pressure variations of the reticulo-ruminal contraction cycle.

Pressure records made in this way show the well-known contraction of the reticulum occurring regularly at 43–52 sec. intervals, the pressure rising from near atmospheric level to 50 cm. water or more in 2–3 sec. and falling rapidly in 1–2 sec. to the resting level. Pressures up to 65 cm. water have been recorded, but 50 cm. water was the more common value of intra-reticular pressure recorded from eight goats on numerous occasions. Electromanometer pressure records from the antrum of the reticulum do not show the biphasic peak which is a feature of recordings when balloon–water manometer systems are used deep in the reticulum. Smaller and irregular pressure waves of up to 20 cm. water were also recorded from the reticulum near the cardia, and since these pressures accord with those obtained when the tube is pushed farther posteriorly it is likely that they are produced by contraction of the rumen musculature.

The figure of 50 cm. water reported here, although more than double the value recorded from the reticulum by balloon systems inserted through a rumen fistula, can be regarded as authentic, the disparity being due to the physical characteristics of the recording systems. This new result agrees very well with the pressures evoked in the reticulum following electrical stimulation of that region of the medulla oblongata which exerts control of the reticulum and rumen[6]. Pressures of this order have also been recorded by means of electromanometers from the reticulum of cattle during experimental studies of eructation phenomena[7].

It is possible that the rapid development of high pressure within the reticulum close to the cardia plays a part in the forward propulsion of ingesta during the regurgitative phase of rumination. As yet it has not been possible to measure the pressure in the reticular antrum during rumination as the presence of the tube in the œsophagus appears to inhibit the process.

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Distribution of Radioiodinated, Acetone-killed *Brucella abortus* in the Tissues of Normal and Immune Mice

THE distribution of radioactively labelled antigens in animal tissues has been studied extensively. Most of the work has been done in normal animals, using simple antigens. Few direct comparisons have been made of the distribution of labelled antigens in normal and immune animals, and no work seems to have been done along these lines with a killed bacterial antigen.

Table 1. RADIOACTIVITY IN SELECTED MOUSE ORGANS (PER CENT OF RADIOACTIVITY INJECTED)

Time after administration of radioactive bacteria \ Immunizing dose (mgm.)	Liver			Spleen			Peritoneal membrane			Mesenteric lymph glands		
	None	0·07	0·5	None	0·07	0·5	None	0·07	0·5	None	0·07	0·5
6 hr.	13·5	12·0	7·2	4·2	1·2	0·5	3·2	4·8	8·0	1·7	3·8	5·0
1 day	12·0	3·2	7·6	4·3	0·7	0·7	1·5	3·0	3·5	1·3	6·2	2·0
3 days	6·2	4·1	2·7	2·5	0·6	0·4	1·0	0·9	1·3	1·6	3·2	3·1
6 days	3·2	0·7	1·5	1·6	0·15	0·2	1·5	1·2	0·4	0·4	2·6	1·1

Acetone-killed *Brucella abortus* 2308 was used in the present study, both as immunizing and as test antigen to be followed in the tissues. Mice were immunized by a single subcutaneous injection of 0·07 or 0·5 mgm. bacteria. Two weeks later they were 'challenged' intra-abdominally with 0·4 mgm. radioiodinated *Brucellae* of the same strain. The iodination was carried out with approximately 80 μc. iodine-131, following the technique of McFarlane[1] slightly modified for the present purpose. The material injected had a specific activity of 300,000 c.p.m./mgm. dry weight bacteria, as measured in a 'Tracerlab' well-type scintillation counter. More than 98 per cent of the activity was bound to the bacteria. Six mice of each group were placed in metabolism cages. Three were killed at 6 hr. and three at 24 hr. after 'challenge'. Other groups of three mice were killed at 3 and 6 days after administration of labelled *Brucellae*. A thorough search was made for the injected radioactivity in the internal organs of the mice. The main findings are summarized in Table 1, which shows striking differences between the normal and the immune groups. While the livers and spleens of the normal animals had a higher radioactivity than the corresponding organs of the immune animals, the reverse was true for the peritoneal membrane and the mesenteric lymph glands. Moreover, in several instances, especially at 6 hr. after injection, a direct relationship could be observed between the radioactivity in the organ and the immunizing dose. Thus, at 6 hr., the stronger the immunizing dose the smaller the radioactivity in the spleen and liver and the larger that in the peritoneal membrane and mesenteric lymph glands. This regularity of response suggests that it might be possible to use the present technique in the assay of the potency of vaccines. The similar behaviour of the spleen in experiments with living *Brucellae*[2] strengthens this assumption.

An interesting finding was the rapid excretion of the radioactivity from the body. 35–40 per cent of the injected iodine-131 was excreted during the first 6 hr. Since the radioactivity found in the urine was apparently attached to low-molecular compounds, as determined by dialysis, precipitation of the activity with silver nitrate and lack of precipitation with *Brucella* antiserum, it must be concluded that the excretion was due to a rapid breakdown of the antigen. High excretion-rates of the label have been found by several other workers[3-5].

It appears, therefore, that the animal can use two completely different mechanisms for the destruction of foreign antigenic material, one acting rapidly during the first few hours after injection, the other acting more slowly, after the antigen has been deposited in the organs, presumably through the intervention of the antibody.

Full details of this work will be published.

I am indebted to Mr. G. Rasooly for technical assistance.

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Fibrinolysis Autographs

Permin and Astrup used a plate method of demonstrating fibrinolytic activity[1,2]. This technique can be applied histologically. A thin layer of fibrin is

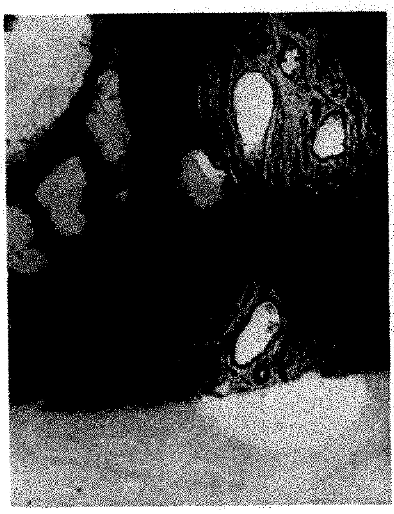

Fig. 1. Section of human prostate showing lysis of fibrin in relation to veins (stained with hæmalum and eosin). × *c.* 47

made on a microslide by adding a drop or two of fibrinogen to a film of thrombin on the glass. When the fibrin layer has formed, a section of fresh or alcohol-fixed tissue cut on the freezing microtome is applied to its surface and the preparation incubated at 37° C. After 30–60 min. patches of digestion of the fibrin appear in relation to structures possessing fibrinolytic activity. These patches appear as clear zones when the preparations are stained with hæmalum and eosin (Fig. 1), and can be related to the structures in the section.

Of the human tissues so far examined (including thyroid, lung, uterus, ovary, prostate, adrenal, kidney, liver, heart muscle and spleen), all, with the exception of liver, show scattered foci of fibrinolytic activity. These are consistently related to veins or venous sinusoids and, to a lesser extent, arteries, except in the lung, when they are predominantly related to pulmonary arteries.

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Prolongation of the Life of *Drosophila subobscura* by a Brief Exposure of Adults to a High Temperature

THE life-span of *Drosophila subobscura* at 20° C. (the temperature at which this species is normally kept in the laboratory) can be increased by exposing adults to a high temperature soon after their emergence from the pupa. But first the results of keeping adults continuously at the same temperature will be described.

It has long been known that the life-span of *Drosophila*, and of poikilotherms generally, decreases with increasing temperature[1,2]. For the F_1 hybrids between the *K* and *NFS* inbred lines of *D. subobscura* the results obtained, for flies kept as mated pairs, and transferred to fresh food at regular intervals, are given in Table 1.

Table 1

Temperature (° C.)	Mean adult life-span (days) Males	Females
20	67·4	55·9
25	27·0	35·5
30·5	7·6	17·6

At temperatures above 31° C. the expectation of life falls very rapidly to less than 24 hr. at 33° C. There are reasons for thinking that the changes which occur in individuals at temperatures above 31° C. are different in kind from those occurring below 31° C. Thus if flies are exposed to 33° C. for 8-hr. periods, with intervening periods of 16 hr. at 20° C., their total survival-time at 33° C. is much greater than that of flies kept continuously at 33° C. In this sense the changes occurring at 33° C. are 'reversible', as are the changes which occur at still higher temperatures[3]. In contrast, changes occurring at 30·5° C. are irreversible, in that the total survival-time at this temperature is not increased by an intervening period of 8 days at 20° C.

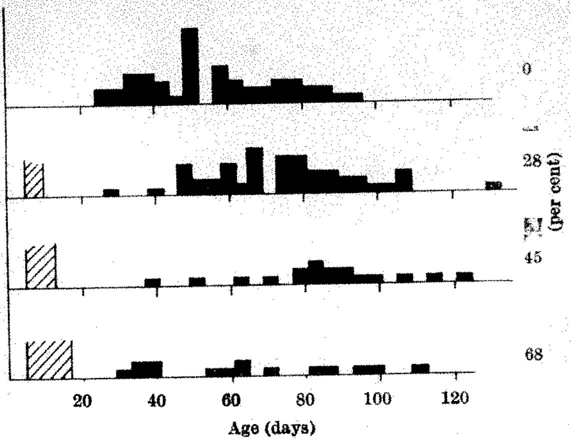

Fig. 1. Ages at death of female *D. subobscura* kept at 20° C., but exposed soon after emergence to 30·5° C. for 0 per cent, 28 per cent, 45 per cent and 68 per cent of their expectation of life at that temperature. Periods spent at 30·5° C. are indicated by hatching

Turning to the evidence for a prolongation of life by exposure to high temperatures, Fig. 1 shows the results of exposing adult females soon after emergence to 30·5° C. for 5–12 days (that is, 28–68 per cent of their expectation of life at that temperature) and then returning them to 20° C. Females so exposed lived for up to 50 per cent longer than did females kept continuously at 20° C.

Two conclusions follow. First, the life-span at 20° C. can be increased by exposing adults to 30·5° C. soon after emergence. It seems likely that one effect of this exposure is permanently to reduce the rates of metabolic processes at 20° C. This is suggested by the fact that the rate of egg-laying is much higher in females kept continuously at 20° C. than in females previously exposed for 5 days to 30·5° C.

The second conclusion is that at least two separate processes of senescence can occur in *Drosophila*. By senescence is here meant those changes occurring in an individual which render that individual more likely to die as it gets older; in other words, senescence is measured by the increase in the force of mortality with age. Now there are some environments in which the force of mortality increases with time, but in which the causes of death have little to do with senescence; for example, animals kept without food would in time die, but this would not be regarded as senescence because it is known that if, after a shorter period of starvation, the animals had been fed, they would have recovered completely. For the same kind of reason the reversible changes in flies kept at 33° C. are not regarded as senescence. But it does seem reasonable to regard as senescence the changes which ultimately kill flies kept continuously at 30·5° C., since they are not reversed in individuals returned for a time to 20° C. Now these senescent changes occurring at 30·5° C. (which may or may not be the same as the changes, also occurring at 30·5° C., which increase the subsequent life-span at 20° C.) cannot be the same as the senescent changes at 20° C., since if they were the same they would be expected to reduce rather than to increase the expectation of life at the latter temperature.

It follows that different processes of senescence occur at 20° C. and at 30·5° C. If so, it does not augur well for attempts to find a single fundamental cause of ageing in this species ; by analogy, there may well be a number of different and partly independent processes of ageing in mammalian species, although in a homiotherm these processes would not be so easily separable.

A full account of this work is in preparation. The investigation was assisted by a grant from the Nuffield Foundation.

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Growth and Titration of Louping-ill Virus in Monolayer Tissue Culture of Pig Kidney

Rivers and Ward[1] reported the propagation of louping-ill virus in a Maitland-type culture of chick embryo tissue. More recently, Oker-Blom[2] has described a cytopathogenicity in HeLa cell culture induced by louping-ill which permitted titration of the virus. I have found a specific cytopathogenic effect by the same viral agent in monolayer culture of pig kidney.

The louping-ill virus was a strain isolated and maintained at the Moredun Institute and is used here as infected mouse brain. Virus dilutions were prepared in physiological saline (0·85 per cent sodium chloride) incorporating 10 per cent normal sheep serum, and titrations were carried out intracranially in four 3–5 week old white mice per dilution. Mice were observed for fifteen days following inoculation, and the 50 per cent end-point arrived at by the method of Reed and Muench[3]. The method of culture of pig kidney was that made available by Sellers (personal communication), the trypsin-dispersion of the renal cells having been modified to follow more closely the recommendations of Rappaport[4]. Initial cultures were grown in 'Pyrex' Roux bottles (12 cm. × 20 cm.) by introducing 60 ml. of cell suspension containing 8×10^5 cells per ml. of nutrient medium. The medium comprised Earle's saline, 0·5 per cent lactalbumen hydrolysate (enzymatic) and 0·01 per cent yeast extract ; to this mixture was added 10 per cent normal cattle serum as well as antibiotics. By this method almost confluent monolayers were formed by the sixth day of incubation at 35° C. At this time the cells were subcultured into 'Pyrex' tubes (1·6 cm. × 15·0 cm.) containing cover-glasses (0·63 cm. × 2·22 cm.) by introducing into each 0·5 ml. of cell suspension containing 8×10^5 cells per ml. of medium. Cultures were ready for inoculation by the second or third day of incubation, when continuous monolayers were formed. Further incubation was carried out in roller drums.

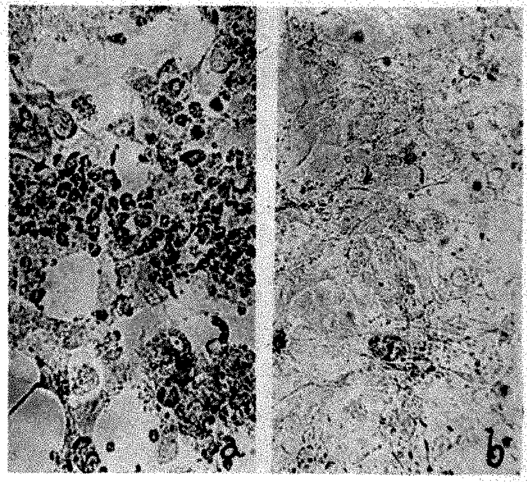

Fig. 1. (*a*) Cytopathogenicity produced in pig kidney monolayer tissue culture by approximately 300 *CPD*50 doses of louping-ill mouse brain virus in the presence of an equal volume of normal sheep serum diluted 1 in 100. (*b*) Normal pig kidney monolayer 'protected' from the same amount of virus by an equal volume of louping-ill hyperimmune sheep serum diluted 1 in 100. The source and age of the cells as well as the period of incubation with virus were identical with (*a*). × 110

Virus was passaged serially in culture by transferring pooled undiluted or diluted infected medium from one group of four to six tube-cultures to each of a group of newly prepared ones. Passage virus was harvested on the sixth day of incubation and titrated immediately in mice. By the fifth passage the original virus inoculum titre of 4×10^4 mouse *LD*50 doses per ml. was diluted 10^7 but yielded $3{\cdot}9 \times 10^7$ mouse *LD*50 doses per ml. Clearly, the cultures were supporting multiplication of the virus. Microscopic examination of live cultures inoculated with low dilutions of mouse brain virus revealed a cytopathogenic effect which commenced on the second to third day. The affected cells became granular, rounded up, and appeared to agglutinate (Fig. 1). As the effect increased in severity, there was almost total cell necrosis and destruction of the monolayers. Fixed coverslip preparations of affected cells stained with Giemsa showed shrinking, pyknosis and disintegration. Uninfected cultures and cultures inoculated with comparable dilutions of normal mouse brain remained unchanged.

Titration of virus in culture on the basis of the presence or absence of cytopathogenicity was carried

Table 1. NEUTRALIZATION OF THE CYTOPATHOGENICITY INDUCED BY LOUPING-ILL MOUSE BRAIN VIRUS IN PIG KIDNEY MONOLAYER TISSUE CULTURE BY SPECIFIC HYPERIMMUNE SHEEP SERUM. SIMULTANEOUS NEUTRALIZATION IN MICE INOCULATED INTRACRANIALLY IS ALSO SHOWN

Test system	Inoculum (ml.)	Quantity of virus	Sheep serum log dilution											
			Normal						Louping-ill hyperimmune					
			Undil.	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	Undil.	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}
Culture	0·1	300 *CPD*50	5/5*	5/5	5/5	5/5	5/5	5/5	0/5	0/5	0/5	0/5	5/5	5/5
Mice	0·05	300 *LD*50	4/4†	3/3	4/4	4/4	4/4	4/4	0/4	1/3	0/4	1/3	4/4	4/4

* Numerator: No. of tube-cultures showing cytopathogenic effect up to the sixth day after inoculation of serum–virus mixture. Denominator: No. of tube-cultures inoculated with serum–virus mixture.

† Numerator: No. of mice killed showing typical symptoms of louping-ill up to the fifteenth day after inoculation of serum–virus mixture. Denominator: No. of mice inoculated with serum–virus mixture.

out by adding tenfold dilutions of mouse brain virus to groups of five tube-cultures. Results were read on the sixth day of incubation under low-power magnification and the 50 per cent end-point calculated as in mice. Mice were inoculated simultaneously with the identical virus dilutions. One cytopathogenic (50 per cent) dose (*CPD*50) was determined to be equivalent to 400–600 mouse *LD*50 doses.

Neutralization of the cytopathogenic effect in culture was carried out both by serum and virus dilution techniques. The results of a test in which tenfold dilutions of sera were tested against approximately 300 *CPD*50 doses and 300 mouse *LD*50 doses of mouse brain virus in cultures and mice respectively are shown in Table 1. Serum–virus mixtures were incubated for 2 hr. at room temperature (22° C.) followed by $\frac{1}{2}$–1 hr. at 4° C. prior to inoculation into the test systems; results were read as before. The marked inhibition of cytopathogenicity by louping-ill hyperimmune sheep serum was regarded as proof of the specificity of the reaction.

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Treatment of Hops with Dimefox

DIMEFOX, a systemic insecticide, is extensively used in commercial practice for the control of the hop aphis (*Phorodon humuli*) and the hop red spider (*Tetranychus urticae*). Because of toxic hazards it is not used as a spray or dust but is applied via the soil at the rate of approximately 0·5 gm. active ingredient in 120 ml. water per plant or hill. A single application is normally made each season in May or June.

The plants involved in this investigation were grown at Wye at a spacing of 6 ft. 6 in. (2 m.) square on wirework 14 ft. 6 in. (4·4 m.) high. Dimefox was applied to all plants at 0·5 gm. per hill on May 31; a second application at 0·25 gm. per hill was made to some of the plants on July 19. Samples of leaves were collected at different heights at intervals throughout the season up to the time of harvesting, and were analysed in the Department of the Government Chemist. Samples of ripening cones and dried hops were also examined.

It was found that the progress of the insecticide from the soil to the plant could be followed by means of the analytical figures. The rate of travel in the plant itself could be measured by examining leaves from different levels.

The method of analysis used throughout this work was that of Field and Laws[1]. The samples, when picked, were packed in air-tight 'Polythene' bags and were examined immediately on arrival at the laboratory. The results are expressed as p.p.m. on the samples as received, no attempt being made to correct for moisture content.

Table 1. DIMEFOX CONTENT OF LEAF SAMPLES FROM TREATED HOP PLANTS

Days from treatment	Height of leaves above ground-level		P.p.m. dimefox	
	Bottom sample	Top sample	Bottom sample	Top sample
Control	2 ft.	—	0·1	—
4	3 ft.	—	3·5	—
11	3 ft.	7 ft.	2·2	1·2
18	3 ft.	8 ft.–8 ft. 6 in.	2·5	3·2
32	4 ft. 6 in.	11 ft.	1·6	0·9
39	4 ft. 6 in.	11 ft.	1·9	1·0
47	4 ft. 6 in.	12 ft. 6 in.	0·9	1·0
53 (3)	4 ft. 6 in.	12 ft.	0·8 (2·9)	0·6 (2·0)
58 (8)	4 ft. 6 in.	12 ft.	1·0 (1·4)	1·1 (6·0)
72 (22)	4 ft. 6 in.	12 ft.	0·1 (0·2)	0·3 (0·4)

Treatments: 0·5 gm. dimefox per hill on May 31, 1937, to all plants; a further 0·25 gm. dimefox per hill on July 19, 1957, to some plants. Data for plants given a second treatment in brackets. 50-gm. sample examined in each case

The results of the leaf analyses are given in Table 1. In each case a representative 50-gm. sample was examined. When dried cones were examined, only 10 gm. was taken.

The figures show that dimefox is rapidly taken up and transmitted to the whole plant until a steady state is reached lasting for several weeks. Increase in the amount of dimefox in the soil brought about by the second application on July 19 showed up about a week later in the upper part of the plant.

Analysis of the ripening cones showed that in the plants which had received only the single application on May 31, 94 days before sampling, the level of dimefox concentration was 0·1 p.p.m. In those plants which had also received the second application on July 19, 44 days before sampling, the level was 0·3 p.p.m.

Harvesting took place in September, 108 and 60 days respectively after the first and second applications. Analysis of samples dried in the commercial manner to about 10 per cent water content showed the level of dimefox to be 0·13 p.p.m. in hop cones from plants which had received the first application only. In the dried cones from plants that received both applications, the concentration of dimefox was 0·33 p.p.m. These values correspond to 0·03 p.p.m. and 0·07 p.p.m. respectively in terms of fresh green material. Such residues would appear to be too low to constitute a health risk.

The results demonstrate the uptake and distribution of dimefox in hops. Many more experiments under different conditions will be necessary before the behaviour of this insecticide is fully understood. It is not at present known whether the dimefox undergoes chemical break-down in the plant or whether it evaporates with the moisture from the leaves. These investigations show that it does not remain as dimefox in the plant tissue.

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Reduction of Parathion induced by Light

While investigating the decomposition of parathion (O,O-diethyl-O-*p*-nitrophenylphosphorothionate) I was able to confirm the findings of Ketelaar[1] on the specific action of Cu^{2+}-ions in catalysing the hydrolysis leading to *p*-nitrophenol. Other metal ions are ineffective, and the catalytic action of copper can be suppressed by various chelating agents[2]. The experiments were carried out at room temperature in a barbiturate milieu at *p*H 8·0 and lasted for more than four weeks. Change in concentration of parathion with a modified polarographic method was followed, and this permitted the estimation of parathion and simultaneously of the *p*-nitrophenol formed. In certain instances however, in solutions not containing the catalyst, a significant decrease of the polarographic wave of parathion was observed though the corresponding appearance of *p*-nitrophenol was not detected. Although in publications dealing with the degradation of parathion[4] there is no allusion to the possibility of a spontaneous reduction, I have shown it to be induced by light.

A 2×10^{-3} *M* solution of parathion (prepared from 20 per cent parathion 'Paridol', Chemisch-Technische Werke A.G. Muttenz-Basel—a material not containing appreciable amounts of degradation products) in 5×10^{-2} *M* *p*H 8·0 barbiturate buffer was divided into several portions and some of them were exposed to direct sunlight. The irradiation was carried out in thin-walled Jena test-tubes. The temperature was controlled continuously and the portions kept in the dark were thermostated according to the temperature of the irradiated specimens. At intervals, samples were taken and analysed by: (*a*) polarography, which gives the amount of non-degraded parathion and any *p*-nitrophenol present; (*b*) the method of Averell–Norris[5], which gives estimates of the intact and reduced parathion; (*c*) the method of Averell–Norris, which was modified for this purpose, omitting the reduction step, thus giving values of the reduced parathion only.

Table 1. Degradation of Parathion Solutions kept in the Dark and exposed to Sunlight

Solution tested	Age of solution	Polarographically		Averell–Norris	
		Parathion	*p*-Nitrophenol	Reduced parathion	Parathion +reduced parathion
		Molarity × 10^4			
'Paridol' alone	2½ hr.				
Dark		20	traces	nil	19
Light		16	traces	5	21
Dark	5½ hr.	20	traces	nil	20
Light		14	traces	7	20
'Paridol'+ copper	2½ hr.				
Dark		13·5	6	nil	14
Light		11	7	1·5	14
Dark	5½ hr.	6·5	12·5	nil	7·5
Light		3	13·5	1·9	6
'Paridol'+ copper+ EDTA	2½ hr.				
Dark		20	traces	nil	23
Light		16	traces	5	21
Dark	5½ hr.	20	traces	nil	24
Light		14	traces	8	22

The solutions contained 0·002 *M* parathion in a 0·05 *M*, *p*H 8·0 barbiturate buffer. Copper ions were applied at a 10^{-4} mol. and ethylenediamine tetraacetate at a 10^{-3} mol. concentration. The results are representative ones, and were obtained on a hot July day in 1957 in Budapest, the temperature of the solutions being 35–45° C.

In parallel experiments I investigated the effect of Cu^{2+}-ions alone and in presence of ethylenediamine tetraacetate. The copper ions, as expected, catalysed the hydrolytic degradation of parathion to *p*-nitrophenol, competing with the light-induced reduction. The chelating agent inhibited the catalytic action.

The results, of which a representative series is given in Table 1, clearly show the photochemical reduction of parathion, presumably to the corresponding *p*-amino-compound. Similar results were obtained by irradiation with a mercury discharge lamp. It is planned to conduct further experiments in order to investigate the effect of *p*H, various other metals and chelating agents, and the behaviour of spray residues under field conditions.

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Gibberellin and the Growth of Plant Tissue Cultures

Two recent publications report the effects of gibberellic acid on the growth of excised plant tissues. Netien[1], working with isolates from the tuber parenchyma of *Helianthus tuberosus*, found a slight increase in growth at 1 p.p.m. in the absence of indolylacetic acid and a decrease at higher levels. In the presence of the auxin all levels of gibberellic acid were quite inhibitory. Schroeder and Spector[2] used explants from the mesocarp of mature citron (*Citrus medica*). They found gibberellic acid, in the absence of indolylacetic acid, caused an increase in weight at 5 p.p.m. In the presence of indolylacetic acid all levels tested resulted in increases in weight.

This report is concerned with the effect of gibberellins on the growth of plant tissues *in vitro* using well-established, actively proliferating clones. The present results are part of a larger report now being prepared. The tissues discussed here were selected to show that an increase in growth, no effect, or a decrease in growth can be obtained under the same conditions by changing the test material.

All the tissues listed in Table 1 have been in culture in this laboratory for the past seven years. The basal synthetic medium used for all tissues consists simply of mineral salts, sucrose, three vitamins, trace elements, and agar[3]. Gibberellin stock solutions were made up at ten times the desired concentration, sterile-filtered through sintered glass, and added to give the desired level to previously autoclaved basal medium just prior to solidification. Experimental transfers of equal size were made to the solid medium and initial weights recorded. After four and eight weeks growth in an air-conditioned culture room at 22·5° C., the tissues were weighed. The results are expressed in Table 1 as 'growth value', which is a number obtained by dividing the final wet weight by the original wet weight. All values are the average of two experiments with five replicates in each experiment.

Table 1. Effect of Gibberellin on Growth of Plant Tissue Cultures on Synthetic Medium

Plant source	Part	Type of tissue	Growth value			
			4 weeks		8 weeks	
			Control	Gibberellin (10 p.p.m.)	Control	Gibberellin (10 p.p.m.)
Helianthus annuus	Petiole	Crown gall	12·8	4·4	49·1	11·0
Vinca rosea	Stem	Crown gall	6·3	2·0	35·4	4·3
Nicotiana tabacum	Stem	Crown gall	3·4	3·8	13·5	15·8
Melilotus officinalis	Stem	Crown gall	2·6	2·9	8·9	14·3
Melilotus officinalis	Root	Callus	2·2	3·1	7·0	15·8

These results are only indicative of the results using 10 p.p.m. of gibberellin. Even at this one level, however, it is apparent that no generalizations can be made concerning the effects on plant tissues *in vitro* since both stimulation and inhibition result according to the test material.

A broader account is now being prepared which takes into consideration such problems as the effects of different levels of the gibberellins, the effects of varying the medium and the importance of the type of tissue used as well as its source.

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Effect of Gibberellic Acid on the Growth of Pea Seedlings when imbibed through the Seed Coat

Stowe and Yamaki[1], in a recent review paper, have listed two hundred and two references relating to the isolation and effects of the gibberellins upon various physiological processes in plants.

Work with these plant-growth substances has, however, been primarily concerned with their effects upon plant growth and development subsequent to germination. It is the purpose of this brief communication to demonstrate that gibberellic acid may produce a typical response when imbibed through the seed coat of the dwarf Telephone pea prior to germination.

Approximately fifty dwarf Telephone pea seeds were planted in each of two small wooden flats filled with sterile vermiculite. The flats were placed over porcelainized germination pans so that added solutions could be retrieved after dripping through the vermiculite. Directly after planting, the vermiculite in one flat was saturated with a solution of 1·0 mgm./l. gibberellic acid. The second flat was supplied with distilled water. The solutions caught in the germination pans were poured back over the respective flats daily until utilized or lost. Plants were grown in the greenhouse under long-day (16 hr.) conditions.

Eleven days after planting, treated and control seeds had germinated and were well above the level of the vermiculite. Treated dwarf pea seedlings were, at this time, approximately six times as tall as the control seedlings. The percentage of germination in both flats was comparable.

Seventeen days after treatment the plants in both flats were harvested. The heights of treated seedlings were significantly greater than the heights of control seedlings. The axillary buds, as well as the main axes of the stems, exhibited markedly increased elongation in treated plants. The stems of the treated seedlings were markedly thin as compared with the controls.

Subsequent experiments have revealed that the response to gibberellic acid described above may also be obtained by allowing dwarf pea seeds to imbibe gibberellic acid solution prior to planting.

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Genetic Effects of Carbon Monoxide, Cyanide and Azide on *Drosophila*

The study of chemical mutagenesis has directed attention to the possibility that the so-called spontaneous gene mutations may in fact result from the accumulation of mutagenic substances arising as a consequence of normal metabolism. In bacteria, the spontaneous mutation-rate of dividing cells may be 40 times greater than that of non-dividing cells[1]. On the other hand, there does not seem to be any simple relation between mutation and cell division itself[2]. This may be interpreted to mean that, as a result of metabolic activity associated with synthesis and growth, chemical mutagens arise and may eventually react with the genetic material. The discovery of 'anti-mutagens'[3] would appear to support this hypothesis. An anti-mutagen might directly mop up traces of the mutagen, or it might initiate further biochemical reactions serving to divert the mutagen into alternative channels.

D'Amato and Hoffman-Ostenhof[4] have recently reviewed the possibility that spontaneous mutation in plants may result from the accumulation of mutagenic by-products of metabolism. The genetic effects of respiratory inhibitors are clearly relevant to the problem. Although some inhibitors might prove to be mutagens in their own right, capable of reacting more or less directly with the genetic material, others might operate simply by disturbing normal metabolic activity in such a manner that an excessive production of natural mutagens results, enabling a greater number of 'spontaneous' mutations to be recorded. Cytogenetic analysis of such mutations would give a picture essentially the same as that obtained from the analysis of spontaneous mutations obtained from untreated material. We should also keep in mind the possibility that any genetic effects of respiratory inhibitors might stem from interference with recovery processes. Wolf and Luippold[5] have found an association between oxidative metabolism and the restitution of radiation-induced breaks in root tip cells of *Vicia*.

Conger and Fairchild[6] reported some years ago that even the simple metabolic experiment of increasing oxygen tension can induce chromosome breaks in *Tradescantia*, suggesting that the oxygen normally present in the air may be responsible for the low spontaneous frequency of aberrations. If the normal rate of oxygen metabolism is exceeded, more genetic damage results.

Inhibitors known to block heavy-metal respiratory enzyme systems have been shown in some cases either to be mutagenic or to be capable of modifying the effectiveness of irradiation treatments[7–13]. In *Drosophila*, injection of cyanide or azide solutions into adult males does not prove to be mutagenic[14]. Nor is carbon monoxide mutagenic when used alone. However, it seemed possible that combined treatment with two inhibitors might prove effective where single treatments had given negative results.

Genetic effects were scored as sex-linked recessive lethals obtained by the usual Muller-5 technique, using Canton *S* males as test material. The incidence of such lethals in untreated males of this stock is about 0·1 per cent for sperm produced within the first few days.

Successive broods were obtained by transferring each male to three fresh females every third day. Both the azide and cyanide were used as 0·005 *M* solutions in 0·7 per cent sodium chloride. In the case of the cyanide, the *p*H was adjusted to 7·0 just prior to injection. The carbon monoxide treatment consisted of exposure of the flies immediately after injection to a gas mixture of 95 per cent carbon monoxide with 5 per cent oxygen at 18° C. for 6 hr. Carbon monoxide alone is not mutagenic under the conditions of testing. However, when supplemented by simultaneous treatment with either cyanide or azide, a mutagenic effect is obtained (Table 1). On the other hand, in the absence of carbon monoxide, cyanide and azide are themselves not mutagenic[14], although together they may elicit a weak response (Table 1).

Table 1. SEX-LINKED RECESSIVE LETHALS OBTAINED FROM CANTON *S* MALES

Brood	Carbon monoxide	Azide–carbon monoxide	Potassium cyanide–carbon monoxide	Azide–potassium cyanide
	(per cent)	(per cent)	(per cent)	(per cent)
1	1/545 (0·18)	6/436 (1·38)	3/319 (0·94)	0/374
2	1/496 (0·20)	4/573 (0·70)	2/377 (0·53)	2/449 (0·44)
3	0/407	3/355 (0·84)	1/281 (0·35)	1/412 (0·24)
4	0/284	1/419 (0·24)	1/312 (0·32)	1/390 (0·26)
5	0/178	0/242	0/195	0/211

Combined treatment with carbon monoxide and either cyanide or azide is also mutagenic to spermatozoa stored within the spermathecæ of inseminated females, although in this case the yield of offspring is small owing to the small number of eggs laid by *Drosophila* females after exposure to the gas.

Theories of peroxide formation have been prominent in much of the current work on chemical mutagenesis and a peroxide theory might appear to provide the simplest explanation for the effectiveness of carbon monoxide when supplemented by azide injections. The first inhibitor, by blocking the cytochrome pathway, would direct activity into a flavoprotein respiratory pathway with peroxide as a terminal product. The second inhibitor, by blocking the activity of catalase, would facilitate the accumulation of the peroxide beyond the threshold concentration. However, this simple explanation ignores the fact that cyanide and azide alone are not mutagenic in *Drosophila*, although they are inhibitors of both cytochrome oxidase and catalase. In the case of cyanide, it is possible that the inhibition of catalase is only transitory, for the accumulation of peroxide might well serve to oxidize the cyanide to cyanate and thus relieve the inhibition of the enzyme. On the other hand, cyanide is not to be regarded as a cytochrome oxidase inhibitor with the same degree of specificity as carbon monoxide. Nor for that matter is azide. No doubt both these inhibitors have other important biochemical effects. There is evidence that even carbon monoxide itself may, under certain conditions, serve to stimulate respiration[15], and the mutagenic effectiveness of combined treatments with this inhibitor might find an explanation along these lines.

Hydrogen sulphide is also capable of blocking the activity of both cytochrome oxidase and catalase, but it does not seem to be mutagenic in *Drosophila*. We have found that exposure of males or inseminated females to 1 : 1,000 hydrogen sulphide for 15 min. (approximately *LD*50) fails to increase mutation-rate. Combined treatments with cyanide or azide give weak responses which, however, are not statistically significant. The effect of simultaneous treatment with carbon monoxide and hydrogen sulphide has not been tried.

As hydrogen sulphide is extremely toxic to *Drosophila*, it may not be possible to administer a dose that is mutagenically effective without at the same time achieving a killing action on the cells. Certainly, flies which have been treated with this gas show very poor fertility.

The different mutagenic responses obtained from these various treatments emphasize the complexity of the biochemical mechanisms involved. Interpretation in terms of the simultaneous inhibition of heavy-metal respiratory enzymes is undoubtedly an over-simplification. It is hoped that further work along these lines will be directed towards a cytogenetic analysis, enabling a qualitative comparison to be made between spontaneous mutations recovered from untreated material and those recovered from material receiving combined azide–carbon monoxide treatment.

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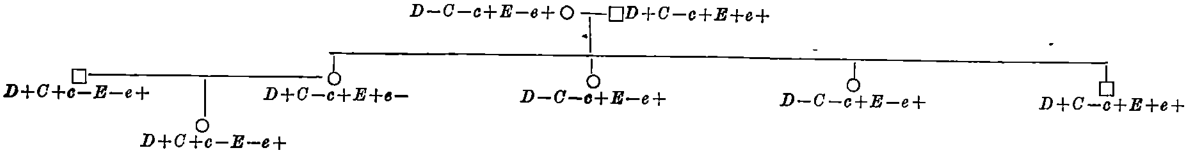
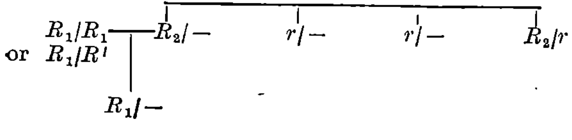
A New 'Deleted' *Rh*-Chromosome

In 1950, Race, Sanger and Selwyn reported[1] a very unusual *Rh* phenotype characterized by an extraordinary strong reaction with anti-D sera and completely negative reaction with anti-C, anti-c, anti-E and anti-e sera. The case was explained as the homozygous form of a partially deleted *Rh* chromosome, designated $D - -$. Since then several examples of this chromosome have been reported, and further other partial deletions have been found[2].

Recently an apparent mother-child exclusion was found in our laboratory. In a legal paternity case the mother was of phenotype $D + C - c + E + e -$, the child of phenotype $D + C + c - E - e +$. The results were checked with a number of different anti-Rh sera both in saline and using papainized cells and the indirect Coombs reaction. The possibility of an error while taking the blood sample was excluded by investigating new samples from the people concerned. The child was born in hospital, but the risk of an interchange of babies in the maternity ward was negligible, as the child was the only premature baby in the ward at that time. However, the ensuing investigation of the family definitely established the kinship of mother and child. The *Rh* types of the family, which were rather surprising, are shown in the following pedigree, + signifying positive and − signifying negative reaction with the corresponding antibodies.



It is seen that there is an apparent exclusion of maternity in the first generation as well as in the second, the *Rh*-negative grandmother having a daughter who appears to be of genotype R_2R_2 or R_2R''. We knew that the irregularity affected the *Cc* as well as the *Ee* loci, but the really unexpected finding was, of course, that the grandmother was *D*-negative. The most simple explanation is a new, partially deleted chromosome involving $d(d - -)$, or a triple deletion ($- - -$). It is of course impossible to ascertain if *d* is present or not, as long as anti-*d* is not available. It is further obvious that one of the criteria on the hitherto known partial *Rh*-deletions, the enhanced agglutinability of the *D*-receptor, cannot be put to use in the diagnosis of $d - -$ or $- - -$. However, it is to be expected that the erythrocytes from persons carrying the abnormal chromosome would show single-dose reactivity with regard to the *Rh* receptors, which according to the phenotype appear to be homozygous. Titration experiments against the pertinent sera appear to substantiate this expectation. According to these experiments the genotypes of the family are the following, − denoting chromosome $d - -$ or $- - -$:



A detailed report on the case and the results will be published later. I wish to thank Dr. A. E. Mourant and Dr. D. Parkin, of the Blood Group Reference Laboratory, Lister Institute, London, who kindly checked the results.

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Mitosis and Chromosome Numbers in the Euglenineae (Flagellata)

Nuclear division and the associated division of the cell and cell organelles have been examined in thirty-two species of the Euglenineae, drawn from thirteen genera. The main findings on the structure and mechanics of mitosis in this group are as follows.

Nuclear division in the Euglenineae is a true mitosis in that:

(1) Individualized chromosomes duplicate themselves longitudinally.

(2) Sister chromatids segregate to opposite poles.

The mitosis differs from the 'classical' form in the following ways:

(1) An achromatic body in the nucleus, the 'endosome', persists throughout mitosis, dividing as a structure distinct from the chromosomes (Fig. 1).

(2) The endosome retains its ribonucleic acid during mitosis.

(3) There are no centromeres or spindle.

(4) Mitosis and cell activity are unaffected by 4 per cent colchicine, or by ionizing radiations at doses of up to 100,000 r.

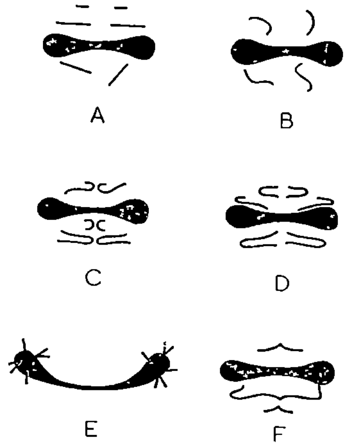

Fig. 1. Chromatid shapes during mitotic anaphase in the Euglenineae. The dividing endosome is also shown

(5) There is no evidence for the presence of centrioles or centrosomes during mitosis. The basal granules of the flagella do not act as division centres.

(6) The chromatin threads become arranged parallel to the division axis at 'metaphase'; in some species the threads are segregating chromatids still associated at one end (Fig. 1, *F*), in others they are chromosomes which become duplicate in their parallel position and segregate in anaphase.

(7) Separation of chromatids is staggered in some species.

(8) There are four main chromatid shapes during anaphase movement: straight rods (Fig. 1, *A*); curving threads (Fig. 1, *B*); U-shapes towards the division equator (Fig. 1, *C*); and U-shapes towards the poles (Fig. 1, *D*). Rods and V-shapes radiating from the ends of the dividing endosome occur in a few species (Fig. 1, *E*).

(9) Anaphase movement of the chromatids is staggered.

(10) The nuclear membrane persists throughout mitosis.

(11) The mitosis lasts 2–4 hr., anaphase occupying 35–86 min. in different species, as compared with 1–20 min. in all other organisms and tissues for which records exist.

(12) The absolute velocity of the chromatids separating at anaphase is less than 0·1μ per min. at 20° C., compared with 0·3–6·0μ per min. for all other recorded material.

In the light of the above evidence, and in the absence of centrioles, centrosomes, true blepharoplasts, centromeres, and spindle, it is suggested that chromatid movement in the Euglenineae is autonomous—a mutual repulsion by sister chromatids to opposite poles. The dense nucleoplasm and the retention of the nuclear membrane during mitosis prevents a scattering of chromatids in the cell. The nuclear membrane is stretched by the two groups of repelling chromatids and separation to two cytologically and genetically equivalent nuclei finally occurs.

A further feature of euglenoid mitosis is the general occurrence of high chromosome numbers. Chromosome counts have rarely been attempted in the Euglenineae. Pringsheim[1] says, "The number of chromosomes has not been established in any case, owing no doubt to difficulty caused by their number, length and dense accumulation. This is to be regretted, because polyploidy may be expected in certain groups".

I have made counts for six species, and estimates for a further eight (Table 1). In most species the clearest counts are obtained in anaphase or telophase.

Table 1. CHROMOSOME NUMBERS IN THE EUGLENINEAE

Counts		Estimates	
Euglena spirogyra	86	*Astasia klebsii*	18
Euglena viridis	42	*Colacium mucronatum*	35
Eutreptia lanowii	90	*Euglena gracilis*	45
Eutreptia viridis	44	*Lepocinclis ovum* var. *buetschlii*	34
Hyalophacus ocellatus	92	*Menoidium cultellus*	15
Phacus pusillus	42	*Peranema trichophorum*	177
		Trachelomonas bulla	25
		Trachelomonas grandis	40–60

The only direct comparisons with records by previous workers are my estimate of 45 for *Euglena gracilis* and a count of 14 by Baker[2], and my estimate of 177 for *Peranema trichophorum* and counts of 6 (!) by Hartmann and Chagas[3] and 32 by Brown[4]. The low counts by these authors were probably caused by fusion of the separate elements in poorly fixed material. The counts of 44 for *Eutreptia viridis* and 90 for *Eutreptia lanowii* indicate possibly polyploidy in this genus.

A full account of this work will be published elsewhere. The study was carried out in the Department of Botany, Queen Mary College, London, and will be continued at the Durham Colleges in the University of Durham. I would like to acknowledge the help and advice of Dr. M. B. E. Godward of Queen Mary College, and of Prof. E. G. Pringsheim of the University of Göttingen.

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Number of Mating Types required for Balance in Multipoint Linkage Programmes

IN two-point linkage work it is advantageous to use coupling and repulsion back-crosses in approximately equal numbers, for, with equal numbers of progeny, disturbances due to differential viability need not affect the estimation of the recombination fraction between the two loci. In fact, it is only possible to allow for differential viability in all the segregating phenotypes by this method of 'balance', and it may be shown that the estimation of the recombination fraction is most efficient when the balance is exact. The minimum requirement for balance is that the numbers of progeny from the coupling and repulsion back-crosses must be equal; in other contexts the definition of balance may be narrower, but it is used here as defined by this minimum requirement. This idea is just as fruitful in multi-point linkage work, but it is not necessary to make up matings using all the possible genotypes of multiple heterozygotes in order to ensure a set balanced for all pairs of loci. The present problem is to determine the minimum number of mating types needed for making up a balanced set for any given number of loci.

With two loci we may represent the heterozygote in coupling by $+ +$, and the heterozygote in repulsion by $+ -$. The symbols indicate that in the coupling heterozygote both wild-type genes are on the same chromosome, while in the repulsion heterozygote they are on different chromosomes. The existence of either coupling or repulsion may be inferred from these symbols by multiplying them together. Thus $+ \times + = +$ (coupling), and $+ \times - = -$ (repulsion). The set is said to be balanced when there are equal numbers of coupling and repulsion mating types; that is, when there are equal numbers of $+$ and $-$ signs resulting from this multiplication procedure. If, instead of just $+$ and $-$, we use $+1$ and -1, then the set will be balanced when the sum of the products of the two numbers representing each mating type is zero.

This procedure may be simplified for more than two loci by using a matrix notation. In the example above, we write the symbols for the two mating types one under the other:

$$\begin{matrix} 1 & 1 \\ 1 & -1 \end{matrix}$$

Calling this the matrix a, and its transpose (which is in this case its identity) a^*, the condition for balance is:

$$a^*.a = \begin{pmatrix} 2 & 0 \\ 0 & 2 \end{pmatrix} = 2I$$

This is just a convenient way of recording the fact that 'the numbers in any two columns, taken in pairs and multiplied together, sum to zero'. In this example there are only two columns, that is, one pair, but with four loci there are four columns, and so six pairs, one for each pair of loci.

The full solution of the problem is equivalent to the solution of the matrix equation $a^*.a = qI$, where a has p columns and q rows, p being the number of loci, and q the number of mating types in the balanced set.

Mr. S. Wylie, of Trinity Hall, Cambridge, who introduced the matrix notation to this problem, has pointed out that the enumeration of these matrices is equivalent to the enumeration of anallagmatic pavements. An anallagmatic pavement is a square pavement of black and white tiles so arranged that when any two columns or any two rows are placed together side by side, half the tiles next to one another are of the same colour and half are of different colours.

We are only concerned with square matrices, for it is clear that if a set is balanced for p loci, it is also balanced for $p - 1$ loci, and it may be proved, by *reductio ad absurdum*, that there does not exist a balanced set of p mating types for $p + 1$ loci.

A $p \times p$ pavement does not exist for $p > 2$ unless p is a multiple of 4, and it is conjectured[1] that it does exist when p is a multiple of 4. The first doubtful case is $p = 92$, and this is far beyond the range of genetic interest. It is known that pavements exist whenever p is divisible by 4 and of the form $2^k(s^n + 1)$, where s is an odd prime, and k and n are integers. 92 is the lowest multiple of 4 which is not of this form.

Thus we are able to draw up a table of number of loci and the corresponding minimum number of mating types in a balanced set:

Loci	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Mating types	2	4	4	8	8	8	8	12	12	12	12	16	16	16	16,	etc.

The enumeration of these pavements for $p > 4$ presents a formidable problem. Two 'basic' pavements are set out below for 8 loci, and many more may be derived from each by the interchange of columns, etc.

$$\begin{array}{cccccccc}
+ & + & + & + & + & + & + & + \\
- & + & - & + & - & + & - & + \\
- & - & + & + & - & - & + & + \\
+ & - & - & + & + & - & - & + \\
- & - & - & - & + & + & + & + \\
+ & - & + & - & - & + & - & + \\
+ & + & - & - & - & - & + & + \\
- & + & + & - & + & - & - & +
\end{array}
\qquad\qquad
\begin{array}{cccccccc}
+ & + & + & + & + & + & + & + \\
+ & - & - & - & + & - & + & + \\
+ & + & - & - & - & + & - & + \\
- & + & + & - & - & - & + & + \\
+ & - & + & + & - & - & - & + \\
- & + & - & + & + & - & - & + \\
- & - & + & - & + & + & - & + \\
- & - & - & + & - & + & + & +
\end{array}$$

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Chromosome Breakage in *Vicia faba* by Ozone

Important to an understanding of the biological effects of high-energy radiations is the concept of active radical formation in water[1]. The inability of hydrogen peroxide *per se* to simulate irradiation effects at concentrations expected in the cytoplasm of irradiated cells[2] has focused attention on the active radicals OH and HO_2. The chemical activity of such free radicals produced by the catalytic decomposition of hydrogen peroxide with ferric ions has recently been discussed[3], and Phillips[4] describes the production of chromosome aberrations in barley by these hydrogen peroxide 'precursors'.

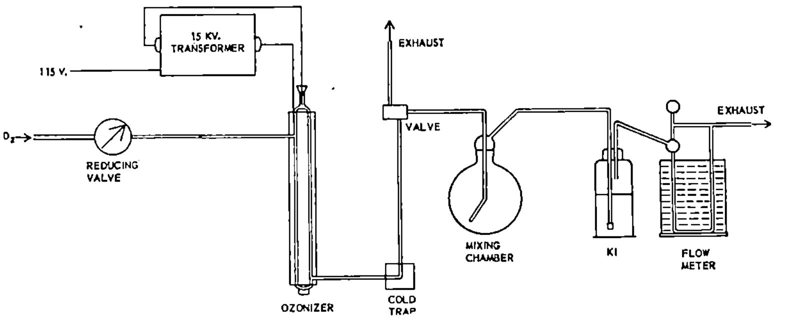

Fig. 1

The decomposition of ozone in solution produces these same active radicals of interest[5]. From studies of the kinetics and mechanisms of ozone decomposition, Alder and Hill[6] assume that in solution the reactions:

$$HO_3^+ + OH^- \rightleftarrows 2HO_2 \qquad (1)$$

$$O_3 + HO_2 \longrightarrow OH + 2O_2 \qquad (2)$$

are responsible for disappearance of ozone and are relatively slow and determine the rate of reaction; also, these authors indicate that reaction (1) represents an equilibrium which is maintained so long as ozone is present. The decomposition of ozone in solution is catalysed by hydroxyl ions and dependent upon temperature[7].

In these investigations, root meristem cells of *Vicia faba* were exposed to an atmosphere of ozone and the fraction of cells showing chromosome aberrations (as anaphase bridges) were recorded. The cells were all exposed in interphase and analysed at the first anaphase.

Fig. 1 is a schematic diagram of the apparatus used for challenging the seeds. The ozone was produced from cylinder oxygen and the concentration calculated by scrubbing replicate samples of known volume through 2 per cent potassium iodide (pH 9·0), the solution acidified and then titrated with 0·1 *N* sodium thiosulphate. With a flow of 2 l./min., 0·4 weight per cent ozone was present. The cold trap was found to be unnecessary and was abandoned. Seed coats were removed from imbibed *Vicia* seeds which were challenged with the ozone–oxygen mixture in the mixing chamber. Batches of seeds were removed after specific intervals, placed in sterile moistened vermiculite, at 19° C. and in the dark, until the radicles were about 2 cm. in length. At this time the first cell divisions occur[8], and Feulgen-stained squash preparations were made.

Table 1 presents the results of exposing *Vicia faba* seeds to 0·4 weight per cent ozone for 15, 30 and 60 min. The term 'abnormal anaphase' is used because no attempt was made to count the number of chromosome bridges per cell; thus an abnormal anaphase may contain one or more bridges. All the bridges observed were of the chromosome-type; that is, they were the result of dicentric or centric ring aberrations. There were neither chromatid-type

Table 1

Experimental group	Percentage abnormal anaphases		
	15 min.	30 min.	60 min.
O_2	0	0	0
$O_3 + O_2$	10	29	42

figures nor sticky bridges, and all the deletions were double. There was good agreement between root tips in a particular experimental group ; for example, in the 60-min. contact group seven root tips were used for obtaining about 500 anaphase figures analysed, with a mean value of abnormal anaphases of 42 ± 1·6 per cent per slide.

Table 2 presents the results of ozone, X-rays, and ozone and X-ray treatments. 150 kV., 15 m.amp. unfiltered radiation was delivered at 50 r./min. as determined by an ionization meter. When the X-rays and ozone were combined, the oxone was administered first and the X-rays immediately after, so that the entire treatment required less than 25 min. The effects of ozone and X-rays were approximately additive.

Table 2

Experimental group	Dose	Percentage abnormal anaphass
O_2	60 min.	0
$O_3 + O_2$	30 min.	23
X-rays	100 r.	25
O_3 + X-rays	20 min. + 100r.	42

A small number of root tips from each group was treated with colchicine and an analysis made of metaphase aberrations. These observations confirmed that the aberrations were all of the chromosome-type (dicentrics and centric rings).

A more detailed report of this work will be published later. These investigations were supported by grant No. *R.G.* 4722 of the National Institutes of Health, U.S.A.

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Use of Defoliants for drying Buckwheat in the Field, and a New Method for the Chemical Determination of Rutin

DEFOLIANTS are commonly used to facilitate the harvesting of cotton[1], beans, clover[2] and birdsfoot trefoil[3] for seeds, or for destroying the haulms of potatoes[4] to inhibit the spread of virus from infected leaves into the tubers. We thought it worth while to examine whether defoliants could be used for drying buckwheat (*Fagopyrum sagittatum* Gilib.), cultivated as medicinal plants, directly in the field, so as to avoid the tedious operations in connexion with artificial drying of the harvested material. As we expected that the rutin content might be influenced by defoliants, we have determined the rutin content of treated plants as compared with the control plants, cut and afterwards dried.

Table 1

Treatment	Rutin (per cent)	Quercetin (per cent)
Artificially dried plants	4·04	none
Sprayed with water alone and dried	3·62	0·10
0·1 per cent of sodium chlorate spray	3·60	0·18
1·0 per cent of sodium chlorate spray	2·68	0·24
2·0 per cent of sodium chlorate spray	2·30	0·27
1 per cent dinitrocresol (sodium salt) spray	2·20	none
10 per cent pentachlorophenol (sodium salt)	2·40	0·16

Buckwheat in full blossom was sprayed with several defoliants (see Table 1). Within five days 1 per cent sodium chlorate solution produced the most suitable drying of leaves, stalks and flowers among other defoliants used. Dried leaves were collected in a perfectly dehydrated form, leaving the empty stalks on the field (Fig. 1). The rutin content of the stalks, which is highest at the stage of bud formation and during that of flowering, is relatively small compared with that of the leaves[5].

The rutin content of the leaves was determined chemically. A new method was developed for this purpose, based on the colour reaction[6] of rutin with diazonium salts after its chromatographic separation[7]. 2·5 gm. of fresh leaves of buckwheat (or 0·25 gm. of dried material) is extracted in a Soxhlet apparatus for 90 min. with methanol (4 per cent pyridine was added when working with dried material) to determine

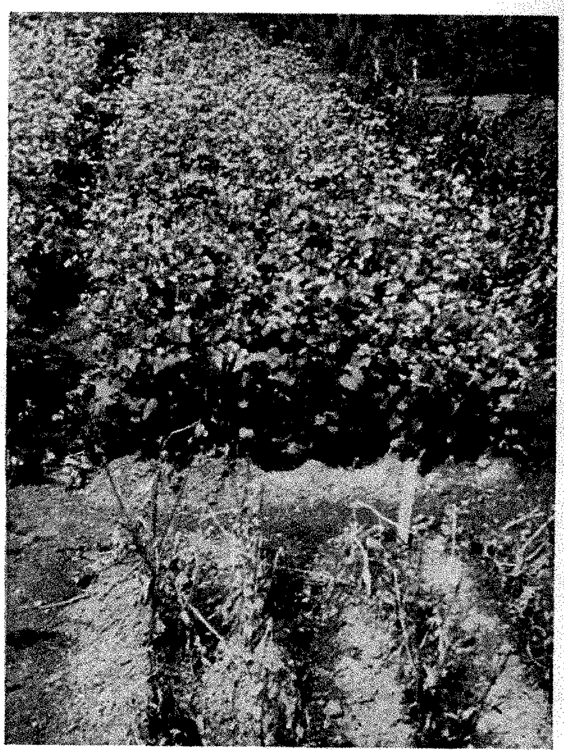

Fig. 1. Buckwheat five days after being sprayed with 1·0 per cent sodium chlorate solution and harvested (in front) and unsprayed (in background)

approximately the total flavonoids (phenolic compounds). An aliquot part (about 1 per cent) of the extract is evaporated to dryness, the rest dissolved in hydrochloric acid, a solution of diazotized sulphanilic acid is added and made alkaline with sodium hydroxide solution. The extinction is measured photometrically after 45 min. using a green filter (5330 A.), and the total flavonoids calculated from the graph for pure rutin.

A suitable quantity of the extract containing 200–300 μgm. of rutin (about 50–60 per cent of the total flavonoids) is chromatographed on Whatman No. 4 paper with 60 per cent aqueous acetic acid. The rutin spots are eluted with 0·1 *N* hydrochloric acid after detection in ultra-violet light and evaluated photometrically in the same manner as the total flavonoids. The quercetin content is estimated by comparison of the intensity of its yellow fluorescence in ultra-violet light with that of a progressive row of standard quercetin solutions chromatographed on the same paper.

We intend to investigate the effect of defoliation on other medicinal plants used not as drugs but as raw material in the pharmaceutical industry. A full account of this work will be published elsewhere.

Note added in proof. The leaves of buckwheat do not remain on the plants if they are not harvested within about seven days after treatment (depending on the weather), but it is hoped that the saving of labour and expense due to the use of this method compared with artificial drying may outweigh this disadvantage.

Recent experiments with defoliation of peppermint show a slow reduction of oil-content (from 1·53 per cent to 1·25 per cent—this difference being highly significant), but the leaves of peppermint plants remain on the stalks, in contrast to the behaviour of buckwheat.

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Spot Chromatography Identification of Citrus Rootstocks

THE importance of knowing the variety of the rootstock in a citrus orchard is more than academic. The tolerance of an orange tree to infectious diseases; the size, the number and quality of its fruits; the palatability of its fresh and processed juice; its rate of growth and its expected longevity are all dynamically affected by the rootstock on which it is growing. Many of the citrus trees in California and elsewhere are growing on rootstocks the identity of which is not definitely known.

Methods for the chemical identification of citrus rootstocks have been published[1,2], and a paper chromatographic test for sour orange roots has been described[3,4].

This communication deals with a new method for the identification of the eight varieties of citrus rootstocks that are used commercially in California. The eight varieties are: sour orange (*Citrus aurantium* 'Brazilian'); grapefruit (*C. paradisi* 'Duncan'); sweet orange (*C. sinensis* 'Koethen'), tangelo 'Sampson', a hybrid of the tangerine 'Dancy' and grapefruit; mandarin (*C. reticulata* 'Cleopatra'); rough lemon (*C. limon*, considered by some to be a hybrid); trifoliate orange (*Poncirus trifoliata*); and 'Troyer' citrange, a bigeneric hybrid between navel orange (*C. sinensis*) and the trifoliate orange (*P. trifoliata*).

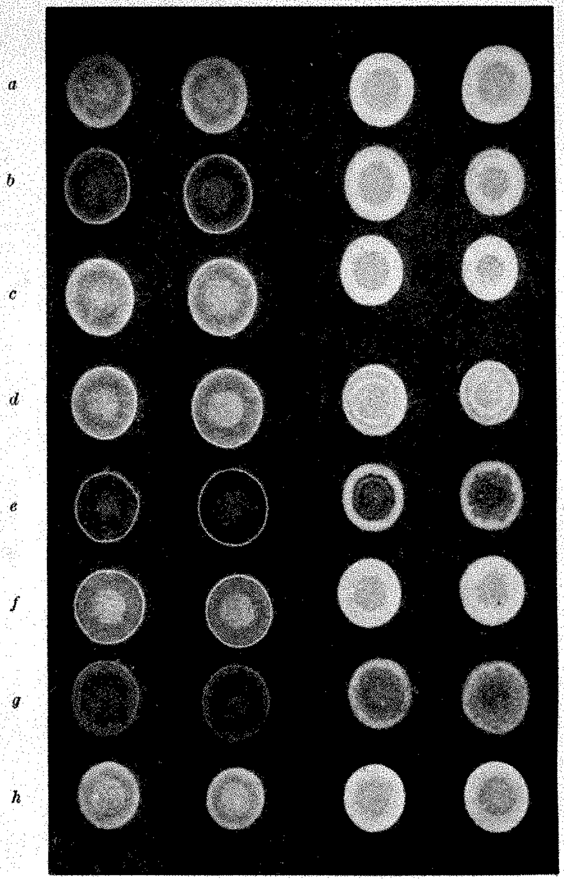

Fig. 1. The two lef -hand columns of spots are those made by dropping single drops of a plain 30-min. dimethoxypropane extraction of each root. The two right-hand columns of spots are from the 30-min. extractions to which anhydrous aluminium chloride was added and allowed to react for 30 min., before the spot was made. *a*, Sour orange (Brazilian); *b*, grapefruit (Duncan); *c*, sweet orange (Koethen); *d*, tangelo (Sampson); *e*, mandarin (Cleopatra); *f*, rough lemon; *g*, trifoliate; *h* citrange (Troyer)

The roots used were obtained from the experimental Valencia orange orchard of the University of California at Riverside, California, through the courtesy of Dr. W. P. Bitters. Each rootstock had been propagated by 'nucellar' seedlings. All the trees were thirty years old except for the Troyer citranges that were planted in 1944.

The method described here compares the spots made on filter paper by drops of extracts of unknown roots with similar spots made from known varieties. Under long-wave ultra-violet light (3650 A.) the spots fluoresce and display distinctive concentric yellow, brown and green circles. Fig. 1 indicates in black and white some of the distinguishing differences.

Of the thirty-three solvents tested, dimethoxypropane was the most satisfactory when used as described in (1) below. Complete identification of all of the rootstocks was not attained by using dimethoxypropane alone; so the extractions were subjected to reactions with salts of heavy metals. Of the thirty-six salts tried, anhydrous aluminium chloride, when used with dimethoxypropane, was the best. See (2) below.

(1) Freshly dug roots, $\frac{3}{8}$ in. diam. and larger, are washed free of dirt and wiped dry. The bark is cut through to the cambium and into pieces $\frac{1}{4}$ in. square and smaller. 10 gm. of the fresh bark are placed in a bottle. 15 ml. of 2,2-dimethoxypropane 98 per cent (Dow Chemical Co.) are added, and the mixture is allowed to stand for 30 min. at room temperature. Then single drops of the extraction are placed with a medicine dropper on a sheet of Whatman No. 1 filter paper. It will be noticed in Fig. 1 that the two left-hand vertical columns of spots represent the 30-min. extractions of the eight varieties of rootstocks. The two right-hand columns of spots were made by following the procedure described in the next paragraph.

(2) Arrange a series of clean, dry, 10 mm. × 75 mm. test-tubes, one tube for each rootstock. In each tube place 0·1 gm. of anhydrous aluminium chloride. This should be done ahead of time so that, immediately following step (1), 1·5 ml. of each of the 30-min. extractions may be added separately to 0·1 gm. of the aluminium chloride. Shake the tubes and allow them to stand for 30 min. At the end of that time single drops of the supernatant fluid in each test-tube are placed on the filter paper in the two right-hand columns. The spots should be allowed to dry thoroughly before comparisons are made between the known and unknown varieties.

The spots tend to deteriorate in a day or two. Precautions should be taken to prevent the spots on one sheet from spoiling those on other sheets which may be piled on top or below by inserting each sheet between a folded piece of wax-paper.

Unused roots may be kept for 2 or 3 days in plastic bags in a refrigerator at 4° C. or less. One batch of roots was kept in a food freezer at 0° C. for 34 months. The fluorescent spots of all of the varieties were within the usual range of colours except for the sweet rootstocks.

I wish to express my thanks to Dr. W. P. Bitters, Mr. Robert Hepler and Mr. James L. Jones.

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Perceptual Stability of a Stroboscopically Lit Visual Field containing Self-Luminous Objects

IT is a familiar observation that when the retinal image is displaced as a result of an externally forced rotation of the eyeball (for example, by light sideways pressure with the finger), the visual world appears to move; whereas when the same rotation is produced voluntarily the visual world remains stable. This stability is often attributed to some (as yet unknown) process by which the effects of retinal change are thought to be accurately compensated or cancelled out during voluntary movement.

In the course of experiments designed to explore a different hypothesis[1], a rather striking phenomenon has been observed. If a room containing self-luminous objects (such as the cathodes of thermionic valves) is lit stroboscopically, it is found that at rates of flash down to some 15 per sec. the effects of pressing the eyeball intermittently (say, twice per sec.) and very lightly, are similar to those in ordinary light. At rates of some 5 or 6 per sec., however, a remarkable disparity is observed between the apparent motion of the self-luminous objects and that of the rest of the room. The glowing cathode of a valve, for example, appears to move whereas its envelope remains at rest, although surprisingly enough their relative positions can be clearly seen to be unaltered. A similar violent perceptual disturbance occurs with an artificial nystagmus, induced, for example, by first rotating the observer rapidly about a vertical axis with his eyes closed. The effect seems insensitive to level of illumination over the range used (0·3–3 Joules per flash), and has been described in similar terms by all of some fifty observers to date. To by-pass speculations invoking distortion of the eyeball, it may be said that the same disturbance occurs when the retinal image is displaced by moving a prism or mirror before the eye.

The apparent movement of the self-luminous objects would seem to be interpretable as the normal result of involuntary displacement of their retinal image, since that image is thrown continuously upon the retina. What is at first sight surprising (especially on any theory of 'compensation') is the relative stability of the stroboscopically lit room. It seems clear that a discontinuous displacement of the retinal image is not so powerful a stimulus for the perception of world-movement as when continuous motion produces the same displacement. If the eyeball is lightly pressed and held in its new position, the stroboscopically lit field is seen to move sluggishly to 'catch up' with the self-luminous objects, requiring several flashes to do so. The interesting conclusion suggested is that the magnitude of perceived movement is a function of the amount of information (in the technical sense) supplied by the retinal image, rather than of the magnitude of its displacement.

Two related observations seem to support this tentative conclusion. First, even in normal light the motion perceived during involuntary rotation of the eyeball seems to most observers to be greater in the central than in the peripheral parts of the field. This again suggests that the greater density of foveal information is transformed into a greater magnitude of perceived motion. Secondly, when a retinal image of radial lines (such as my 'ray' figure[2]) is involuntarily displaced, the normal apparent movement of the centre is accompanied by a fanwise movement of the rays lying nearest to the line of motion. The pattern appears to open out, as if on a distended rubber sheet, on the side away from which the centre moves, and to contract on the opposite side. The effect is suppressed if a line is drawn across the pattern at right angles to the rays concerned. The suggested inference is again that the magnitude of motion perceived is greater in those directions in which more information is generated by the retinal displacement.

The foregoing observations afford some encouraging confirmation of the hypothesis I have put forward[1]—this having, for once, had the good fortune to be advanced ahead of them on theoretical grounds. Briefly, the argument is that if perception is the adaptive 'keeping up to date' of an organism's state of organization for activity in its world[3], then what requires informational justification is not the maintenance of stability but the perception of change. The internal state of organization, which implicitly represents the perceived world, should remain unaltered unless sufficient information (in the technical sense) arrives to justify a change, by indicating that the current state of organization is significantly mismatched to the state of affairs sampled by the receptor system[4].

Thus the retinal changes resulting from voluntary movement evoke no perception of world-motion, because they are not an awkward consequence to be compensated, but part of the goal to be achieved. If these changes are prevented from occurring, for example by stabilizing the retinal image, the absence of retinal change evokes an impression of movement.

From this point of view, all the anomalies reported above make some sense as evidence that: (*a*) perceptive activity is relatively detached from that of the receptor system; (*b*) in sampling the receptor field, the perceptive system is relatively insensitive to the position of the image, and demands a combination of evidence exceeding some 'threshold of significance' before it responds by the perception of a change; (*c*) the strength of the impression of change depends on the total amount of information validating a change in the state of organization—in other words, it depends on the informational weight attached to discrepant samples from the receptor system; (*d*) the change perceived, however surprising to the observer, is always the most parsimonious which will match the discrepant information; perception would appear to be organized on the conservative principle of a null-hypothesis.

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Sub-aerial Volcanicity in Snowdonia

Extensive recent work in south-central Lleyn (F. J. F.), Beddgelert (N. R.) and the pass of Llanberis (F. J. F. and N. R.), supplemented by observations from the pass of Aberglaslyn (R. V. B.) warrants a new interpretation of Snowdonian volcanics of mid-Ordovician age.

It appears now that the acid volcanics of Snowdonia exhibit many phenomena found in areas where recent volcanicity has been in progress (for example, New Zealand, Alaska). Four main features of Snowdonian volcanics are worthy of emphasis. (1) The bulk of the volcanics consist of ignimbrites or welded tuffs. A wide variety of these rocks are found ranging from fine dusty varieties (National Grid No. $SH_{(2)}576_{(3)}509$) to coarse welded agglomerates ($SH_{(2)}632_{(3)}563$). The general absence of bedding and the widespread presence of flattened vesicles in these rocks is suggestive of sub-aerial rather than submarine deposition of the glowing avalanches. Frequent vertical explosive shoots and tuff pipes traversing the ignimbrites are now recognized (for example, $SH_{(2)}593_{(3)}525$). The tuff pipes are probably produced by fumarolic action similar to that recorded from the Valley of Ten Thousands Smokes, Alaska.

(2) In many cases extrusion of basic lavas preceded the deposition of welded tuffs. Well-preserved top surfaces of ropy lava have been found suggesting that the top of the flow was sub-aerial. Since these lavas are often blocky or even pillowy at their lower boundary, where they are often mixed with muddy sediments, a transition from sub-marine to sub-aerial conditions must have taken place during their extrusion. The basic lavas have been mapped by H. Williams[1] as deformed dolerites.

(3) The acid deposits often contain rocks previously called 'the nodular rhyolites'. There are several varieties of 'nodular rhyolites', each originating in a different way. For example, some of the so-called 'nodular rhyolites' near Beddgelert are spherical bodies of medium grain welded tuff in a matrix of a fine grain welded tuff.

(4) Near Pont y Gromlech in the pass of Llanberis a volcanic centre has been recently identified. West of Pont y Gromlech a vent of agglomerate ($SH_{(2)}623_{(3)}565$) traverses the grits and slates of the Gwastadnant Group terminating in the Lower Rhyolite Tuff. Hereabouts, the main volcanic sequence is underlain by deposits consisting of large boulders of grit, slate and volcanic material in muddy or silicified matrix. These deposits seem to represent mud-flows (lahars), which preceded the main Snowdonian ignimbrites.

The presence of welded tuffs in Snowdonia was first recorded by Oliver[2], who identified as such a thin section from Capel Curig. Our work suggests that the bulk of Snowdonian acid volcanics are welded tuffs with subsidiary basic lavas. If so, then the thickness of such deposits has no direct bearing on the proximity to the volcanic centres, since the modern welded tuffs are known to thicken in the pre-existing topographic hollows (for example, see Enlows[3]). That the main Snowdonian ignimbrites were deposited on an irregular surface possessing such hollows has been now proved by detailed mapping of the well-exposed lower boundary of the Lower Rhyolite Tuff near the Pen-y-pass Hotel, Pass of Llanberis.

In so far as their mode of extrusion is concerned, accumulating evidence suggests that the Snowdonian volcanics were derived from numerous small sub-aerial explosive vents, such as have been recognized in the Pass of Llanberis and in Lleyn. These vents are associated with intrusive rhyolites but, contrary to Matley's[4] opinion, not with granophyre or micro-granite intrusions.

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London.

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[1] Williams, H., *Quart. J. Geol. Soc.*, **83**, 346 (1927).

[2] Oliver, R. L., *Geol. Mag.*, **91**, 473 (1954).

[3] Enlows, H. E., *Bull. Geol. Soc. Amer.*, **66**, 1215 (1955).

[4] Matley, C. A., *Quart. J. Geol. Soc.*, **94**, 555 (1938).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 17

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. A. Stephenson: "Surveying and the Modern Expedition".

Royal Institution, Library Circle (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Mr. S. Rees Jones: "The Painter's Eye—a Talk on Science and Painting".

University of London (at Birkbeck College, Malet Street, London, W.C.1), at 5.45 p.m.—Dr. J. A. Kitching: "Physiological Mechanisms in the Protozoa".* (Further lectures on February 19 and 21.)

Society of Chemical Industry, Pesticides Group and Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. R. J. Courshee: "Corrosion of Spraying and Dusting Machinery".

British Computer Society (at York Hall, Caxton Hall, Westminster, London, S.W.1), at 6.15 p.m.—Prof. A. C. Aitken: "Mental Arithmetic, an Historical Review with Demonstrations".

Institute of Metal Finishing (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 6.30 p.m. —Mr. A. R. Thompson: "Health Hazards Associated with Metals Affecting the Finisher".

Society of Cosmetic Chemists of Great Britain (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Mr. W. C. Botfield: "Perfumery".

Tuesday, February 18

Bedford College (at Regent's Park, London, N.W.1), at 5.15 p.m. —Dr. W. Grey Walter: "The Physiology of Mentality".*

University College, London (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.15 p.m.—Dr. C. A. G. Wiersma (California Institute of Technology): "Comparative Physiology of Crustacean Neuro-Muscular Systems".*

Imperial College (in the Main Chemistry Lecture Theatre, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Prof. F. D. Richardson: "The Changing World of the Extraction Metallurgist" (Inaugural Lecture).

Institute of Physics, Electronics Group (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. J. E. Flood: "Electronic Devices in Telephony".

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. H. C. Husband: "Jodrell Bank Radio Telescope".

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. C. D. Mee: "Magnetic Tape for Data Recording".

Society for Analytical Chemistry, Physical Methods Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Meeting on "Solid Source Mass Spectrometry".

Oil and Colour Chemists' Association (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. F. Schollick: "Some Aspects of Amino Coating Resins".

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. E. G. Broadbent: "Aeroelastic Problems associated with High Speeds and High Temperature".

Wool Education Society (at the Royal Institution, 21 Albemarle Street, London, W.1), at 7 p.m.—Mr. H. B. Carter: "Science and the Wool Grower".

British Glaciological Society (joint meeting with the Challenger Society, at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Dr. Erkki Palosuo: "Sea Ice Prediction Techniques in the Baltic".

Wednesday, February 19

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. J. E. P. Dunning: "Rocket Propulsion".

Eugenics Society (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Prof. Aubrey Lewis: "Fertility and Mental Disorder"* (Galton Lecture).

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. G. A. Corby and Mr. J. A. Sawyer: "The Air Flow Over a Ridge—the Effects of the Upper Boundary and High-level"; Mr. C. E. Wallington and Mr. J. Portnall: "A Numerical Study of the Wave-length and Amplitude of Lee Waves".

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Prof. M. G. Kendall: "Research in Statistics".

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Sir Christopher Hinton, F.R.S.: "Nuclear Power Development—Some Experiences of the First Ten Years"* (Melchett Lecture for 1957).

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. L. C. Jesty: "The Relation Between Picture Size, Viewing Distance and Picture Quality with special reference to Colour Television and to Spot Wobble Techniques".

Institute of Physics, London and Home Counties Branch (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Annual General Meeting, followed by Dr. A. H. Willbourn: "High Polymer Properties and Structure".

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Scientific Papers.

Royal Institute of Chemistry, London Section (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6.30 p.m.—Prof. Arne Tiselius, For.Mem.R.S. (University of Uppsala): "Purity and Purification of Chemical Substances" (First Humphry Davy Lecture).

Society for Analytical Chemistry, Biological Methods Group (in the restaurant room of "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion Meeting on "The Stage at which a Biological Assay Can be Replaced", introduced by Mr. W. L. M. Perry.

Thursday, February 20

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. R. E. Peierls, F.R.S., Dr. D. H. Wilkinson, F.R.S., and Prof. W. E. Burcham, F.R.S.: "Recent Advances in Nuclear Physics".

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. W. Milnor: "Groups Which Act on S^n Without Fixed Points".

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. J. H. Welch: "Direct Observation of High-Temperature Processes with the Microscope".

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Prof. B. S. Platt: "Malnutrition and Pathogenesis of Zymotic Diseases".

Friday, February 21

British Psychological Society, Industrial Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Dr. N. H. Mackworth: "The Television Eye-marker" (Chairman's Address).

Institute of Physics, Applied Spectroscopy Group (at 47 Belgrave Square, London, S.W.1), at 3 p.m.—Meeting on "X-Ray Fluorescence".

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "The Transition from the Ionosphere to Interplanetary Space". Chairman: Mr. J. A. Ratcliffe, F.R.S. Speakers: Prof. Sydney Chapman, F.R.S., Dr. D. E. Blackwell, Dr. J. V. Evans and Dr. A. Hewish.

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Air Commodore R. T. Gething, O.B.E., A.F.C.: "Air Search and Rescue Problems".

British Institute of Radiology, incorporated with the Röntgen Society (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 5.30 p.m.—Papers on "Recent British Gamma Ray Beam Units". Speakers: Mr. T. Ashton, Mr. G. S. Innes, Mr. R. G. Wood, Dr. J. R. Clarkson and Mr. J. C. Jones.

North East Coast Institution of Engineers and Shipbuilders, (in the Lecture Theatre of the Mining Institute, Neville Hall, Newcastle-upon-Tyne), at 6.15 p.m.—Mr. D. Firth: "The History and Development of Hydraulic Transmissions for Marine Propulsion".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Alexander Haddow: "Cancer Research—Its History and Prospects".

Saturday, February 22

Association of Clinical Biochemists, Southern Region (at King's College Hospital Medical School, Denmark Hill, London, S.E.5), at 2 p.m.—Scientific Papers. 4.15 p.m.—Demonstrations by Staff of the Department of Chemical Pathology, King's College Hospital.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Principal Lecturer (with high qualifications in physiology and preferably some experience as a university lecturer) in Anatomy and Physiology—The Principal, Loughborough Training College, Loughborough (February 21).

Assistant Lecturer or Lecturer in Applied Mathematics—The Secretary, The University, Exeter (February 22).

Scientific Officer (with an honours degree in zoology) in the Nematology Department—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (February 22).

Assistant Lecturer in Organic Chemistry; an Assistant Lecturer in Pure or Applied Mathematics; and an Assistant Lecturer in Physics—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8 (February 28).

Assistant Lecturers (2) (honours graduates, with some research experience in physical, inorganic or physical-organic chemistry) in Chemistry—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (February 28).

ENTOMOLOGIST (with a good honours degree and a keen interest in applied entomology), to develop and apply laboratory techniques for investigating the biological activity of insecticides and spray deposits —The Secretary, East Malling Research Station, near Maidstone, Kent (February 28).

SENIOR LECTURER IN MEDICINE at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, February 28).

CONSULTANT BIOMETRICIAN (fully qualified) with the Government of the Federation of Rhodesia and Nyasaland, for duties which include the design of experiments in all phases of agriculture and animal husbandry research and the analysis of data and related statistical practice—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (March 1).

SENIOR LECTURER or LECTURER IN THE DEPARTMENT OF SURGICAL SCIENCE—The Secretary, The University, Edinburgh (March 1).

LECTURER or ASSISTANT LECTURER IN THE HISTORY AND PHILOSOPHY OF SCIENCE—The Registrar, The University, Leeds 2 (March 10).

CHAIR OF EDUCATION in the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 12).

ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Secretary, The Queen's University, Belfast (March 15).

ASSISTANT LECTURER (with a special interest and qualifications in petrology, and research experience, preferably in either geochemistry, ore mineralogy or structural geology) IN GEOLOGY—The Secretary, University College, Gower Street, London, W.C.1 (March 15).

CHAIR OF GEOLOGY—The Secretary and Registrar, The University, Southampton (March 15).

LECTURER IN AGRICULTURAL ENTOMOLOGY at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 15).

LECTURER IN NATURAL PHILOSOPHY—ELECTRONICS—The Secretary, The University, Aberdeen (March 15).

PROFESSOR AND HEAD OF THE DEPARTMENT OF GEOLOGY at the Memorial University of Newfoundland, St. John's, Newfoundland, Canada—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Canada, March 15).

IMMUNOLOGIST (graduate in either science or medicine and with a sound knowledge of immunology) IN THE DEPARTMENT OF SURGICAL SCIENCE, to work on problems of transplantation immunity under the general direction of the Professor—The Secretary, The University, Edinburgh (March 31).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN CHEMISTRY, CIVIL ENGINEERING or PHYSICS—The Registrar, Trinity College, Dublin (March 31).

PROFESSOR OF PREVENTIVE AND SOCIAL MEDICINE at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, March 31).

ASSISTANT, Grade B (with a good honours degree) FOR MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham, Essex.

ASSISTANT LECTURER IN METALLURGY IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Principal, Royal Technical College, Salford 5.

ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Nottingham.

ASSISTANT (preferably with experience of biochemical or genetic techniques in microbiology) for research on the mode of action of antituberculous drugs—The Secretary, Guy's Hospital Medical School, London Bridge, S.E.1.

ASSISTANT SEISMOLOGIST (with an honours degree in physics or in geology with physics to degree standard, and preferably with research experience in geophysics) at the Imperial College of Tropical Agriculture, Trinidad, British West Indies—The Secretary, I.C.T.A., 40 Norfolk Street, London, W.C.2.

CHEMISTS (with an honours degree), to join a team working on the surface chemistry of carbon and graphite, particularly in relation to the reactivity of these materials with gaseous coolants at elevated temperatures—The Recruitment Officer (1022/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

EXPERIMENTAL OFFICER (with a degree in chemistry or agricultural chemistry, or equivalent qualifications), to carry out chemical analyses of soils and plants—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

HARWELL RESEARCH FELLOWS (JUNIOR and SENIOR) (with at least two or three years postgraduate experience), for research in Chemistry, Mathematical Physics, Chemical Engineering, Physics, Metallurgy, Biochemistry and Food Technology—Group Recruitment Officer (1053/2), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

HOSPITAL BIOCHEMIST (Senior grade)—The Group Secretary, Cardiff Hospital Management Committee, 44 Cathedral Road, Cardiff.

PROTEIN CHEMIST or PHYSICIST (preferably Ph.D. or with equivalent research experience), to work on immunological problems—The Secretary, The Wright–Fleming Institute of Microbiology, St. Mary's Hospital Medical School, Paddington, London, W.2.

READER IN WOOL TECHNOLOGY; READER IN MAN-MADE FIBRES AND TEXTILE CHEMISTRY; READER IN HIGH POLYMER CHEMISTRY; READER IN COLOUR CHEMISTRY; READER IN MECHANICAL OR PRODUCTION ENGINEERING; READER IN ELECTRICAL ENGINEERING; and a READER IN PHARMACEUTICS—The Principal, Institute of Technology, Bradford 7.

SCIENTIFIC OFFICER (with a good honours degree in natural science, preferably zoology, with two years postgraduate training or experience in scientific research) IN THE JOINT FISHERIES RESEARCH ORGANIZATION, Northern Rhodesia, to undertake research as may be required into any aspect of freshwater biology, fish and fisheries in Northern Rhodesia and Nyasaland—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.87/3/01.

SENIOR CHEMISTRY MASTER—The Headmaster, Malvern College, Worcs.

SENIOR LECTURER IN MATHEMATICS; SENIOR LECTURER IN PHYSICS; SENIOR LECTURER IN INDUSTRIAL ADMINISTRATION; SENIOR LECTURERS (2) IN PHARMACEUTICS; SENIOR LECTURER IN PHARMACOLOGY; LECTURER IN CHEMICAL ENGINEERING; LECTURERS (2) IN CIVIL ENGINEERING; and a LECTURER IN PHYSICS—The Principal, Institute of Technology, Bradford 7.

VICE-PRINCIPAL (with good academic qualifications and administrative experience, preferably in advanced technological education) —The Principal, Institute of Technology, Bradford 7.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Institution of Gas Engineers. Publication No. 511: 18th Report of the Chairman's Technical Committee, 1956–57. Pp. 26. Publication No. 512: 34th Report of the Gas Education Committee, 1956–57. Pp. 28. Publication No. 513: The Future of Nuclear Power. By Dr. J. V. Dunworth. Pp. 21. Publication No. 514: The Gas Integrale Plant at Kensal Green. By A. F. Grant and C. H. Lewis. Pp. 38. Publication No. 515: The Use of Light Petroleum Distillate for Gas Making. By E. R. Ward. Pp. 15. Publication No. 516: Eighth Arthur Duckham Research Fellowship Report, 1955–56. By D. Fitzgerald. Pp. 42. Publication No. 517: Investigations Into the Stress-Corrosion Cracking in Welded Gas Plant (Concluding Report). Submitted by the British Welding Research Association. Pp. 16. Publication No. 518: The Shellhaven-Romford Refinery Gas Pipeline of the North Thames Gas Board. By A. D. L. Copp. Pp. 23. Publication No. 519: Official Programme, 23rd Autumn Research Meeting, London, 19th and 20th November, 1957. Pp. 8. (London: Institution of Gas Engineers, 1957.) [2511

Ageing on the Factory Floor: The Production of Domestic Furniture —an Inquiry made through Works Records and Work Descriptions into the Prospects of Ageing Men within a Mechanized Industry. By F. Le Gros Clark. (Studies of Ageing Within the Conditions of Modern Industry.) Pp. 36. (London: The Nuffield Foundation, 1957.) [2511

Year Book of the Physical Society, 1957. Pp. iv+132. (London: The Physical Society, 1957.) 12*s.* 6*d.* [2511

Imperial Institute Commodity Leaflets (New Series). No. 29: Whales and Whaling. Pp. 4. (London: Imperial Institute, 1957.) 4*d.* [212

Other Countries

Bulletin of the American Museum of Natural History. Vol. 113, Article 5: Natal Plumages and Downy Pteryloses of Passerine Birds of North America. By Prof. David Kenneth Wetherbee. Pp. 339–436 +plates 6 and 7. (New York: American Museum of Natural History, 1957.) 2 dollars. [2511

United States Department of the Interior: Geological Survey. Bulletin 1019–J: Annotated Bibliography and Index Map of Salt Deposits in the United States. By Walter B. Lang. Pp. iii+715–753+plate 4. 60 cents. Bulletin 1036–M: Model '54 Transmission and Reflection Fluorimeter for Determination of Uranium with Adaptation to Field Use. By Ernest E. Parshall and Lewis F. Rader, Jr. Pp. iii+221–251+plate 3. 60 cents. Bulletin 1045–C: Core Logs from Soda Lake, San Bernardino County, California. By Siegfried Muessig, George N. White, and Frank M. Byers, Jr. Pp. iii+81–96+plate 3. 50 cents. Bulletin 1046–C: Uranium-Bearing Minerals in Placer Deposits of the Red River Valley, Idaho County, Idaho. By F. C. Armstrong and P. L. Weis. Pp. iii+36+plate 1. 30 cents. Bulletin 1046–D: Uranium Resources of the San Rafael District, Emery County, Utah—a Regional Synthesis. By H. S. Johnson, Jr. Pp. iii+37–54+plate 2. 40 cents. Bulletin 1050–L: The Spotted Horse Coalfield, Sheridan and Campbell Counties, Wyoming. By W. W. Olive. Pp. v+83+13 plates. n.p. Bulletin 1063–A: Stratigraphic and Structural Controls of Uranium Deposits on Long Mountain, South Dakota. By William A. Braddock. Pp. iii+11+4 plates. 1 dollar. Bulletin 1066–B: Geophysical Abstracts 169, April–June, 1957. By Mary C. Rabbitt, Dorothy B. Vitaliano, S. T. Vesselowsky, and others. Pp. iii+95–190. 25 cents. Bulletin 1071–A: The Gold Pan as a Quantitative Geologic Tool. By Paul K. Theobald, Jr. Pp. iii+54. 25 cents. (Washington, D.C.: Government Printing Office, 1957.) [2511

United States Department of the Interior: Geological Survey. Water-Supply Paper 1388: Surface Water Supply of the United States, 1955. Part 5: Hudson Bay and Upper Mississippi River Basins. Prepared under the direction of J. V. B. Wells. Pp. xii+548. 1.75 dollars. Water-Supply Paper 1398: Surface Water Supply of the United States, 1955. Part 14: Pacific Slope Basins in Oregon and Lower Columbia River Basin. Prepared under the direction of J. V. B. Wells. Pp. viii+279. 1 dollar. Water-Supply Paper 1413: Geology and Ground-Water Resources of Kitcat County, Washington. By Jack E. Sceva. Pp. vi+178+3 plates. n.p. (Washington, D.C.: Government Printing Office, 1957.) [2511

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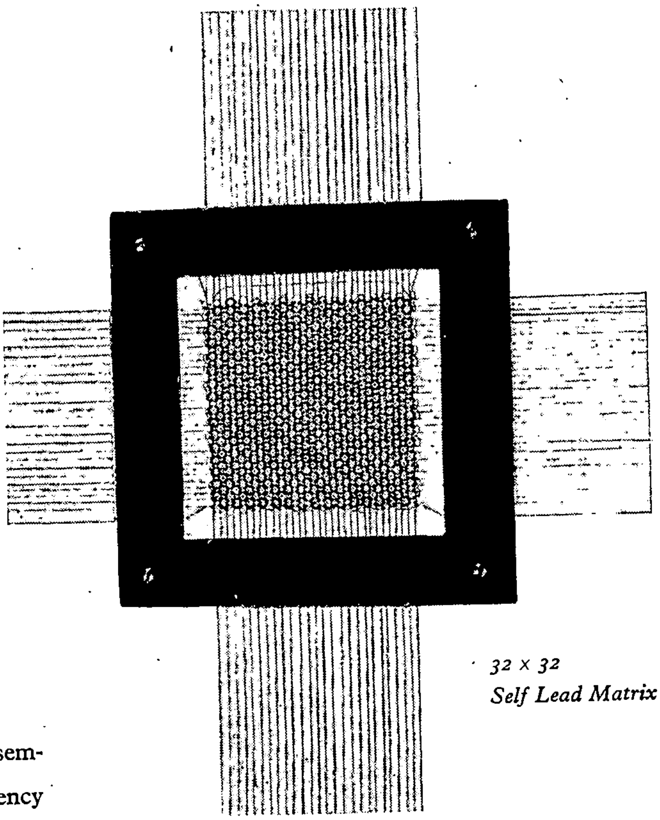

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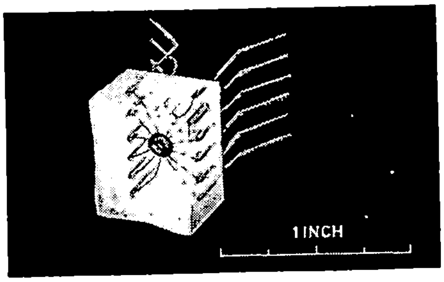

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LECTURES AND COURSES

UNIVERSITY OF LONDON KING'S COLLEGE

CHEMICAL ENGINEERING

Applications for places next October in the postgraduate one-year course for the College Diploma should reach the Registrar, from whom particulars and forms may be obtained, by March 15.

The College offers Shell Studentships of the value of £375, with free tuition and examination fees. Applications for these should also be in by March 15.

This course is approved by the D.S.I.R. for Advanced Course Studentships. Applicants interested in these should inform the Registrar of the College by February 24.

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CATHAYS PARK, CARDIFF

ASSOCIATESHIP SANDWICH COURSE IN APPLIED PHYSICS

A four-year Sandwich Course, leading to a College Associateship, will commence in October, 1958. The Institute of Physics has approved this course, and the Associateship will satisfy completely the Institute's academic requirements for Graduateship and corporate membership. Students may be " works " or " college " based, and will spend alternate six-monthly periods in college and industry. Normal requirements for admission to the course will be success at G.C.E. " A " level or O.N.C. at a high standard in applied physics or electrical engineering.

Details of the course may be obtained from, and applications should be made to, the Principal.

R. E. PRESSWOOD,
Clerk to the Governors.

UNIVERSITY OF LONDON: A LECTURE entitled " Some Studies on Non-benzenoid Aromatic Compounds " will be delivered by Dr. E. Hellbronner (Zürich) at 5.30 p.m. on February 24 at University College (Chemistry Lecture Theatre), Gower Street, W.C.1. Admission free, without ticket.—James Henderson, Academic Registrar.

GRESHAM LECTURES. DR. W. H. Steavenson, P.R.A.S. (Gresham Professor in Astronomy) will deliver a course of four Lectures entitled " The Stars and the Universe " on Monday to Thursday, February 17 to 20, at Gresham College, Basinghall Street, E.C.2. Tel. MONarch 2433.—The Lectures are free and begin at 5.30 p.m.

OFFICIAL APPOINTMENTS

UNIVERSITY OF BRITISH COLUMBIA

DEPARTMENT OF PHYSICS

Applications are invited for appointments as Lecturer, Assistant Professor, Postdoctorate Fellow and Research Assistant in the Department of Physics. The vacancies have been created by the rapid expansion of the university. They are mainly in the fields of nuclear physics, optical spectroscopy, solid state physics and geophysics. Applicants should have an honours degree in physics and, except in the case of Research Assistants, a Ph.D. degree. They should not be more than 30 years of age and should be available in September, 1958. There are also Teaching Assistantships available to help students who wish to pursue graduate work towards a Ph.D. degree.

Applicants wishing fuller information regarding any of these positions or awards should write to G. M. Shrum, Head, Department of Physics, University of British Columbia, Vancouver, B.C., Canada.

SCUNTHORPE HOSPITAL MANAGEMENT COMMITTEE

RADIATION MONITORING SERVICE

Vacancy for Technician or Technician in Training. Work mainly concerned with radiation measurement to ensure safe working conditions in X-ray and Therapy Departments of Lincolnshire Hospitals. Qualification for Technician in engineering or appropriate apprentice including experience in applied physics or design of instruments or O.N.C. in approved subjects, minimum age 21. Salary scales: Technician, £475 to £600 ; Trainee, £155 at age 16 rising to £380 at 25 or over. Whitley Council conditions of service.

Application form from Group Secretary, War Memorial Hospital, Scunthorpe.

NATIONAL RESEARCH DEVELOPMENT CORPORATION

requires an honours graduate in biology or chemistry, with thorough training in formal genetics, for research work in microbial genetics at the Ministry of Supply's Microbiological Research Establishment at Porton.

Starting salary would be within the scale for Senior Scientific Officers or that for Principal Scientific Officers in the Civil Service, according to which seemed the more appropriate to age, qualifications and experience.

Initially the person appointed would be required to lead a small team in the study of the genetics of micro-organisms of value in the fermentation industry, particularly the organisms used in antibiotic production. This work would be conducted under the auspices of the Corporation and is expected to take two years. During that period or at its termination he would, subject to satisfactory work and suitability in other respects, be considered for employment at Porton by the Ministry of Supply ultimately on research in the broad field of microbial genetics.

Apply, in confidence, to N.R.D.C., 1 Tilney Street, London, W.1.

UNIVERSITY OF EDINBURGH

DEPARTMENT OF SURGICAL SCIENCE

IMMUNOLOGIST

Applications are invited for the post of Immunologist in the Department of Surgical Science, to work on problems of transplantation immunity under the general direction of the Professor. Applicants should be graduates in either science or medicine and have a sound knowledge of immunology. The successful applicant, who will be given the status of either Lecturer or Senior Lecturer according to qualifications and experience, will be expected to give some postgraduate instruction in experimental methods and may also be called upon to supervise research students but will have no other teaching duties. If the person appointed is given the status of Senior Lecturer the salary scale will be £1,950 by £100 to £2,550 per annum ; if the status of Lecturer the scale will be £900 by £100 to £1,300 ; Bar: £1,400 by £100 to £1,900 with placement according to qualifications and experience. The post is subject to superannuation and family allowance is payable where applicable.

Further particulars may be obtained from the undersigned, with whom applications (six copies), giving the names of two referees, should be lodged not later than March 31, 1958.

CHARLES H. STEWART,
Secretary to the University.

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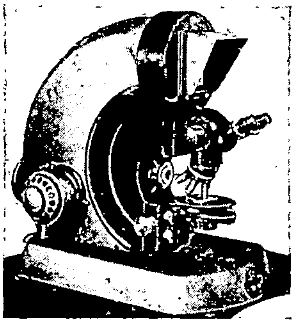

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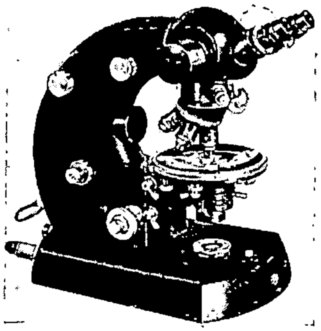

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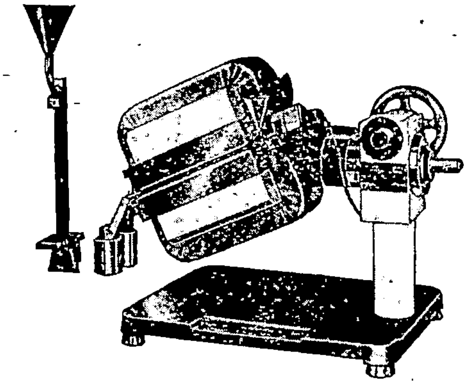

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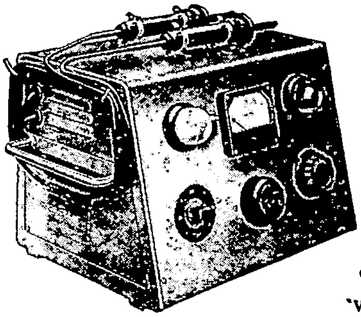

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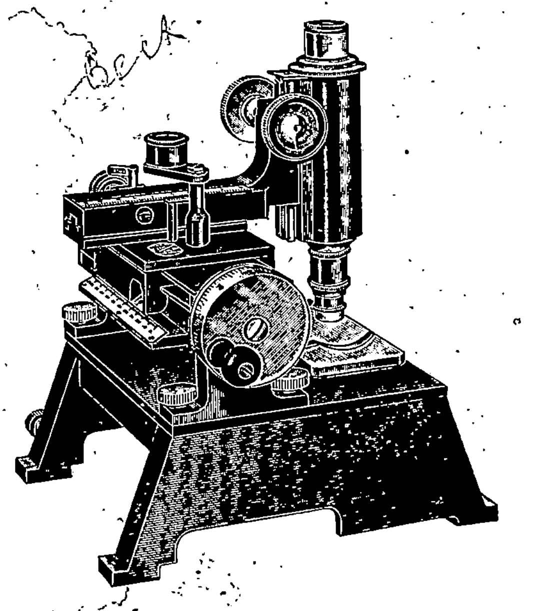

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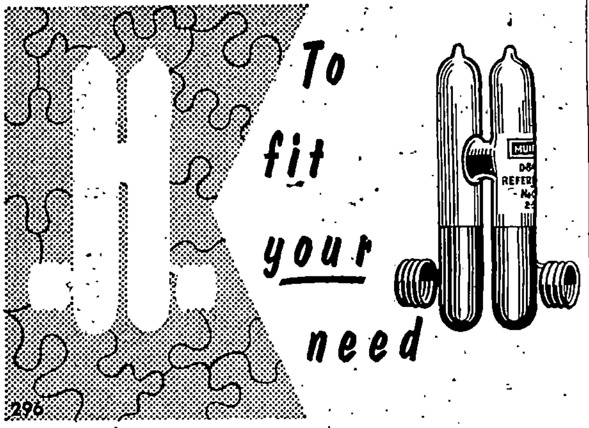

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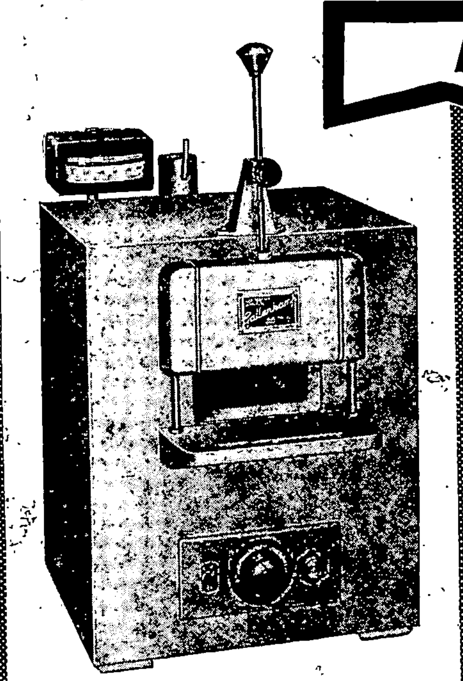

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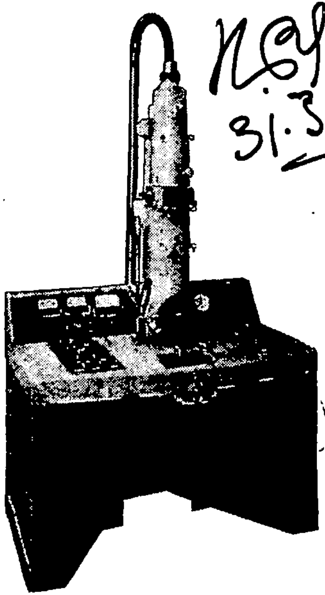

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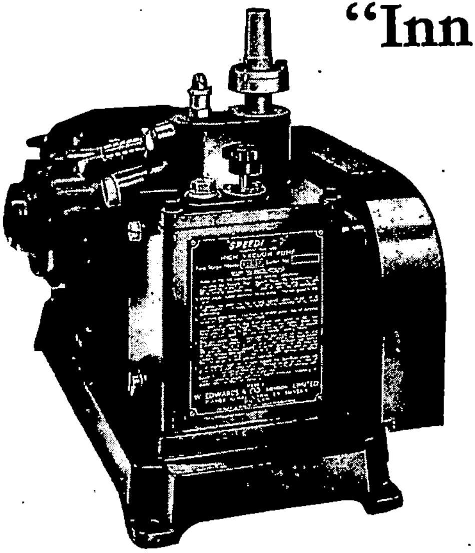

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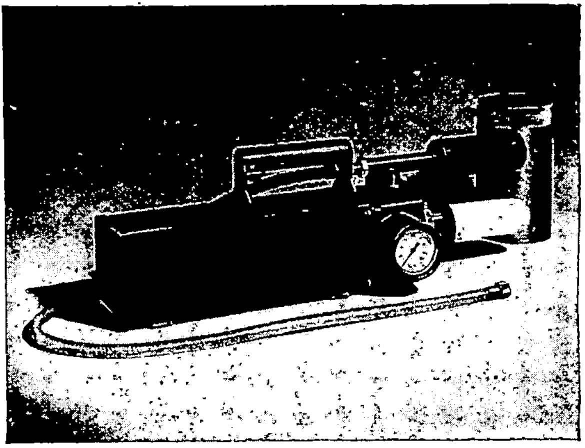

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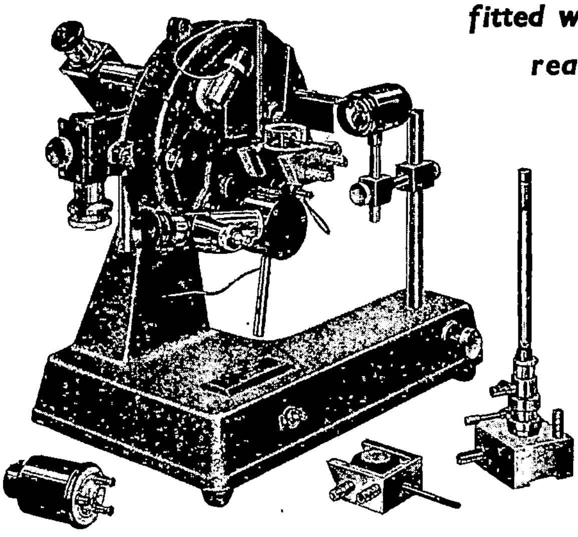

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SCIENTIFIC MANAGEMENT IN NATIONALIZED INDUSTRIES

LORD SIMON OF WYTHENSHAWE'S pamphlet, "The Boards of Nationalized Industries"*, arises out of his experience as governing director of two private engineering firms and as chairman of the British Broadcasting Corporation. It is a noteworthy contribution to the objective discussion of the nationalized industries which party politics have hitherto largely denied. The pamphlet expounds Lord Simon's conviction that the most important single reform in the nationalized industries is that the chairman and other members of the Board should have the same kind of experience, independence and security of tenure as is common in the best concerns of private enterprise ; but it is of wider importance as endorsing the stress laid on the quality of management in the recent reports of the Fleck Committees dealing with the Atomic Energy Authority, to which reference has already been made in these columns (see *Nature*, February 15, p. 439).

The first of those reports stressed the over-riding importance of a suitable organization for recruitment, training and progression of promotion of technical staff and of a positive policy of selection of promising men at an early stage in their careers, followed by planned training on the job by moving them from one part of the organization to another. That policy should be designed to provide managerial staff with a sound understanding of all the main aspects of the organization's work, and while the report outlines in some detail general principles of organization which should govern a large technological production group, it repeatedly stresses the need for some scientific and technical knowledge on the part of those holding the highest managerial posts. The question of management is thus put right in the context of the shortage of scientific and technical man-power and of Britain's need to expand as a matter of urgency both technological and scientific education as well as to modify it to provide men of the qualities needed. The report of the second committee dealing with nuclear safety points no less emphatically to the shortage of technical staff in this field at all levels, though the emphasis is not so much on the management side.

Lord Simon comes out as emphatically as the well-known report of the Fleck Committee on the organization of the National Coal Board as to the vital importance of the quality of leadership at the highest level, and the need for encouraging the development of people capable of filling those positions. The most important single quality in the successful conduct of any large concern, whether public or private, is the quality of the highest authority in it, and Lord Simon's careful comparison of the board of Imperial Chemical Industries, Ltd., with the National Coal Board is intended to throw into relief the strength and weakness of the two boards and the way they are selected, and especially to suggest means by which the National Coal Board could be strengthened. One other observation is of interest in relation to the expansion of technological education, and in particular to the need for fuller attention to training for management. In spite of all the efforts of the National Coal Board in training managers, it must be expected, writes Lord Simon, that another ten or twenty years will elapse before there will be an adequate supply of well-trained executives ready to take on jobs as members of the Board.

This long-term aspect of the selection and training of managers gives urgency to the expansion of technological education in Britain, and to its modification so as to ensure that both the colleges of technology and the universities provide industry and the public services with a constant supply of men and women imaginatively alive to human issues as well as to the scientific and technical aspects of the problems which will confront them—both civilized scientists and citizens understanding the essentials of science, as Sir Hugh Beaver puts it. Unless that supply is ensured and appropriate measures are taken now, both as regards numbers and quality, men of the desired quality may not be forthcoming in sufficient numbers even if, as Lord Simon suggests, the nationalized industries follow the methods adopted by the leading concerns in private enterprise in recruiting their boards. Like the Windscale accident, this analysis of the experience of the National Coal Board points to the need for vision, foresight and vigilance on the part of all concerned.

Lord Simon's survey of private enterprise is not limited to Imperial Chemical Industries, Ltd., though he gives greater details of that firm's board and of the National Coal Board. He points out very fairly that the boards of most good private enterprises to-day, especially some of the largest, are marked by a very deep sense of accountability not only to their shareholders but also to their employees, to their customers, and to the community. There is little reason for thinking that the general attitude of their board members either to efficiency or to public service differs from that of the board members of a nationalized concern.

Reviewing the boards of eight large private enterprises, Lord Simon notes the considerable number of graduates among their members, the substantial number of full-time directors, the care taken in the selection of new directors, and the background of long experience in the industry possessed by the majority of directors, in addition to the usual qualities that are looked for in an administrator and director of policy. The outstanding characteristic stressed by Lord Simon is their security of tenure. Changes in the boards are slow, and while this encourages confidence in the security of their jobs on the part of the directors, the consequent continuity is of the first importance in building up good traditions, wise policy and high efficiency.

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* The Boards of Nationalized Industries. By Lord Simon of Wythenshawe. Pp. 54. (London: Longmans, Green and Co., Ltd., 1957.) 2*s*. 6*d*. net.

It is here that private industry is in most marked contrast with the nationalized industries. Whereas the director of a large private company is virtually sure of keeping his job until he reaches retiring age, the National Coal Board, for example, has been reconstituted twice since 1947. There have been twenty-four full-time members of the three Boards, although the number at any one time has never exceeded nine. The average length of service of those who have left has been 3·6 years, and no present member has yet served for three years; nevertheless, Lord Simon thinks that the present Board, whose members, on the average, have more experience of the industry than the average of the first two Boards, may be much more stable than its predecessors.

Lord Simon is convinced that security of tenure is by far the most important step towards continuity and efficiency of a board of directors, and it will be recalled that the Fleck Report on the National Coal Board also stressed the importance of continuity. Membership of the board of a nationalized industry should, he argues, be a career appointment; and although he agrees that the members should be appointed by the appropriate Minister, this should only be done after full consultation with the chairman and with the acceptance of the board. Further, candidates should have been selected and trained by the methods and on the scale of the best known practice, and appointments once made should continue up to retiring age, subject to the power of the Minister to terminate any appointment—a power which should rarely be used. Salaries, pensions and other conditions of service should be at least comparable with those in leading private firms; in this connexion the recent revision of salaries of members of various public boards, taken with the security of tenure stressed by Lord Simon, may help to overcome the present reluctance of outstanding men in a nationalized industry to accept appointments to its board.

This factor will obviously be of increasing importance when in ten to twenty years time the boards of the nationalized industries have an adequate supply of first-rate candidates from within the industry competing for vacant positions on them. Lord Simon's remarks on accountability also have a bearing in this connexion, though their chief interest is in a wider context. Having obtained a good board, an industry should be given the maximum freedom and responsibility subject to the necessary minimum of control by the Minister. This is essential if the board is to acquire the status that ultimately will enable it to recruit members of the calibre desired; and incidentally, as Lord Simon notes, to attract to the industry a sufficiency of the ablest graduates leaving the universities and colleges of technology of Great Britain.

The question of the exercise of Ministerial powers is regarded by Lord Simon as mainly a matter of good sense, but it should be a matter of high principle for every Government and every Minister to allow a board the maximum freedom and responsibility within the broad limits of national policy. On the strict issue of accountability, Lord Simon maintains that Parliament must realize that it is not competent to contribute anything whatever to the efficiency of, for example, the coal industry, while too much interference may cause serious inconvenience and even inefficiency. He agrees with Lord Heyworth that autonomy and responsibility to Parliament are inconsistent, and approves of Mr. Herbert Morrison's suggestion that accountability is best served by a periodical inquiry, at intervals of not less than seven years.

Lord Simon recognizes the value of parliamentary discussions in clarifying broad lines of public policy and indicating trends of public opinion, and also that the Parliamentary question, if it avoids matters of day-to-day management, is an important means of securing information and a safeguard against abuse. Here again it is largely a matter of common sense, and accountability may well become easier as the discussion of the problems of nationalized industries becomes more objective. That in itself should contribute to public confidence in the industries, as well as encourage greater stability and self-confidence within the industry and thus provide conditions in which the industry can develop its own standards and criteria of efficiency.

Here a suggestion made by Mr. R. Nottage, director of the Royal Institute of Public Administration, could be helpful. Discussing the use of the annual reports of the nationalized industries, he suggests that the adoption of a standard pattern might assist Parliamentary discussion. The record of operational results, both physical and financial, should facilitate adequate comparison with previous years and an understanding of the basis on which indices are selected. Presentation in such a form, with adequate reference to future plans and the periodical discussion of major topics on such a time scale as is adopted, for example, in the Unilever annual report, would give Parliament the information which the public interest rightly demands, and turn discussion into constructive channels rather than the detail and sterile issues which have been encouraged so much in the past. Lord Simon at least has indicated some of the opportunities. The juxtaposition of his pamphlet with reports of the Fleck Committees and of some other management literature should give a fresh impetus to measures for the expansion of scientific and technological education in Britain, upon the adequacy of which the quality of management and the efficiency of British industry ultimately depend. Education is, as always, the keystone of any such developments, and until a broad view is accepted of the scope of technical and technological education, the problem of supplying the men for the higher levels of management will remain with us.

ARCHITECT OF BRITISH MEDICAL RESEARCH

The Bright Countenance

A Personal Biography of Walter Morley Fletcher by Maisie Fletcher. Pp. 351+8 plates. (London: Hodder and Stoughton, Ltd., 1957.) 25*s*. net.

I HAVE heard it argued that it is a mistake for anyone to review the biography of a friend. He is biased from the start and likely to pay too much attention to the biographer's treatment of his friend, and too little to the literary or historical merit of the book itself. If this is so, then I should not be reviewing Sir Walter Fletcher's biography, for I am certainly biased from the start. Fifty years ago he was my tutor at Trinity College, Cambridge. He never attempted to preach at undergraduates or talk down to them. Instead he held up to us, quite unconsciously and in an almost diffident manner, a great example of poise, manliness and integrity of thought. Here was a man, we felt, firm of purpose and bound to the highest ideals of behaviour—a guide to be remembered in facing the moral and material issues of life which lay before us.

It was with these thoughts in mind that I opened this biography by his widow with some anxiety, for it is notoriously difficult for any woman to paint a true picture of her husband—difficult for her to interpret actions or even characteristics apart from their impact on her and apart from her own intimate association with them. I need not have feared. Lady Fletcher has succeeded in being objective. I am sorry, however, that, doubtless with this in view, she has written in the third person, thus removing not only herself but also the reader one stage from the scene. On the whole I should rather have read "I was delighted to see him back" than "Maisie was delighted to see him back". Another regret is that she has not used as her title Milton's words in full—"the bright countenance of truth". Not everyone is familiar with the quotation, and her publishers should not have allowed the abbreviation which makes the title so dreadfully misleading.

These, however, are small points. To me, at any rate, this book was a strangely moving revelation. His singleness of purpose, his amazing industry, his freedom from petty thoughts of all kinds, his joy in holidays and all out-door activities, his readiness to give always of his best whether in small things such as helping a troubled undergraduate or in great affairs of national medical policy—all these things we knew. What we now more fully realize is his courage, his deep spiritual convictions, and the real happiness he found in his family, his home and his friends.

To turn from the man to his work: this falls into two main periods—first, his years at Cambridge as research worker and tutor and Fellow of Trinity College, and then after 1914 his secretaryship of the Medical Research Committee (later Council) until his death in 1933.

His research work is summarized in Sir Arthur MacNalty's supplement to the book under review, but as full accounts are available elsewhere—notably in Prof. T. R. Elliott's obituary notice ("Obituary Notices of the Fellows of the Royal Society", 1, 153; 1933)—there is no need to refer to it in any detail here. It is sufficient to say that his studies, extending over some sixteen years, on the chemistry of muscular respiration were classical. As W. B. Hardy wrote, "origins are as difficult in science as in literature: here, however, it is safe to credit Fletcher with that first step that counts". He gave a new direction to biological thought.

From 1914 onwards Fletcher's life-work was to originate, inspire and support the research work of others. The National Insurance Act of 1911 provided that for each insured person one penny should be set aside for medical research. This, it was thought, would yield £57,000 per annum—an interesting comparison with to-day's annual expenditure of some £2½ million. The original proposal was to assign the whole sum to research on tuberculosis, a disease which was expected to be especially costly to the taxpayer. Wiser counsels prevailed, however, thanks principally to Dr. Christopher Addison (Viscount Addison), Lord Astor and Sir Robert Morant, and it was finally enacted that research could cover "any disease to which insured persons are liable". A Committee under Lord Moulton of Bank was appointed to administer the fund, with an advisory council of some forty medical men. But the appointment of a secretary was long postponed. As Gowland Hopkins wrote, "an ideal appointment seemed almost impossible of achievement. Looking back to those weeks during which it was in suspense, I feel that the future of medical research in this country was then facing a critical moment. But at last came the happy solution and it was T. R. Elliott who suggested it". Fletcher's appointment met with instant and general approval, particularly from Sir Robert Morant, chairman of the National Insurance Committee to which the Medical Research Committee was attached, who was a man inspired by almost fanatical zeal for benefiting the people of England in education, health and well-being. "These ideals," wrote a friend, "found not an echo but a counterpart in what had been innate in Fletcher, whose spiritual depths were uplifted by the vision of service for others in so wide a field. Scientific research became more than a beautiful use of the intellect in approaching the truths of Nature, for he now realized the need by England of its direct application to all the problems of ill-health. Henceforward he, too, became a great public servant and sank his own conspicuous abilities for research in guiding and helping countless other men."

From the first the Committee's policy was to set up a comparatively small central research institute with its own staff, and to spend the greater part of the funds in support of investigations in private or voluntary institutions, where hitherto nearly all medical research had been done with little if any help from the State. The Mount Vernon Hospital at Hampstead was purchased and four Departments set up in temporary accommodation—(1) Bacteriology (Sir Almroth Wright and S. R. Douglas), (2) Biochemistry and Pharmacology (H. H. Dale), (3) Applied Physiology (Leonard Hill and Martin Flack), and (4) Statistics (J. Brownlee). A proposal to include a research hospital of twenty beds was abandoned on Fletcher's advice: he rightly considered that clinical research could better be carried out at existing and fully equipped hospitals.

The outbreak of the First World War interfered with many other plans, but Fletcher at once saw that military needs gave him an opportunity for establishing beyond all doubt the importance of medical research and the vital service which it could render.

He submitted a White Paper (Cd. 7922) containing proposals for research in direct connexion with the war and, most important of all, established full collaboration with the Army Medical Department. With the active help of Sir Alfred Keogh, Director General of the R.A.M.C., a channel for information and research on specific problems was operative between the Medical Research Committee and the army medical services in the field and home hospitals throughout the war.

With the return of peace and the establishment in 1919 of the new Ministry of Health came another moment of crisis in the history of the Medical Research Committee, for it was proposed to place it under the control of the new Ministry. Fortunately Fletcher had two enlightened men to deal with—Addison and Morant. Fletcher argued, first, that a progressive Ministry of Health will inevitably find itself committed from time to time to particular policies of health administration. A research organization under its control would be obliged to keep in step with current policy, instead of being free to recommend changes in policy in the light of new knowledge. Secondly, if the research organization formed part of the Ministry, its activities might come to be unduly restricted to problems of pressing practical urgency relating to the Ministry's executive functions, thereby excluding fundamental work which in the long run might be of more value. Thirdly, the Ministry operated only in England and Wales, but research organizations should cover the United Kingdom and reach out to the whole Commonwealth and Empire.

These views were accepted and in 1920 the Medical Research Committee became by Royal Charter the Medical Research Council, reporting to the Privy Council (an arrangement already in force with the Department of Scientific and Industrial Research and to be repeated in 1931 with the Agricultural Research Council). Only the other day a senior official of the Ministry of Health commented on this decision. "I am devoted", he said, "to the Ministry I have served so long. I believe it has done and is doing good work. But the greatest of the services which Fletcher rendered to medicine was to prevent the Medical Research Council from becoming its servant."

The subsequent progress and achievements of the Council need no recapitulation here. As Sir Arthur MacNalty writes, "it is not given to every pioneer to see the results of his labours, but Fletcher had the supreme satisfaction of knowing that the cause to which he had devoted all his energy and gifts had triumphed, and that he had established medical research in this country on secure foundations".

Lady Fletcher has written this biography primarily, she says, for "Walter's nine grandchildren", but she has placed all who knew him in her debt. Two comments which she quotes together sum up, I think, what we realize still more clearly after reading her book. The first is from *The Times* leader on the day after his death: "Fletcher was friend to every honest seeker after truth and he possessed in special degree the faculty for friendship. . . . His loyalty was unquenchable and he served no ends except those of the good of his fellows". The other is from his cousin, Sir Clement Jones: "Ever since my first year at Trinity I remember Walter as one who excelled in everything he tried to do, and he always aimed at the very best things and the high and honourable things. I shall never hear his name mentioned without thinking of those high standards in work, in play, in conversation and perhaps above all in friendship". May I, in conclusion, add one more quotation, from a letter by Sir Ernest Gowers, because it so exactly reflects my own feelings: "I never ceased to feel his friendship was an honour as well as a delight". WILLIAM GAVIN

IRRIGATION WORKS

Irrigation and Hydraulic Design

By Dr. Serge Leliavsky. Vol. 2: Irrigation Works. Pp. xvi+864+85 plates. (London: Chapman and Hall, Ltd., 1957.) 294*s* net.

THIS, the second volume of Dr. Leliavsky's monumental trilogy on irrigation, is devoted to the specific design of irrigation works. The first volume, comprising Chapters 1–3, contained the theoretical background necessary for the hydraulic side of the design, while this volume, comprising Chapter 4–8, is concerned with the detail of the structures and irrigation planning. As in the first volume, the approach is basically historical, a treatment which has both advantages and disadvantages. The main advantage for the reader is that of having the steady progress of the subject explained and commented on by one who was himself in daily contact with, and in the forefront of, these developments. The disadvantage is that as a design manual, which is the intention of the book, the treatment in places becomes discursive and prolix.

The scope of the book is sufficiently well illustrated by the chapter headings, which are: the design of regulators (Chapter 4); the design of irrigation and drainage syphons (that is, cross-drainage works) (Chapter 5); weirs and other hydraulic works (Chapter 6); planning and designing a perennial irrigation scheme (Chapter 7); and canal bridges, aqueducts and gates (Chapter 8). The engineer will particularly welcome the detailed analyses of examples of various types of structure drawn from existing works mainly within the author's own experience. Study of these should enable a competent engineer to design similar structures for himself. The last chapter comprises more than a third of the book, and is devoted exclusively to structural design. In the case of gates, the author is here concerned with the static loading, although vibration normally plays a major part in failure, as it did in the one case quoted by him. In general, problems of chatter and fatigue failure loom large in high head structures, and designers would welcome more guidance on these matters.

The general system of irrigation used as a model in the book is naturally, in view of the author's close association with it, that practised in Egypt. It is clear that the main problem now facing engineers in that country is waterlogging, due to the too liberal application by cultivators who had for many years been starved of water. However, the problem of soil salinity now menacing the irrigation communities in India does not seem to have appeared in Egypt. A comparison of the two systems might reveal why this is so, and it might well be that the installation of a system of drains and pumping stations rendered necessary to deal with waterlogging in Egypt might also have to be faced in India for the quite different purpose of leaching out salts.

The second major difficulty of irrigation, namely, siltation and the problem of designing canals which neither silt nor scour, has received a somewhat superficial treatment, the author contenting himself with quoting a number of design formulæ and graphs without probing the matter more deeply. The reasons for the different formulæ used in Egypt and India are not stated and no guidance is given as to the particular form to be adopted in other areas. The most recent formula for the velocity–depth relation for non-silting canals has quite a different form from that previously adopted, although a thorough analysis is precluded by lack of data concerning the size and amount of solids carried by the canal.

The layout of the book is excellent and the text, which is both lucid and fluid, is illustrated by a large number of diagrams and plates. However, design offices will regret the frequent changes of units.

G. H. Lean

DISEASES OF CEREAL CROPS

Cereal Diseases in Ireland

By Prof. Robert McKay. Pp. x+161+54 plates. (Dublin: At the Sign of the Three Candles, 1957.) 21*s*.

THIS is the sixth in the series of handbooks dealing with crop diseases in Ireland written by Prof. R. McKay, illustrated with splendid photographs by G. H. McLean and published by the Three Candles Press. Of similar format to its predecessors, this volume deals with the diseases of cereal crops; it has an excellent frontispiece in colour with occasional colour plates scattered through the text. The foreword is by the Earl of Iveagh. The book is divided into six sections with an appendix. The sections deal respectively with the rusts, smuts, other parasitic diseases, parasitic diseases occasionally seen, miscellaneous diseases of non-parasitic origin and eelworm attack, while the appendix gives some account of the barberry and buckthorn, alternate hosts of some of the most important cereal rusts, with special reference to their distribution in Ireland. It could be suggested that the material dealt with in the appendix would have been better placed with the section dealing with the rusts.

Some passages, such as appear, for example, in the section dealing with loose smut of oats, read a little more like a text-book of plant pathology than a semi-popular treatise, but this merely illustrates the great difficulty the author of such a work as this has in consistently envisaging the needs of the readers for whom the book is intended. It is no easy matter to prepare a glossary of terms for a work such as this and, although a useful one is provided, the omission of some such as ascocarp, stroma, mesocotyl, etc., is noticeable. The illustrations of disease symptoms are profuse and excellent, but when so much mention is made in the text of the various spore forms of the rust fungi, for example, it seems a pity that some attempt was not made to illustrate these and their methods of germination. The choice of references would have been improved by being more inclusive.

The book is written in a simple straightforward style and is very readable. Part of the reason for its appearance is as a guide to agricultural advisers to help them to be able to identify, more readily, cereal diseases in the field. It is also intended to be of service to young farmers attending winter classes in agriculture or engaged in club work. The book is excellently produced and maintains the high standard of the Three Candles Press. There are very few errors, printing or otherwise, and only two were detected. The illustrations are particularly valuable and up to the high standard one might expect. Priced at one guinea, the publication is worth the money as a book, although it may seem a little expensive for many for whom it is intended. The whole tenor and tone of the work, like that of the earlier volumes, denote the enthusiasm of the author and mark him out as one of the keenest plantsmen that Ireland has produced.

A. E. Muskett

GUIDES TO ORGANIC CHEMISTRY

Organic Synthesis

By Dr. Vartkes Migrdichian. Vol. 1: Open-Chain Saturated Compounds. Pp. xxviii+834. Vol. 2: Open-Chain Unsaturated Compounds; Alicyclic Compounds; Aromatic Compounds. Pp. xiv+835–1822. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957.) £14 the set of two volumes.

SINCE the inception of the fundamental theory of organic molecular structure a century ago (1858), with the addition seven years later of that "crowning achievement of the doctrine of the linking of carbon atoms", the idea of the benzene ring, organic chemistry has advanced in a kind of geometrical progression. A concrete expression of its vast scope at the present day is embodied in the current edition of "Beilsteins Handbuch", which includes to date some ninety massive volumes, although (except for the latest volume) these cover the literature only to 1929. It is understandable, therefore, that the specialist in organic chemistry is nowadays largely dependent upon various types of more concise and up-to-date guides to this great efflorescence of organic chemical information. Such guidance is afforded by a multiplicity of monographs on special fields and by various periodicals exemplified by the American publication, "Chemical Reviews", and the British "Annual Reports", *Quarterly Reviews* and *Current Chemical Papers*.

A fundamental problem lies in the effective presentation of the large number of chemical reactions now available for preparative and research work, in both pure and applied organic chemistry. Very helpful in this way are the American publications, "Organic Syntheses", an annual collection of reliable preparative methods for individual compounds, and "Organic Reactions": each of the nine volumes of the latter, issued since 1942, deals in detail with a number of reactions of synthetical importance.

Dr. Vartkes Migrdichian's work, although bearing upon the same ultimate problem as these two publications, differs from them in two important respects. First, it is not a periodical but a complete work; secondly, his review of reactions is comprehensive and systematic, instead of being limited to an arbitrary selection and arrangement. The first volume covers the open-chain saturated compounds; the second takes in the much wider field of open-chain unsaturated compounds, alicyclic compounds, and aromatic compounds. A third volume dealing with heterocyclic compounds is contemplated.

The thirty chapters follow closely the arrangement of a standard text-book of organic chemistry. Methods of formation are followed by a review of reactions of the type of compound under discussion. The Grignard and Friedel–Crafts reactions, and the diene synthesis, with their exceptionally wide applications, are treated separately. In general, however, reactions are classified under the heading of compounds of the type with which they are chiefly associated: thus, the Fries reaction will be found under the heading of phenol esters; and the Wagner, Nametkin and Demjanow rearrangements under alicyclic hydrocarbons.

The work is a useful compendium of an enormous amount of material, and is fully documented, although the literature of the past decade is sometimes sparsely represented. Theoretical discussions are not included, and reaction mechanisms are mentioned only when generally accepted. The text, formulæ and tables are clearly printed by a modern economic process; nevertheless, the price is distinctly high. As might be expected, in so extensive a compilation, misprints are not uncommon.

Dr. Migrdichian, who is senior research chemist to the American Cyanamid Co., with a record of some thirty years in the field of work leading to these volumes, is to be congratulated upon the result of prolonged labours that will minimize those of the many organic chemists who will derive welcome help from this publication. John Read

ELECTRICITY AND ELECTRICAL MACHINES

Electrical Engineering (General)

Electrical Circuits—Instruments and Measurements—Electric and Magnetic Fields—Conductors—Insulating and Magnetic Materials—Electronic Tubes. By A. T. Dover, Dr. F. T. Chapman, Prof. F. Brailsford and Harley Carter. (Electrical Engineering Series.) Pp. ix+489. (London and New York: Longmans, Green and Co., Ltd., 1956.) 50*s.* net.

Electrical Machines

By A. Draper. (Electrical Engineering Series.) Pp. xvi+346. (London and New York: Longmans, Green and Co., Ltd., 1956.) 40*s.* net.

The General Theory of Electrical Machines

By Bernard Adkins. Pp. ix+236. (London: Chapman and Hall, Ltd., 1957.) 45*s.* net.

THE first two books belong to a series intended for use by students preparing for Higher National Certificate, degree, and other examinations. The preface states that "Electrical Engineering (General)", the first of the series, is limited in scope to theory connected with electric circuits, instruments and materials for use with direct currents and alternating currents of power frequencies. The manner and depth of treatment vary considerably from topic to topic. Three chapters contributed by Prof. Brailsford provide a lucid and up-to-date account of ferromagnetic phenomena. Unfortunately, the same fundamental approach has not been applied to the discussion of conducting and insulating materials, the treatment of which is reminiscent of an engineer's handbook. This criticism could also be levelled at some of the material concerning commercial measuring instruments. It is perhaps inevitable that a book written by a panel of authors should consist of discrete sections, but it must be confusing to students to find, for example, a discussion of network theorems as part of direct-current circuit theory, without any mention of their general application, while later the star-delta equivalent impedances of a 3-phase circuit are derived without any reference to an earlier and similar derivation among the network theorems. Despite the declared limitation to power frequencies, two chapters on electronics describe various types of radio-frequency apparatus. A useful and comprehensive selection of examples, with answers, many taken from examination papers, is provided at the end of the book.

" 'Electrical Machines' has been written as a text-book for students and not as a treatise for designers." Here, at last, students can find under one cover details of nearly all types of electrical machines. The omission of the single-phase machine is, however, to be regretted; it is, after all, very common. Academically there also appears to be no justification for including the mercury-arc rectifier in a book on machines. The approach to the subject is logical and on traditional lines, and should appeal to the student of electronics studying machines as a secondary subject. He will also find the sections on rotating and magnetic amplifiers very useful. The book can be recommended unconditionally to such students. Those taking heavy-current subjects for a degree course will probably wish for greater depth of treatment, but it is an excellent second-year book. The author and the British Thomson-Houston Co., Ltd., are to be highly commended for the clarity of the diagrams, so essential to a book on machines. The examples at the end of the book are well chosen, even though there is a mixture of units. The appendix on the measurement of three-phase power will prove very useful to students in the laboratory.

The general theory of electrical machines has been presented by several writers in a form so mathematical as to appear remote from whirling masses of copper and iron, and the publication of Mr. Adkins's book, in which the theory is applied to computing the details of machine performance under varying conditions, is all the more welcome. The author is a reader in the University of London, and his careful explanation of small detail shows his appreciation of the needs of students; but he has behind him an industrial career much longer and more distinguished than most professors or lecturers. This greatly enhances the value of his work, for he speaks with authority on the relative numerical importance of the terms in his equations, and is thereby enabled, by eliminating small effects, to present a clearer picture of the chief phenomena. His use of the 'per-unit' system is perhaps open to criticism in a students' book; it is easy to see its value to the designer, but it takes the student too far from fundamentals, destroys the dimensional consistency of the equations, and involves the author in quite a number of interpolated explanations of the values of coefficients. It is also possible to regret the somewhat disproportionate space accorded to the synchronous machine as compared with other types of a.c. motor. Nevertheless, the book is the best yet written in English to develop machine performance from general principles in a manner calculated to appeal to engineers and engineering students.

T. Wilson
D. A. Jones
G. W. Carter

Science and Existence

Two Ways of Knowing. By Alan Richardson. (Technics and Purpose, No. 1.) Pp. 30.

Scientific and Technological Education

By Edwin Barker. (Technics and Purpose, No. 2.) Pp. 37.

Technical Education

By H. A. Warren. (Technics and Purpose, No. 3.) Pp. 37.

Purpose in Teacher Training

By Monica Wingate. (Technics and Purpose, No. 4.) Pp. 38.

(London: S.C.M. Press, Ltd., 1957.) Each 2*s*. 6*d*. net.

THE British Council of Churches is sponsoring a series of booklets to examine the issues arising out of the growth of science in society and the rapid expansion of technological education, particularly in relation to the purposes and values involved in the light of the Christian faith. For several years a working party convened by the Education Department of the British Council of Churches, under the chairmanship of Sir John Wolfenden, vice-chancellor of the University of Reading, has been meeting to consider some of the issues involved; it has now asked certain individuals to take responsibility for bringing together some of the views expressed in discussion. In the first booklet Prof. Alan Richardson, of the University of Nottingham, distinguishes with great clarity between 'scientific' and 'existential' knowledge. The narrowness of scientific and technological education is examined by Edwin Barker, assistant general secretary of the National Council of the Young Men's Christian Association, in the second booklet, while in the third, H. A. Warren, principal of the South-East London Technical College, describes the system and scope of technical education in England and Wales and makes an appraisal of some of its social and cultural effects. In the fourth booklet, Monica Wingate, principal of Balls Park Training College, searches out the purpose in teacher-training with irresistible persuasiveness; her readers might have been even more sympathetic if she had first made sure that they were aware of the ways in which teachers are trained in Britain's training colleges. Before other booklets in this series are produced, more thought might be given to the purpose behind each and to make this clear in a preface; the sequence in which they are issued should also be examined.

T. H. Hawkins

Malayan Orchid Hybrids

By M. R. Henderson and G. H. Addison. Pp. iv+191. (Singapore: Government Printer, 1956.) 21 Malayan dollars.

ALTHOUGH there is such a wealth of orchid hybrids available for cultivation in temperate countries, many of these are not happy when grown under tropical conditions. Successful efforts have therefore been made in recent years to develop hybrids within other orchid genera which are better suited to the tropics. These include the genus *Dendrobium* (particularly the section *Ceratobium*), the climbing orchids of the Vanda-Arachnis group, the strap-leaved *Vanda* species and *Spathoglottis*. The chief two centres in which this hybridization has been carried out are Malaya and the Hawaiian Islands. The present book aims at providing photographic illustrations of the more important and beautiful hybrids which have been raised, or are commonly cultivated, in Singapore.

For most varieties dealt with there are photographs of a single flower and of a complete inflorescence. These photographs reach a high standard and are excellently reproduced on art paper. Accompanying them are brief texts which include information about parentage and place of origin as well as short descriptions and notes on cultivation. Well-illustrated and concise accounts of the cultivation in Singapore of the main groups of hybrids precede each section of the book.

Orchid growers in Malaya and in the neighbouring countries will welcome this book and it will be of value to growers in other tropical regions. It will also serve to stabilize the nomenclature of these hybrids, to which additions are continually being made. Altogether the authors are to be congratulated on the production of a useful as well as very attractive book.

A Glossary of Mycology

By Walter H. Snell and Esther A. Dick. Pp. xxxi+171 (15 plates). (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1957.) 40*s*. net.

MYCOLOGY, like all other sciences, has developed its own shorthand terms to describe the diversity of form, substance and function of fungal organisms. The present volume describes nearly seven thousand such terms, and, apart from the names of colours and certain words used in general botany, most have no meaning outside this science. This number of words is almost enough, in a simpler context, to found a language; have we too many of them? The majority save quite lengthy explanations, and so are justified as shorthand. A considerable number apply only in special parts of mycology, but this serves to indicate fungal complexity rather than redundant verbiage. A few terms, now obsolete but used in earlier literature, have historical value. A minute minority are colloquial. Colour names link those in the authoritative but relatively inaccessible "Repertoire de Couleurs" with other and more available specifications. Fifteen very clear line blocks by Henry A. C. Jackson elucidate many terms. The authors have, in all, performed a most necessary service, and have done it in a most scholarly manner.

J. Grainger

The Life of the Shrew

By Dr. Peter Crowcroft. Pp. vi+166. (London: Max Reinhardt, Ltd., 1957.) 15*s*. net.

THIS is an excellent account of the biology of the species of British shrews, with perhaps more emphasis on the common and pigmy shrews. Their general behaviour, fighting propensities, reproduction, activity rhythm and feeding, their longevity (or should it be brevity?) and their position both as predators and prey are all dealt with. Much is the result of the author's own observations and experiments; but all the previously known facts have been incorporated in a very readable book. The shrew's reputation in folk-lore and in naturalists' accounts, even as late as 1911, is shown to be largely erroneous. The gaps in our knowledge and the methods by which they may be filled are dealt with in a stimulating and attractive manner. There are a good bibliography and index, while the tailpieces by Erik Thorn portray the characteristic postures and behaviour of shrews most admirably.

H. R. Hewer

ALPHA-RAY ACTIVITIES OF HUMANS AND THEIR ENVIRONMENT

By R. C. TURNER, J. M. RADLEY and Prof. W. V. MAYNEORD
Physics Department, Institute of Cancer Research: Royal Cancer Hospital, London, S.W.3

THE radioactivity of the human body and its environment has become a matter of increasing importance and concern particularly in view of the hazards now known to be associated with the ingestion or inhalation of small quantities of radioactivity. It is well known that the human body normally contains small quantities of naturally occurring radioactive elements particularly concentrated in bone[1-3]; but to what extent these materials are derived from foodstuffs, drinking waters, or other ingested substances, is largely unknown for a particular individual. The knowledge of the natural radioactivity of our environment is so scanty that it seemed possible that a number of natural sources of irradiation of human beings exist of which we are, at the moment, ignorant. Although largely unknown, these levels of radioactivity have been assumed to be of rather academic importance, yet they form the only sure ground upon which we may argue as to the dangers of different levels. For example, the natural background of γ-rays gives us a standard by which we may judge the possible effects of increased radiation on the genetic material of the race, while the natural radiation to which bone for many generations has been exposed gives us a basis on which to judge any possible increase in the production of bone tumours or leukæmia. Since many of the naturally occurring radioactive nuclides emit α-particles it seemed worth while to look again for such α-activities both within the human body and its environment. This article outlines the results of investigations over a fairly wide range on many hundreds of samples.

Experimental Technique

We have devised a simple method which enables us to measure α-activities without elaborate chemical preparation[4].

The material, the activity of which is to be measured, is often human or animal tissue and is normally prepared by ashing at 600–700° C., and grinding the residue to a powder. A shallow translucent tray is formed by stretching Scotch tape over one surface of a 'Perspex' ring about 11 cm. internal diameter and about 3 mm. thick. The inside adhesive surface of the tray so formed is covered with a thin layer of finely powdered nickel-killed zinc cadmium sulphide which serves as the α-detecting phosphor. The tray is filled with the powdered sample and is sealed by further layers of Scotch tape stretched across its upper surface. Such a tray holds 2–3 gm. of unit density material of which only about 150 mgm. contribute to the counting, the precise amount depending, of course, upon the range and therefore the nuclide from which the α-particles come. This sealed tray ensures freedom from contamination. Samples may be stored indefinitely, and repeated measurements made at appropriate intervals, the rate of rise of activity to equilibrium after sealing yielding important data in identification of nuclides present. The sealed sample is presented to the photo-cathode of a multiplier and the α-particles counted by suitable techniques. The lowest backgrounds observed by us were obtained using samples of aged distilled water, and are approximately 3 counts per hour in counting periods extending over a week. The sensitivity of the method may be gauged from the fact that 1 count per hour above the background corresponds to about 4×10^{-14} c./gm. of sample and thus enables the normal α-activity in bone ash (that is to say, about 2×10^{-13} c./gm.) to be determined to an accuracy of some 15 per cent in a counting time of 24 hr. Details of the technique will be published elsewhere[4]; but it is obvious that great care has to be taken to avoid contamination. The method has been modified to measure the activities of solid, liquid or gaseous samples. A study of the elementary geometry of counting shows that the number of particles (N) emitted per unit volume per unit time and the range (R) of the particles in the material are the determining constants, and that the product $NR/4$ gives the number of particles per cm.^{2} which are observed in a given time. We have discussed in detail[4] the effects of density and of atomic number on the range of the particles and calculated mean ranges in media of varying atomic numbers and densities.

Early in the experiments it was observed that materials containing thorium and its daughters, at low counting rates of the order of 10–100 counts per hour, yielded a number of closely spaced pairs of α-particles. These arise from the two consecutive α-transitions thoron (220) to thorium A (216), and thence to thorium B (212). Since the half-life of thorium A (216) is only 0·14 sec., and since no analogous phenomenon occurs in the radium series, the frequency of occurrence of these fast pairs gives a direct measure of the rate of disintegration of thoron atoms. The results must, of course, be corrected for the chance occurrence of spurious pairs. By a development of this argument it is possible to estimate what fraction of the observed total α-count arises from the uranium and from the thorium series respectively. This phenomenon, well known in the history of radioactivity[5], has enabled us to demonstrate and measure the fraction of the activity of normal human bone which arises from the thorium series.

Abnormal Radioactive Contents in Humans

Some of our first experiments were carried out on samples of the humerus from a radium worker who ingested active material around the period 1910. The observed counting rates were very high, 17,500 counts per hour in our normal sample, and the resulting activity of $4{\cdot}70 \times 10^{-11}$ gm. radium-226 per gm. wet bone was in good agreement with estimations of radium which had previously been made by pressure ionization chamber techniques, autoradiography, physical-chemical assays and excreted radon[6]. We have also measured a number of samples of humerus from a worker who ingested both radium and mesothorium 8–10 years earlier. Again, the estimated ratio of radiothorium to radium was in good agreement with previous measurements, as were the absolute values of $5 \cdot 3 \times 10^{-12}$ c. and $5 \cdot 9 \times 10^{-12}$ c./gm. wet bone respectively (Spiers, F. W., private communication). It was established that other bones of the same subject (ribs and sternum) gave values for the radiothorium ranging from $6 \cdot 0 \times 10^{-13}$ c. to $5 \cdot 3 \times 10^{-12}$ c. per gram of wet bone, but the ratio of radiothorium to radium (0·89) was surprisingly constant throughout the various parts of the skeleton.

As a further example of the flexibility of the technique we may mention that we have measured the breath and the blood of a patient who was given 'Thorotrast' for diagnostic reasons some twenty years ago. The estimated breath activity was $1 \cdot 5 \times 10^{-9}$ c. thoron per litre and the blood content of thorium $B = 3 \cdot 5 \times 10^{-12}$ c./cm.^{3}.

Normal Radioactivity in Humans

The cases we have quoted are of patients having very large radioactive burdens perhaps ten thousand times greater than those of the general population, and we now turn to studies designed to find the mean level of α-activity of normal populations. We were particularly anxious to obtain data concerning young children since little information exists as to the concentrations of radioactive material present at birth. We have, therefore, made measurements on as much stillborn material as could be obtained.

Observations have been made on the α-activities of bones of persons native to Cornwall, London and Cumberland, respectively. 31 Cornish (humerus), 17 Cumberland (femur) and 12 London (humerus) bone specimens have been examined. In the case of the 11 stillborn children, all of whom were full-term, low calcification and small size of the bones make it necessary to ash the whole of one of the long bones, in this case the femur.

The results of the human bone measurements are shown in Fig. 1. It will be observed that there is great variation in absolute level, and that on the whole Cornish bones have higher values than those observed from the London area or from Cumberland. The mean content of the Cornish material was $5 \cdot 0 \times 10^{-13}$ c. of α-activity per gm. bone ash compared with $1 \cdot 7 \times 10^{-13}$ c. for the London area. This difference appears to be statistically significant; but the question remains as to whether the subjects form representative samples of the inhabitants of the two regions. The values could be influenced by geographical factors, and also by the fact that a number of the specimens drawn from the London area were cases of advanced malignant disease known to have low calcium content. It will be shown later that differences in feeding habits could also be very significant. One of the most interesting findings is the unexpectedly high value for the concentration of α-activity of stillborn children[7], the mean value in our experiments being $4 \cdot 5 \times 10^{-13}$ c. per gm. bone ash. It appears that in adult bone approximately 40 per cent of the α-activity is due to the radiothorium series. For the 11 stillborn children the mean fraction is the same, a result which is particularly interesting.

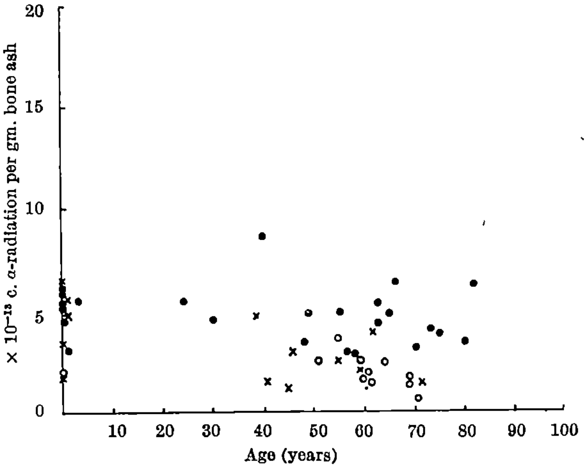

Fig. 1. Human bone ash, total α-activity. ●, Cornwall; ×, London; O, Cumberland

The other striking feature of Fig. 1 is that there is no obvious correlation of α-activity with age. In view of the great interest in the radioactivity of children we have measured four samples of liquid milk and found a mean value of $3 \cdot 1 \times 10^{-13}$ c. per gm. ash. This implies that the total α-content and the mean radium content of a pint of milk from the London area are, respectively, 1·3 μμc. per pint and 0·22 μμc. of radium per pint. In a few months the total intake of the human infant, if completely incorporated into the body, would be sufficient to provide most of the radium found stored in the adult. Later experiments suggest, however, that a large fraction may be excreted.

We have also measured the total α-content of two samples of human mothers' milk ash, and obtained values of $7 \cdot 9 \times 10^{-13}$ and $3 \cdot 1 \times 10^{-13}$ c. of total α-activity per gm. ash. The activity appears to be divided about evenly between radium and radiothorium.

Radioactivity in Animals

It seemed natural in view of these activities in milk to study the radioactivity of cows. Measurements of samples of long bones of 18 cows yielded values of total α-activity ranging from $2 \cdot 0 \times 10^{-12}$ c./gm. ash to $6 \cdot 0 \times 10^{-12}$ c./gm. ash with a mean of $3 \cdot 0 \times 10^{-12}$ c./gm. ash. It will be seen that the mean total α-activity per gm. of ash for cows is about ten times that of the humans. One very high activity in a 'marrow bone' ($1 \cdot 0 \times 10^{-11}$ c. per gm. ash) is interesting, as also is the observation that the radioactivity in the bone of cows consists of about equal parts of radium and thorium series. By ashing the bone marrow of cows separately we found that the activity of the bone marrow is the same as the activity of the bone (c. per gm. ash) but relatively rich (2 : 1) in radiothorium compared with radium. In further experiments we have measured the activities of cow spleens and found a mean value of $1 \cdot 8 \times 10^{-12}$ c./gm. spleen ash, again, with about equal parts of the thorium and radium series. The ratio of α-activity in milk to the activity appearing in bone is very different in humans and cows, the ratio being at least ten times higher for humans. These observations suggest interesting comparative physiology of different species.

It may be of interest to mention that we have also made preliminary observations on some other

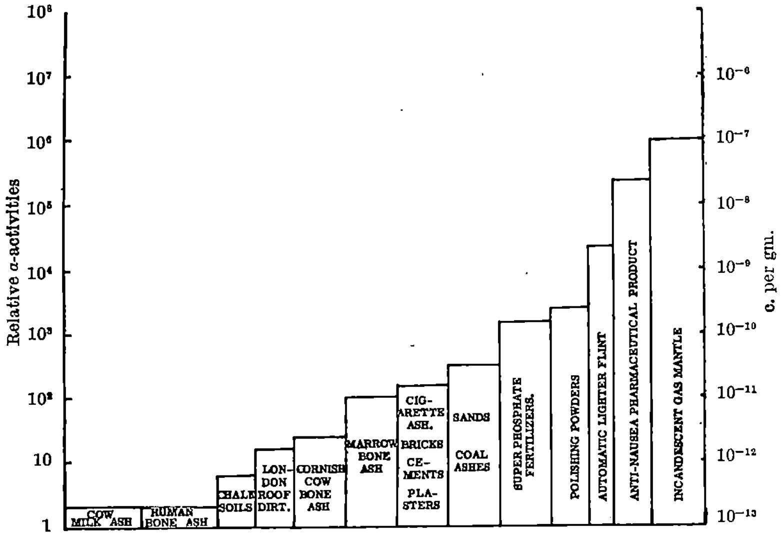

Fig. 2

species, as, for example, bones of five sheep which show values between 2 and 6 × 10^{-12} c. per gm. ash. Observations on the bones of pig reveal very low activity, while the bones of a horse, 18 years of age, are also quite low at 3·8 × 10^{-13} c. per gm. ash. It is evident there are differences between the natural radioactive content of bones of various species, but we are at the moment ignorant as to whether or not these are real species differences or determined by feeding habits.

Soils

We have also made observations on forty types of soils and fertilizers. They were not necessarily representative, but grab samples taken in various ways. We have found that chalk is low in activity (7 to 8 × 10^{-13} c. of α-activity per gm.), a fact of great importance to us in the design of new low background laboratories. The next lowest soils are the limestones, as is indeed well known[8]. One of the most active materials we have encountered is fossil superphosphate (1 to 2 × 10^{-11} c. α-activity per gm.), but again these activities were well known and may be so high that in the United States, for example, the extraction of uranium from superphosphate residues is worthwhile commercially[9]. The high values for superphosphates may have a bearing upon the observed activities of cattle bones.

Various Environmental Materials

In another series of experiments α-activities have been found in a number of substances in which thorium and rare earths are closely associated. It is not uncommon for thorium to pass through the chemical separation processes in company with materials like cerium, thus giving rise to the activities we have observed. Among the materials examined, conspicuous ones are lighter flints (3 × 10^{-9} c. α-activity per gm.), cleaning materials of various kinds involving cerium (4 × 10^{-10} c. α-activity per gm.) and in one instance a pharmaceutical product which evidently contains a large percentage of thorium (Fig. 2).

Human Metabolic Experiments

In view of the extremely wide range of naturally occurring activities in the human environment it seemed of great importance to discover the immediate sources of radioactivity of the normal human. We have, therefore, carried out a 'balance' experiment on a normal young human subject with the view of investigating the magnitude of the intake and excretion of naturally occurring radioactive material.

Samples of every food eaten by a boy (4 years old) over a period of a month were assayed for α-activity,

Table 1

Foodstuff	Maximum α-activity observed per 100 gm. × 10^{-12} c.
Cereals (breakfast)	60
Liver and kidney	15
Flours	14
Chocolates	8
Biscuits	2
Milks (evaporated)	1–2
Fish	1–2
Vegetables	0·7
Meat	0·5
Fruit (tinned)	0·5

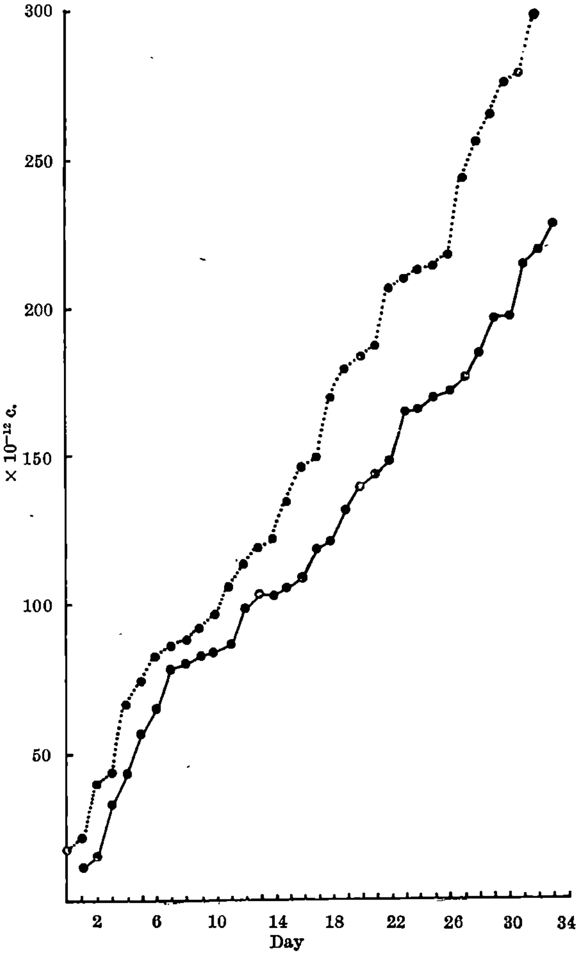

Fig. 3. ●···●, Intake, total α-activity, 299·2 × 10^{-12} c.; ●—●, fæcal excretion, total α-activity, 228·8 × 10^{-12} c.

as was each daily fæcal sample excreted during that time. It was immediately found that not only were the fæcal samples easily measurable but also examination of a number of foodstuffs revealed variations in α-activity ranging over factors of 4–5 hundred times (Table 1 contains a small selection of those found relatively active). The intake over a period of a month was $3 \cdot 0 \times 10^{-10}$ c. of α-activity with the fæcal excretion 20 per cent lower. Fig. 3 shows the integrated daily intakes and fæcal excretions.

The main conclusions from this pilot experiment are:

(*a*) Food is, in this instance, the important factor determining the daily intake of naturally occurring radioactive material, and its contribution completely overshadows the intake from milk and water, hitherto often supposed the main sources.

(*b*) The levels of α-activity in foodstuffs are extremely variable but, in general, high values are obtained for cereals and flours, particularly those in which whole wheat is utilized.

(*c*) The intake per day from food, even for a child of 4 years of age, may approximate the whole body burden. For an adult, the intake can exceed 10^{-10} c. of α-activity per day.

(*d*) The ratios of radiothorium to radium in the intake and in the fæcal excretion are substantially the same (0·75). This ratio is higher than that found in the human bone studies (0·6) possibly because of the relatively higher values of radiothorium in such organs as the liver and spleen.

(*e*) The daily retention of radiothorium and radium is evidently a small fraction of the intake but cannot be estimated accurately by our simple 'balance' study. Excretion in urine is approximately 10 per cent of fæcal excretion, leaving an estimated 10 per cent real absorption.

(*f*) The mechanisms controlling the retention by the body are evidently of great importance in estimating possible biological effects due to the radioactivity presented to it, since the bulk of the daily intake of radium and thorium series is excreted during the next 48 hr. This is demonstrated by the high values of fæcal activity on days following the ingestion of particularly active foods.

(*g*) It is clear from the values found in foodstuffs that two persons on apparently normal diets may differ in total daily radioactive intake by factors of hundreds. This makes the variations of α-activity observed in the human skeletal studies scarcely surprising.

We are continuing these physiological studies with the view of a better understanding of the metabolism and resulting dosimetry due to natural and artificial radioactive substances.

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FORMATION OF TWO- AND THREE-STRANDED HELICAL MOLECULES BY POLYINOSINIC ACID AND POLYADENYLIC ACID

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A GREAT deal of interest has been aroused by problems associated with the structure and function of ribonucleic acid. This substance is found widely distributed in various parts of the cell. Although some of it is in the nucleus, where it is near the deoxyribonucleic acid, most of the ribonucleic acid is in the cytoplasm, where it is either closely associated with protein to form the particles in the microsomal fraction or is free in the supernatant. Because it constitutes almost half the microsomal particles in which protein synthesis is carried out[1], it is widely believed that it takes a fundamental role in this process, such as helping to determine the sequence of amino-acids in the newly synthesized protein. It has also been demonstrated that ribonucleic acid can function as a carrier of genetic information. If ribonucleic acid is isolated from the tobacco mosaic virus, it is capable of infecting the tobacco leaf and thereby producing a large number of new virus particles which carry the genetic markers of the original virus[2].

Studies of the molecular structure of ribonucleic acid have been carried out in the hope of learning something about the molecular mechanisms involved in these processes. However, until recently, it has been extremely difficult to obtain reliable structural information. Ribonucleic acid is somewhat unstable chemically, and most isolation procedures result in a degraded product so that we have only meagre information about the configuration of this substance[3].

However, a number of recent developments have made more promising the prospect of solving this problem. Grunberg-Manago and Ochoa[4] have discovered an enzyme which is capable of converting nucleotide diphosphates into polyribonucleotides. The resultant polymers resemble naturally occurring ribonucleic acid in that they have the same covalent ribose-phosphate backbone, and they have been shown to undergo a similar enzymatic hydrolysis[5]. X-ray diffraction studies of polymers containing all four of the purine and pyrimidine bases present in ribonucleic acid produce an X-ray diffraction pattern which is virtually identical with that produced by the naturally occurring substance[6]. Hence, these materials are ideal analogues for studying molecular configuration problems associated with ribonucleic acid. Since it is possible to control the type of purine or pyrimidine base in the polymer, we can learn how the base composition influences the configuration of the ribose-phosphate backbone. Of special interest, of course, are the hydrogen-bonding potentialities of the various bases, since the specificity of these interactions takes such a crucial role in maintaining the structure of deoxyribonucleic acid[7].

Polyadenylic Acid and Polyuridylic Acid

Among the first combinations of synthetic polynucleotides to be investigated structurally was polyadenylic acid plus polyuridylic acid. When these two elongated polymeric species meet in solution, they wrap around each other to form a two-stranded helical molecule, one strand of which is polyadenylic acid and the other polyuridylic acid[8]. The resultant 1 : 1 complex can be identified by its absorption spectrum in the ultra-violet as well as through its X-ray diffraction pattern. This diffraction pattern has many features in common with that produced by deoxyribonucleic acid, and it is believed that the adenine and uracil residues are joined together by the same hydrogen-bonding system which is found in deoxyribonucleic acid. This work further suggested that the ribonucleic acid backbone is capable of assuming the deoxyribonucleic acid configuration, that is, a helical form with the phosphate groups outside and a translation of 3·4 A., and a screw rotation of 36° between the hydrogen-bonded base pairs. The presence of the additional hydroxyl group on C'_2 of ribose modifies the configuration only slightly in this case.

An additional interaction was discovered between the two-stranded polyadenylic acid + polyuridylic acid molecule and a third strand of polyuridylic acid[9]. It has been shown that, in the presence of 0·012 *M* magnesium chloride, these interact in the ratio of one polyadenylic acid to two polyuridylic acid molecules, as measured by the ratio of reacting nucleotides. The interaction is accompanied by a change in the ultra-violet spectrum and sedimentation constant of the resultant material. It is believed that the third strand of polyuridylic acid has wrapped itself about the two-stranded polyadenylic acid + polyuridylic acid molecule, filling one of the helical grooves. Recently, a diffraction pattern has been obtained from material which was prepared under conditions in which the three-stranded complex forms. This pattern differs from that obtained with the two-stranded complex (unpublished work).

These results led to a search for other two- and three-stranded configurations among the synthetic polynucleotides. This communication reports the discovery of a new two-stranded helical configuration involving polyadenylic acid and polyinosinic acid, as well as a three-stranded complex involving an additional polyinosinic acid.

Polyinosinic Acid and Polyadenylic Acid

At the beginning of this investigation, I was informed by Prof. Paul Doty, of Harvard University, that he had observed a "helix-coil transition" in the system polyadenylic acid and polyinosinic acid (personal communication).

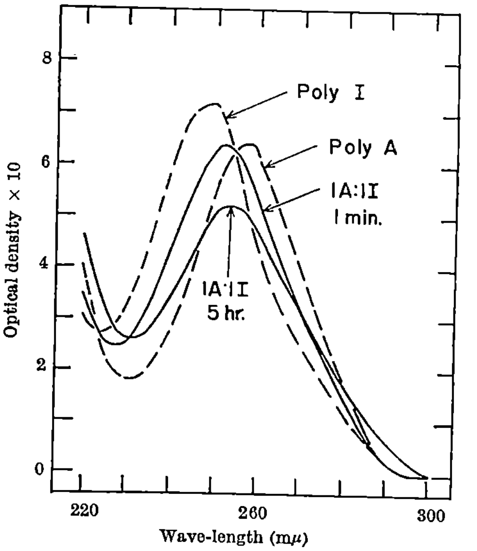

Fig. 1. Broken lines show the absorption spectra of polyadenylic acid (poly A) and polyinosinic acid (poly I) before mixing. The solutions are both in 0·05 *M* sodium chloride, 0·001 *M* sodium cacodylate at *p*H 6·8, $T = 23°$ C. The solid lines show the absorption spectrum of a 1 : 1 mixture (1 A : 1 I) 1 min. after mixing, and at 5 hr. As the complex forms, there is a drop in the optical density and a shift of the maximum and minimum

The polynucleotides used in my investigation were polymerized from nucleotide diphosphates and the enzyme polynucleotide phosphorylase from *Azotobacter vinelandii*. The highly purified enzyme (specific activity 113 units) was kindly supplied to me by Prof. S. Ochoa. Polymers were prepared during a two-hour incubation period and harvested by precipitation with cold ethanol followed by dialysis at 5° C. against 5×10^{-3} *M* sodium chloride and subsequent lyophilization. The sodium salt of the polynucleotides was used for all experiments.

Extinction coefficients were measured by assaying the ribose content of the solutions[10]. In 0·1 *M* sodium chloride, 0·01 *M* sodium cacodylate at *p*H 6·8, the molar extinction coefficient per nucleotide for polyadenylic acid is 9,180 at 259 mμ, and for polyinosinic acid it is 10,300 at 250 mμ.

The interaction between these two molecular species is best seen spectrophotometrically. In Fig. 1, the ultra-violet absorption spectra are plotted for equal concentrations of the individual polymers (dashed lines). These solutions are both in 0·05 *M* sodium chloride, 0·001 *M* sodium cacodylate at *p*H 6·8. When they are mixed together in a 1 : 1 ratio, spectra are observed as shown by the solid lines. At 1 min. after mixing, the resultant absorption spectrum curve lies half-way between the curves for the individual materials. However, the resultant spectrum changes with time. Equilibrium is obtained by 5 hr., at which time the final curve has dropped considerably as shown in Fig. 1. At equilibrium, the spectrum has shifted somewhat and has a new maximum at 254 mμ and a minimum at 231 mμ. The final optical density at the maximum has decreased by 18 per cent when compared to the starting point, and half this drop has occurred in approximately 20 min. under these conditions. Such a lowering of the optical density is called the 'hypochromic effect' and usually refers to the decrease in optical density which is attendant on the polymerization of nucleotides to form nucleic acids. In the synthetic polynucleotides, changes in the hypochromic effect

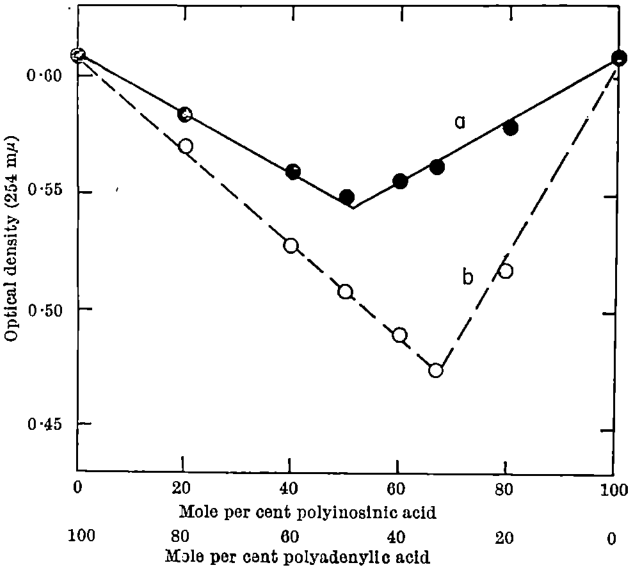

Fig. 2. Optical density at 254 mμ of mixtures of polyinosinic acid and polyadenylic acid. The conditions are the same as in Fig. 1. All points refer to the same total concentration of nucleotide phosphate. The solid curve (*a*) is obtained at 31 min. and the broken curve (*b*) at 5 hr. The minimum shifts from 50 per cent polyinosinic acid in (*a*) to 67 per cent in (*b*)

have been used as a convenient index for following the course of a reaction. Thus, for example, the reaction between polyadenylic and polyuridylic acids results in a similar lowering of the optical density in the ultra-violet[8,11,12].

The stoichiometry of the reaction can be determined by measuring the drop in optical density at a given wave-length as a function of composition. In Fig. 2, the optical density at 254 mμ is plotted as a function of mole ratio of polyadenylic acid to polyinosinic acid. The upper curve, *a*, is obtained 31 min. after mixing two standard solutions, both of which are in 0·05 *M* sodium chloride, 0·001 *M* sodium cacodylate, *p*H 6·8. In all these mixtures, the total concentration of nucleotide phosphate was kept constant, but the relative amounts of the two species vary. At 31 min. a minimum in the optical density is seen near 50 per cent, that is, a 1 : 1 mixture of polyinosinic and polyadenylic acids.

However, if these same mixtures are allowed to stand until equilibrium is reached, the curve changes further (Fig. 2, *b*). At equilibrium, the minimum has shifted to 67 per cent polyinosinic acid, suggesting the formation of a 2 : 1 complex involving two polyinosinic acid molecules and one polyadenylic acid molecule.

The formation of these two complexes is controlled by the ionic strength of the medium. As the salt concentration is decreased, the rate of the reaction decreases. Thus, in 0·01 *M* sodium cacodylate without added sodium chloride, only the 1 : 1 complex forms (Fig. 2, *a*) after 18 hr. On the other hand, in 0·1 *M* sodium chloride, the minimum at 50 per cent is seen clearly only until 40 sec. after mixing. Following that, the optical density – composition curve begins to shift, and the sharp minimum at 66 per cent polyinosinic acid is seen clearly after 4 min. At very high salt concentrations, for example, 1 *M* sodium chloride, no reactions occur. This is probably due to an alteration in the polyinosinic acid molecule and will be discussed in greater detail in another paper dealing with the structure of polyinosinic acid.

Further evidence for the formation of these complexes can be obtained from an ultracentrifuge investigation. For these studies, a 'Spinco' model *E* ultracentrifuge was used in a form modified for ultra-violet absorption measurements. In this way, concentrations were used near $6 \times 10^{-5} M$ in nucleotide phosphate and sedimentation constants were independent of concentration. Polyadenylic acid in 0·05 *M* sodium chloride and 0·001 *M* sodium cacodylate at *p*H 6·8 had a mean sedimentation coefficient (S_{20}) of 7·2, whereas the polyinosinic acid had a value of 8·6 under the same conditions. A 1 : 1 mixture of these had an average $S_{20} = 10{\cdot}4$ at equilibrium. However, an equilibrium mixture of 2 polyinosinic acid to 1 polyadenylic acid had an average $S_{20} = 14{\cdot}7$.

The experiments cited above demonstrate the formation of complexes between polyadenylic and polyinosinic acid. In order to obtain information about the detailed molecular configuration of these complexes, an X-ray diffraction investigation was carried out.

X-Ray Diffraction Studies

A 1 : 1 mixture of sodium salts of polyadenylic acid and polyinosinic acid was prepared by adding together weighed amounts of the dry material. The mixture was dissolved in distilled water without any added salt. Under these conditions, the solution had only the residual sodium chloride from the final dialysis in the preparation of the polymers. At this low salt concentration, only the 1 : 1 complex forms, as described above. After reacting at room temperature for one hour, the solution was lyophilized. The resultant dried fibrous mixture was then moistened until it became sticky and from this were drawn long, tough fibres which upon drying became brittle and highly birefringent ($\Delta n = -0{\cdot}09$). X-ray diffraction photographs were taken using an intense beam of X-rays 100μ in diameter (Hilger 'Semi-Micro' X-ray Tube Stand).

Fig. 3 shows a diffraction photograph obtained at 66 per cent relative humidity in a helium-filled camera. The distribution of scattering intensity is characteristic of a helical structure, as shown by the fact that the innermost maxima on the first, second, and third layer lines lie approximately on straight lines radiating from the origin. In addition, there is a large area on the meridian which is empty. In some respects, the diffraction photograph is similar to that produced by the *B* form of deoxyribonucleic acid[13].

There are two fairly strong reflexions on the equator and several weaker ones. These appear at distances which indicate a hexagonal lattice with $a = 24{\cdot}4$ A. By measuring the layer line spacing, it can be shown that the pitch of the helix is 38·8 A. The specimen was tilted slightly in Fig. 3 to show the upper layer lines more clearly. Several layer lines appear near the meridian in the region of 3–4 A. From these it appears that there is a meridional reflexion near 3·4 A. Hence the fundamental screw repeat for the helix is a translation of 3·4 A. and a rotation of

$$\left(360^\circ \times \frac{3{\cdot}4}{38{\cdot}8}\right) = 31{\cdot}5^\circ$$

The reflexions in the 3·4-A. region are undoubtedly due to the stacking of the planar purine bases at right angles to the fibre axis. This interpretation is

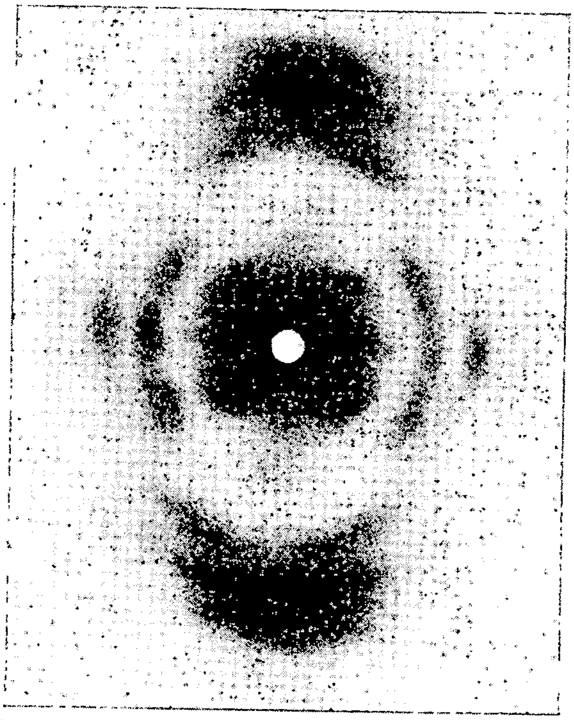

Fig. 3. X-ray diffraction photograph of a fibre of polyadenylic acid plus polyinosinic acid (1 : 1). The fibre is at a relative humidity of 66 per cent in a helium-filled camera, and is tilted slightly from the vertical

compatible with the observed high negative birefringence.

Cochran, Crick and Vand have analysed the diffraction patterns produced by helical molecules[14]. They have shown that the structure factor for a given layer line is the sum of a series of terms each of which contains a Bessel function $J_n(2\pi rR)$, where r is the radius of an atom, and R is the radius in reciprocal space. In the nucleic acids, the diffraction pattern is usually dominated by the contributions of the phosphate groups ; hence it is possible to carry out a very approximate analysis by considering their contributions alone. In this approximate analysis the positions of the innermost maxima on layer lines 1, 2, and 3 can be equated to the first maxima of $J_n(2\pi rR)$, where n is 1, 2 or 3, respectively. Such an analysis yields a weighted 'average' scattering radius of 9·5 A. This strongly suggests that the phosphate groups are on the outside of the molecule, as in deoxyribonucleic acid.

Discussion

With the ribose-phosphate backbone helically arranged on the outside of the two-stranded complex, it is necessary to determine the arrangement of the two purine bases relative to each other in the centre of the molecule. The diffraction data clearly indicate that these planar groups are oriented at right angles to the fibre axis, and it is necessary to consider the manner in which they might be linked together by hydrogen bonds. Before this can be done, one must know the tautomeric forms which exist under the conditions in which the polynucleotides interact.

It has been generally assumed that the adenine residue in the nucleic acids is in the amino-form. A recent study of the infra-red spectrum of adenylic acid in solution has confirmed this assignment[15]. Information concerning the tautomeric form of inosinic acid comes from a variety of sources. Spectroscopic and infra-red evidence has been presented by Brown and Mason[16] in a study of several monohydroxy purines. They have shown that the oxygen on position 6 is probably in the keto-form in 9-methyl hypoxanthine. Crystallographic studies on the somewhat related guanine residue[17] show a ketonic oxygen on position 6 in the solid state. In addition, work now in progress on the structure of polyinosinic acid also indicates a keto-form for the oxygen.

Pairing of the adenine and hypoxanthine bases to form a structure of the type suggested by the X-ray diffraction pattern can most easily be done by the hydrogen-bonding shown in Fig. 4. The amino-group of adenine is linked to the keto-oxygen of hypoxanthine, while both purine nitrogen 1 atoms are linked by hydrogen bonds. These hydrogen-bonded purine pairs are helically stacked according to the screw dimensions cited above, with the phosphate ribose chain on the outside. Fourier transforms have been calculated for models of this type and will be reported elsewhere.

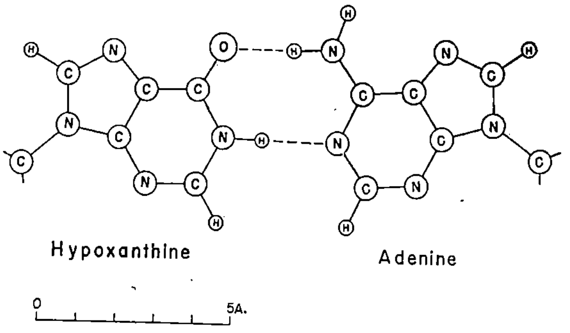

Fig. 4. Hydrogen bonding between hypoxanthine and adenine bases. One carbon atom from the ribose sugar is shown

At the present time, there is only spectroscopic and ultra-centrifugal evidence for the existence of the three-stranded complex. However, we know that the two-stranded molecule is helical, and by analogy with the system of polyadenylic acid plus polyuridylic acid, it is quite likely that the third strand lies in the helical groove of the two-stranded molecule. It is possible, for example, that the second hypoxanthine base is linked to the adenine residue by two hydrogen bonds (hypoxanthine keto-oxygen and nitrogen 1 bonded, respectively, to adenine amino-nitrogen and nitrogen 7 of the imidazole ring). A somewhat similar arrangement has been suggested for the second uracil chain, which is bonded to the two-stranded polyadenylic acid plus polyuridylic acid complex[9].

While inosinic acid is believed to be a precursor of adenylic acid as well as guanylic acid, it has not been found in ribonucleic acid itself. However, it is related structurally to guanylic acid in that it has the same keto-oxygen on carbon 6 of the purine ring, even though it lacks the amino-group on carbon 2. It is less closely related to adenylic acid, since substituting a keto-group for an amino-group radically alters the hydrogen bonding possibilities of the purine. This is, of course, readily seen by noting the great difference between the diffraction pattern of polyinosinic acid + polyadenylic acid relative to that of polyadenylic acid by itself. In the latter case, the structure is believed to be a two-stranded helix with each chain organized around an axial two-fold rotation axis[18]. The amino-group has a position in that structure which could not be substituted by the oxygen on the hypoxanthine base.

The studies reported here have shown that mixtures of polynucleotides are capable of forming hydrogen-bonded helical structures which are susceptible to crystallographic analysis. Just as the structure of the fibrous proteins was finally solved by working on the simpler synthetic polypeptides, it is hoped that structural analysis of synthetic polyribonucleotides will aid the solution of the structure of ribonucleic acid and facilitate our understanding of its function.

I would like to acknowledge the generous assistance and advice of Dr. D. R. Davies and the technical assistance of Mrs. J. Johnson. I am indebted to Prof. S. Ochoa and Miss P. Ortiz for the supply of polynucleotide phosphorylase, and for information concerning its use.

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THE BAND THEORY OF METALS

A SHORT and valuable conference was held in the Imperial College of Science and Technology, London, on December 19 and 20 on "The Band Theory of Metals and the Structure of the Fermi Surface". It was attended by about 240 members of the Physical Society and visitors, including Prof. Vonsovski from the U.S.S.R. The chief value of the conference must lie in the way in which it has drawn together many aspects of the subject. In the years 1928–35, almost the whole theory of metals was fairly satisfactorily sketched in outline, and we were often reminded of this during the conference. Since then, much work has gone into filling in the many gaps that remained. The different threads have now been drawn together again into a more comprehensive theory of metals and into a united research front. There were several review papers of various experimental techniques and theoretical developments, emphasizing what relevance the results obtained from them had for the theory of metals as a whole. There was also a good mixture of theoretical and experimental papers, and much emphasis on turning all this to good account by trying to understand, in detail, the properties of at least a few individual metals. As a further elaboration of this theme, the following thoughts remained in the mind of one participant after the conference. In some places the remarks go beyond what was actually said in the formal sessions.

Prof. N. F. Mott opened the conference with a paper on "Band Theory and Ferromagnetism", which brought out the distinct types of wave function that we use in different circumstances to describe electrons in metals. In the earliest development of the subject, the wave functions of the individual electrons were taken as waves $\psi_{\mathbf{k}}$ (with wave vector $\mathbf{k}$) extending throughout the crystal, and the wave function of the whole metal was written as a product or as a single determinant:

$$\Psi_{\text{Bloch}} = (N!)^{-1/2} \mid \text{determinant of the } \psi_{\mathbf{k}}\text{'s} \mid \qquad (1)$$

where N is the total number of conduction electrons in the metal. This we shall refer to as the Bloch picture. Because of the periodicity of the lattice, $\mathbf{k}$ is restricted to a certain region in k-space known as the Brillouin zone. The energy $E(\mathbf{k})$ varies continuously with $\mathbf{k}$ in each zone. Because of the exclusion principle, all the states below the Fermi level E_F are occupied by electrons. The surface in k-space:

$$E(\mathbf{k}) = E_F \qquad (2)$$

is the boundary between the occupied and unoccupied levels, and it determines many of the properties of the metal. The earliest successes of this theory include the resolution of the classical difficulty that the electrons in a metal seem to be free enough to give a high conductivity and yet contribute very much less than $\frac{3}{2}kT$ each to the specific heat. It also explains the qualitative difference between a metal and an insulator, and how semi-metals like bismuth can exist with an apparent number of 10^{-5} free electrons per atom. On this sort of picture, most of the present theory of metals is based, and Prof. Mott reminded the audience how it could account for the ferromagnetism of some metals like cobalt and nickel. However, he emphasized that in other cases we are driven to use wave functions of a qualitatively different type, namely, the Heitler–London type of function. In this picture each electron is more or less tightly bound to a particular atom (position $\mathbf{R}_n$), and moves in an orbital $\psi(\mathbf{r} - \mathbf{R}_n)$ localized around this atom. The whole wave-function is:

$$\Psi_{HL} = (N!)^{-1/2} \mid \text{determinant of } \psi(\mathbf{r} - \mathbf{R}_n)\text{ 's} \mid \qquad (3)$$

In this picture the concept of a Fermi surface does not arise. Prof. Mott mentioned different kinds of ferromagnetics and anti-ferromagnetics which are thought to correspond to the two types of wave function. In particular, the ferromagnetic $3d$-electrons in iron, and similarly the $4f$-electrons in gadolinium metal, should be described by the Heitler–London type of wave function (3), in contrast to cobalt and nickel. This view is supported, for example, by data on the saturation magnetic moment of iron–copper alloys. The moment is just 2·22 Bohr magnetons multiplied by the number of iron atoms, in accordance with the view that each magnetic electron is localized around an iron atom and is therefore removed when the iron atom is replaced by a non-magnetic copper atom. The behaviour is quite different from that of cobalt–copper and nickel–copper alloys. Later in the conference, these ideas were developed more fully and more experimental evidence was brought forward by the following: W. M. Lomer and W. Marshall, "Electronic Structure of Ferromagnetic Alloys"; Miss Y. Cauchois, "X-ray Spectroscopy of Metals"; B. R. Coles, "Electrical Resistivity and Electronic Structure". There was also ample time on the programme for the lively discussion which recurred throughout the conference, and in which many other people contributed. J. R. Schrieffer outlined how wave functions, which are quite different again from either (1) or (3), are being used in "Recent Developments in the Theory of Superconductivity".

All the rest of the conference was devoted to non-ferromagnetic good metals like the alkalis, and copper, aluminium and lead, and their alloys. Even for a good metal, the Bloch type of wave function (1) cannot be regarded as satisfactory, in spite of its many successes. For a free-electron gas which can be worked out in detail, it gives a zero density of states at the Fermi-level, in contrast to all the experimental evidence, which demands a finite one. As R. S. Leigh pointed out in his paper on "Correlation in the Free Electron Gas", this difficulty can be traced to the long-range ($1/r$) nature of the Coulomb potential. The use of the Bloch wave function (1) implies that each electron moves in its orbital ψ_k independently of all the other electrons. This cannot be correct, for the Coulomb repulsion between two electrons is quite strong and must influence their motion so as to keep them from getting too close to one another. This is called 'correlation'. It is closely allied to the longitudinal plasma oscillations of the electron gas as a whole, for which the Coulomb repulsion is also responsible. By starting from these plasma oscillations, a more complicated theory of the free electron gas can be built up following the work of Bohm and Pines, which gives reasonable agreement with experiment for the alkali metals. Mr. Leigh discussed how these results could also be obtained from a somewhat different point of view.

If this left the conference momentarily stunned by the complication of the theory of even a free-electron gas, despondency was soon dispelled. In spite of the complications of correlation, the wave function for the free-electron gas can be written (to a good degree of approximation):

$$\Psi = (N!)^{-1/2}\ \chi\ |\ \text{determinant of } \psi_k\text{'s}\ | \qquad (4)$$

This is very similar to (1), while the extra factor χ, called the plasma term, describes the correlation of the electrons. The determinant again describes N particles moving independently of one another through the metal. But these particles are no longer simple electrons. The Coulomb repulsion means that each electron is surrounded by a denuded region in which other electrons are unlikely to be. Because of the positive charge of the ions making up the lattice, this denuded region has on the average a positive charge. The particles now consist of the electrons together with the denuded region around each one. Each particle is therefore electrically neutral, and there is now no long-range Coulomb force between them. Only a weak short-range force remains. For this reason there is little correlation and the particles can be described as moving nearly independently. The wave function (4) thus contains a single determinant of extended orbitals, ψ_k. This removes the deficiencies of the simple Bloch theory based on (1), and yet at the same time retains its successes. The concepts of the wave vector **k**, Brillouin zones and Fermi surfaces remain, and so does our interpretation of physical properties in terms of them. The theme was developed further by J. Hubbard in "Description of the Electron Gas in Terms of the Independent Particle Model". Using this model as a basis for the first time, V. Heine described a "Self-consistent Band Structure Calculation for Aluminium". In this calculation he was also able to overcome some of the mechanical difficulties that have always made calculations of band structure so unreliable, and to obtain reasonable agreement with what is known experimentally about the Fermi surface in this metal. W. M. Lomer presented a paper for Mrs. E. C. Ridley on the energies of the "6*s*-, 6*p*-, 7*s*-, 7*p*-, 6*d*-, 5*f*-Wave Functions of Metallic Uranium". From this the six valence electrons would appear to be predominantly in the 5*f*-band. Prof. R. Eisenschitz described how one could calculate the "Electronic Levels of Disordered Structures".

We may summarize by saying that for various experimental and theoretical reasons, some of which have been mentioned above, we believe that the concepts of Brillouin zones and Fermi surface have real validity and physical significance, in spite of the complications of electron correlation. Most of the conference was therefore devoted to methods of determining experimentally the shape of the Fermi surface in a given metal (as well as other aspects of the band structure), since this is the key to an understanding of most of the electrical and magnetic properties of the metal. The de Haas–van Alphen effect, discussed by Dr. D. Shoenberg in a paper of that title, would appear to be in principle the most powerful tool for obtaining the shape of the Fermi surface experimentally. The observations give the area of cross-section of the surface normal to the magnetic field, as a function of the field direction, and from this the shape of the surface can be calculated. If the Fermi surface consists of several pieces in different zones, then each piece can be so determined. A. Gold described how "The de Haas–van Alphen Effect in Lead" had enabled him to map out by this method the Fermi surface in lead, which consists of several pieces in the second, third and fourth zones. It is noteworthy how close the band structure is to what one obtains if the Fermi surface is taken as a sphere containing four electrons per atom (free-electron gas model) and the pieces of the sphere are fitted correctly into the zone scheme. This work made us feel that perhaps all other methods could be put in a subsidiary category; but Dr. Shoenberg reminded us that the de Haas–van Alphen effect has its 'blind spots', where it does not at present seem to be applicable. For example, the effect has not yet been detected in any alkali or noble metal. For these metals other methods must be used, and Dr. A. B. Pippard discussed "The Anomalous Skin Effect" with particular reference to determining the Fermi surface of copper. He concluded that the Fermi surface either just touches or just does not touch the zone face in the (111) direction. Circumstantial evidence would favour the former. Dr. R. G. Chambers presented a paper on "Cyclotron Resonance in Metals". The resonance could in principle determine the effective mass at all points on the Fermi surface, as in semiconductors, but some of the differences from cyclotron resonance in semiconductors were pointed out. So far only bismuth has been studied systematically, but the resonance has also been detected in tin.

This more or less concludes the most powerful tools, in which some quantity is measured as a function of orientation for all directions in space so that much detailed information is obtained. In contrast, the following determinations give a specific piece of information, which may not be obtainable in any other way, but which is an average over the whole band structure or the whole Fermi surface. J. A. Catterall discussed "X-ray Emission from Alkali Metals" with particular reference to lithium. He concluded that the maximum in the emission spectrum definitely came below the Fermi level. Miss R. Coldwell-Horsfall presented a paper on the "Electrical Conductivity Tensor and the Fermi Surface". There was considerable discussion about the density of states at the Fermi-level and related experimental quantities such as the electronic specific heat and the Knight shift. Papers on this were presented by Prof. H. Jones ("Experimental Data Related to Band Structure"); P. L. Smith ("Electronic Specific Heat of Simple Alloys"); L. E. Drain ("Nuclear Magnetic Resonance in Ag–Cd Alloys"). Prof. Jones pointed out that the electronic specific heat measurements require a density of states about 50 per cent higher than one would expect, and gave a theory of how this might be accounted for. The results presented by P. L. Smith and L. E. Drain showed how much more difficult it is to make sense of the results for alloys, and there was considerable discussion about this.

At the end of the first day of the conference, Prof. L. C. Jackson helped to take our minds off metals when he delivered the Duddell Lecture of the Physical Society on "Measurements of the Thickness of the Helium Film". The subject of this very interesting lecture was particularly appropriate to the conference since many of the experimental methods discussed involve low-temperature techniques. V. HEINE

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OBITUARY

Prof. R. W. Whytlaw-Gray, O.B.E., F.R.S.

THE death of Robert Whytlaw-Gray on January 21 at the age of eighty removes one more link with the days when the Curies and Ramsay were rejuvenating inorganic chemistry. He was a student of Lord Kelvin and then a research worker in Ramsay's laboratories, where he developed a life-long interest in the physical properties of gases and great experimental skill in their manipulation. This led him to work on molecular and atomic weights, and in 1906 while in Bonn he re-determined the atomic weight of nitrogen by gravimetric analysis of liquefied and fractionated nitric oxide and by density determination. Whytlaw-Gray then returned to University College, London, and in collaboration with Ramsay, determined the atomic weight of niton. This was an outstanding achievement. The density was determined with a modified Steel–Grant micro-balance and about $0{\cdot}1$ mm.^{3} of niton.

In 1914 he became senior chemistry master at Eton, where his steadiness of purpose enabled him to carry out a considerable amount of research. In 1915 and for long afterwards he engaged in confidential work on toxic and other smokes, their physical properties and the methods by which their effects could be countered. In the fifth Liversidge Lecture, entitled "The Process of Coagulation in Smokes", delivered before the Chemical Society in 1935, he discussed his own and other work on this subject, and in 1936, with H. S. Patterson, published a book entitled "Smokes". His expert knowledge was again utilized by the Ministry of Supply in 1939 and he formed a group of about twelve workers at the University of Leeds to study problems connected with chemical warfare.

Whytlaw-Gray had been appointed to the chair of chemistry at Leeds in 1922 in succession to Arthur Smithells. His research activity there was intense and he developed a buoyancy micro-balance of high accuracy and employed it in the determination of the atomic weights of carbon, fluorine, nitrogen, sulphur and silicon by the use of gaseous compounds of these elements. He was elected to fellowship of the Royal Society in 1928. After ten years in laboratories designed by T. E. Thorpe, he entered the new building which he, Dawson and Ingold had so successfully planned.

His regime was marked by tact, by careful consideration of the views of others (especially when he differed from them), by an informed appreciation of the needs of other scientific and technological departments and by a firm adherence to those principles which guided his personal and scientific life. On his retirement the Senate was "happy to learn that he is to continue his investigations in the Chemistry Department of which the spirit no less than the fabric owes so much to his unselfish devotion". One of his colleagues said of him: "It may be that some aspects of his character are derived from, or at least, related to the quiet detachment of the exact experimentalist —his unruffled calm to the poise and exactness of his own micro-balances".

When Whytlaw-Gray left Leeds in 1950 the University conferred upon him the degree of D.Sc. *honoris causa*. In recent years he worked at the Imperial Chemical Industries' Akers Laboratory, Welwyn, on the isothermals of xenon at low pressures and also on the normal density of the gas. The communication, with Dr. G. A. Bottomley, published in *Nature* as recently as December 7, 1957, is characteristic of his life-long struggle towards perfection in measurements of the properties of gases and vapours. Some earlier work on the deviation from ideality of vapours at low pressures was shown to be subject to significant error due to adsorption. This they reduced to a constant minimum in a re-designed differential compressibility apparatus, mainly by avoiding passage of mercury through greased stopcocks. The PV/P graphs for benzene vapour, after correction for adsorption, then deviated from straight lines by less than two parts in 10^5.

His colleagues and friends will be happy to think that he was able to continue in active work to the end of his long life. He rarely spoke about himself, but it was clear to those who knew him well that he served God 'with a quiet mind'.

FREDERICK CHALLENGER

NEWS and VIEWS

British Association : New Lecture for Children

Prof. J. Rotblat, professor of physics in the University of London, at St. Bartholomew's Hospital Medical School, will lecture on "Peaceful Uses of Atomic Energy" at Northgate Grammar School, Ipswich, on February 25. The lecture will be given in two sessions to different audiences, and will be illustrated by films and demonstrations ; there will also be visits to an atomic energy exhibition which the Atomic Energy Commission is arranging in Northgate School for the whole week. It is expected that some nine hundred children will hear the lecture, arrangements for which have been made by Mr. L. R. Missen, chief education officer, East Suffolk, in co-operation with the British Association for the Advancement of Science, as part of the new campaign of the latter to present science to the people.

Pure Mathematics at Cambridge :

Prof. A. S. Besicovitch, F.R.S.

Prof. A. S. Besicovitch, Rouse Ball Professor of mathematics in the University of Cambridge, retires this year, having reached the age of sixty-seven. He was elected to the chair in 1950, succeeding J. E. Littlewood, who was the first holder. He has recently worked at a number of problems in real-function theory, in particular the theory of area and extremal problems. He has directed research in these topics but he has not restricted his teaching to graduates. To the pleasure and profit of those working for the Mathematical Tripos, he has organized seminars for them. He has also maintained a flow of 'Contest Problems', at which an aspiring young analyst may try his skill with the possible reward of a public announcement : 'Perfect solution of problem was made by *A. B. C.*'. Prof. Besicovitch has been credited with the remark that a mathematician's reputation rests on the number of bad proofs that he has given—in the sense that pioneer work can be rough. He preserves unimpaired his mastery of intricate mathematical situations, and many more good and bad proofs are expected from him.

Prof. H. Davenport, F.R.S.

Prof. Harold Davenport, who has held since 1945 the Astor chair of pure mathematics at University College, London, will succeed Prof. Besicovitch on October 1. Born in 1907, he took degrees at Manchester and at Cambridge, becoming a Fellow of Trinity College. He was elected to the Royal Society in 1940. Most of his work has been in some branch or other of the theory of numbers. His early papers dealt with problems of the analytic theory, following the methods of Hardy and Littlewood. Later he turned to Diophantine approximation and the geometry of numbers. He has written about a hundred papers and some of them give solutions of problems which had been long outstanding. To mention only one example, Minkowski's problem, of the minimum value of the product of three linear forms the determinant of which is 1, was solved with consummate skill and elegance in 1938. He has now in course of publication some fundamental results on the minima of indefinite quadratic forms. Prof. Davenport has built up a strong school of research at University College and there are mathematicians of international repute who owe their early guidance and encouragement to him. He is one of the founders of the journal *Mathematika*, and he has just been elected president of the London Mathematical Society. One of the most resourceful English pure mathematicians of his generation, he is expected to solve with distinction as difficult a problem as he has yet tackled—that of succeeding Littlewood and Besicovitch.

Aircraft-propulsion Studies at Cranfield :

Mr. A. G. Smith

Mr. A. G. Smith, who has been appointed to the chair of aircraft propulsion in the College of Aeronautics, Cranfield, entered the Royal College of Science and Technology, London, as a Royal Scholar in 1937 and graduated with a first-class degree in physics in 1939. He studied aeronautics for a postgraduate year at the City and Guilds College, London, and then worked for Blackburn Aircraft, Ltd., at Brough, until 1942, when he joined Power Jets, Ltd. During the rest of the Second World War he was engaged on research and development work on various Whittle engines, and particularly on compressor aerodynamic development. He joined the National Gas Turbine Establishment on its formation and worked on theoretical and experimental aspects of turbine cooling. In 1952 he was appointed reader in the University of London in applied thermodynamics with special reference to gas turbines. Since that time, besides carrying out research on aerodynamic and heat-transfer problems, he has run a very successful postgraduate course in gas-turbine technology at the City and Guilds College. He has published papers on turbine cooling and on heat transfer, aerodynamic and thermodynamic matters related to gas turbines.

Horticulture at Nottingham :

Prof. J. P. Hudson, O.B.E.

The newly created chair of horticulture at the University of Nottingham has been filled by the appointment of Dr. J. P. Hudson, the present head of the Department of Horticulture, who thus becomes the first student of the old Midland Agricultural College to succeed to a chair. Dr. Hudson has had a varied career. Entering college in 1927, he graduated with the degree of B.Sc. (Hort.) of the University of London in 1930, and then served one year as student assistant in the Agricultural Economics Department at the Midland Agricultural College. From then until the outbreak of war in 1939 he was engaged in practical horticulture, at first in industry but later as horticultural instructor at the East Sussex School of Agriculture. During the War he served with considerable distinction in the Royal Engineers and in 1942 spent six months in the United States organizing a bomb disposal school. For the last four years of the War he was engaged on bomb disposal research and experimental work, and was made O.B.E. and awarded the George Medal (and Bar) for his services. Indeed, he must be one of the few professors to discover an aptitude for research, six years after leaving the university, on a material where a decisive result might well have the rather unusual effect of terminating one's research career.

Leaving the army on the termination of hostilities with the rank of major, he proceeded to New Zealand to take charge of the Dominion Horticultural Station at Levin, where he was responsible for horticultural extension work in the market garden, glasshouse and nursery industries. He returned to England in 1948, as lecturer in horticulture at his old institution, now become the Faculty of Agriculture of the University of Nottingham. He was appointed head of the Department of Horticulture in 1953, after being acting head for two years. Since 1951, Hudson has been steadily developing his Department from that of a college concerned largely with certificates and diploma courses into a University Department of Horticulture. The depression in the horticultural industry which led to a fall in the number of candidates coming forward for degree courses made this a difficult period for the change, but Hudson successfully piloted his Department through, initiating at the same time a vigorous research school. The theme has been the influence of cultural practices on plant growth, and his contributions in two fields, namely, the control of soil moisture for glasshouse crops, and the influence of environment on the growth of biennial crops, have shown his excellent grasp of the fundamental principles involved, and the manner in which they may be applied to the benefit of the horticultural industry.

Dean of Graduate Studies at the Rockefeller Institute, New York: Dr. Frank Brink, jun.

Dr. Frank Brink, jun., has been appointed to the newly created office of dean of graduate studies at the Rockefeller Institute. Dr. Brink is a member and professor of the Institute, doing research work on biophysics. As dean, he will assist the president and the faculty committee on educational policies in the development of graduate education. The charter of the Rockefeller Institute was amended in November 1954 so that the degrees of Ph.D. and M.D. could be granted with the authority of the Regents of the University of the State of New York. The Institute is now in its third year as a graduate university and has a limited enrolment of graduate students. Dr. Brink has been closely associated with the education programme of the Rockefeller Institute since its inception in 1954. Since 1956 he has served as secretary of the Trustees' Committee on Educational Policies under the chairmanship of Dr. Robert F. Loeb, of the Columbia University College of Physicians and Surgeons. Dr. Brink graduated from Pennsylvania State University in 1934. After a year of graduate work at the California Institute of Technology, where he received the degree of M.S., he began graduate work in biophysics at the Johnson Foundation at the University of Pennsylvania, where he received the degree of Ph.D. in 1940. He was later instructor in physiology at the Cornell University Medical College, assistant professor of biophysics at the University of Pennsylvania, and associate professor of biophysics at Johns Hopkins University. Since 1953 he has been at the Rockefeller Institute, where he has worked in the field of biophysics and neurophysiology in association with Dr. D. Bronk, the president. He is also a member of the board of editors of the *Journal of General Physiology* and is on the editorial board of the *Journal of Cellular and Comparative Physiology* and the advisory board of the *Journal of Neurochemistry*.

Baghdad Pact Nuclear Centre

The Baghdad Nuclear Training Centre was established in 1956 by the member countries of the Baghdad Pact. It is at present concentrating on the practical applications of radioisotopes to the problems of Middle Eastern countries and is organizing intensive short courses in the uses and techniques of these materials. Two instructors each from Iraq, Iran, Pakistan and Turkey were trained at Harwell during 1956, and the United Kingdom also assisted by the gift of equipment and the loan of staff to supervise, teach and promote the development of the Nuclear Training Centre until local staff can assume responsibility. The first director of the centre, Mr. W. J. Whitehouse, was seconded from the U.K. Atomic Energy Authority in 1957 with four other members of the Authority's staff to prepare the Nuclear Training Centre, supervise the installation of British equipment there and to organize and assist in running the first course.

Mr. H. A. C. McKay of the Chemistry Division, Atomic Energy Research Establishment, Harwell, has now been appointed director of the Baghdad Pact Nuclear Centre from July 1958, in succession to Mr. W. J. Whitehouse. Mr. McKay, who was born in 1913, was educated at Balliol College, Oxford, and in 1935 was the Goldsmiths' Senior Scholar at the Institute for Theoretical Physics, Copenhagen. He was Beit Memorial Fellow at the Imperial College of Science and Technology, London, in 1937, and a demonstrator at King's College, London, in 1939. He served in the Royal Navy during the Second World War and in 1947 became a senior scientific officer in the Chemistry Division at Harwell, where he was appointed group leader of the Heavy Element Group in the Chemistry Division in 1954. He has specialized in solution chemistry.

World List of Scientific Periodicals

One result of the advances and developments in science and technology in recent years is reflected in the vast number of new scientific and technical journals that have appeared, together with an increase in the output of periodical publications throughout the world. This, combined with the fact that the third edition of the "World List of Scientific Periodicals" will soon become out of print, has led to active preparation for the issue of a fourth edition. In the new edition, brought up to date to include the new scientific and technical periodicals that have appeared in the past decade, the abbreviations of titles, where necessary, will be modified to conform with the International Standards Organization Recommendation *R*4 of the International Code for the Abbreviation of Titles of Periodicals. The system recommended by the Royal Society for the transliteration of Russian, Serbian and Bulgarian for bibliographic purposes will also be adopted.

Since the location of the periodical publications available for reference in libraries is of the utmost importance to research, the librarians of the 247 libraries who contributed to the last edition are being requested to participate in the new edition of this important bibliographical work of reference. They are asked to send the titles of journals not appearing in the third edition, with particulars of their holdings, and amendments or corrections to the entries of their holdings of the 46,000 titles contained in the last edition, to the Secretary, World List of Scientific Periodicals, c/o the Zoological Society of London, Regent's Park, London, N.W.1, from which office further information may be obtained.

Thermal Insulation of Houses

The Thermal Insulation (Dwellings) Bill which Mr. G. Nabarro introduced into the House of Commons on January 29, sponsored by members of both major political parties, extends the principle of the

Thermal Insulation (Industrial Buildings) Act of July 1957 to all new dwelling houses built in the United Kingdom after 1959. Mr. Nabarro said that on the evidence of the Egerton Committee's report of 1946 and of the Ridley Committee's report of 1952 we used on average five tons of coal or its equivalent per dwelling per annum, of which four tons were used for space- and water-heating services generally. He claimed that at least 25 per cent of this would be saved by proper insulation of houses. Accordingly, at an annual construction of 250,000 houses, an initial saving of 250,000 tons should be achieved, rising progressively to 5 million tons per annum at the end of twenty years. The minimum economy of £40 million per annum, at to-day's price, made investment in thermal insulation, which should not cost more than £8 on a £1,600 four-bedroom council house, well worth while.

Stars Month by Month

There are many people who have a general interest in the phenomena of the night sky and who need a simpler description of the visibility of the stars and planets than is found in the almanacs. To meet this need *The Times* produces an annual booklet. The latest edition, "The Night Sky 1958" (pp. 27. London: The Times Publishing Co., Ltd., 1958. 3*s.* net), gives charts for every month of 1958. Each chart shows the sky as it appears at 11 p.m. on the first day of the month together with the positions of the moon and planets. Each chart is accompanied by notes on the visibility of the planets and the phases of the moon for the month. There are notes on the eclipses which occur during the year, and some general explanatory notes. The booklet is well produced and the information which it contains clearly presented. The booklet is suitable not only for the general public but also for use by those schools, societies and clubs in which efforts are made to introduce young people to the phenomena of Nature.

Bishop's Stortford School Natural History Society

The value of school natural history societies and the contribution they can make to new knowledge is illustrated by the activity of the Bishop's Stortford College Natural History Society. Observations on the mistletoe by a senior boy, D. J. Cove, were noted in *Nature* (178, 779; 1956), and will now be included by the Forestry Commission in a new book on the diseases of forest trees. Besides the usual sectional reports, the latest issue of the Society's journal, *Coturnix*, contains details of studies on the larger fungi of the Bishop's Stortford district by J. W. Neal and the distribution of certain myriapods and crustaceans in organic debris during the winter months by M. Morton. Interesting observations on the reactions of certain myriapods to light, gravity, certain smells, water and oxygen were made by J. G. Pickard, who was able to show that the relatively high rate of respiration of the lithobiomorph centipede may be correlated with its observed restlessness; the low rate in the case of *Julus* with its observed sluggishness. A regional survey of the local sewage farm was made by R. G. Oakley, while P. H. King made continuous observations at Mersea Island, the centre of the oyster industry.

Extension of Primary Cell Walls

The mechanism of deposition and extension of primary cell walls has been further investigated by G. Setterfield and S. T. Bayley (*Canadian J. Bot.*, 35, 435; 1957). Walls of elongating parenchyma and epidermal cells of *Avena* coleoptiles and onion roots were studied by autoradiography, using sugars labelled with carbon-14, and by electron microscopy of thin transverse sections. The autoradiographs showed that deposition of cellulose takes place over the whole length of the cell, ruling out the possibility of bipolar tip growth. Autoradiographs of cells grown for short periods in labelled sugar gave no evidence of localized incorporation of the isotope around primary pit-fields, but rather indicated that deposition of microfibrils is finely dispersed over the entire wall surface. The thin sections revealed a marked change in wall structure as elongation proceeds. Walls of young cells contain only transversely oriented microfibrils, while older walls include an inner region of predominantly transversely oriented microfibrils bounded outside by a region with microfibrils showing an irregular transition to longitudinal orientation. The degree of longitudinal orientation in the outer region increases with length of cell. These results for thin walls are consistent with the multinet model for wall growth deduced by other workers from electron microscope studies on cell fragments. Thin sections have also revealed layering in several types of growing walls which is difficult to interpret on the basis of the multi-net model alone.

Graft Unions between Meristematic Tissues

Under the title of "The Regeneration of Severed Pea Apices", H. F. Gulline and R. Walker (*Australian J. Bot.*, 5, 129; 1957) have described successful graft unions between meristematic tissues in apices of the pea, *Pisum sativum* L. A technique for preventing desiccation of apices during and after the operations is described. Apical segments ranging from about 200μ down to 50μ in depth were successfully grafted back to their parent plant. The subsequent development of grafted apices was completely normal. These experiments show that a complete shoot can be regenerated from an apical segment less than one-thousandth of a cubic millimetre in volume, containing about 600 cells. This is smaller than any graft previously recorded. The morphogenetic interest of this investigation needs no emphasis.

U.K. Atomic Energy Authority: Appointments

Dr. H. Kronberger has been appointed director of research and development at the Industrial Group Headquarters at Risley, Lancashire, of the United Kingdom Atomic Energy Authority. He succeeds Mr. L. Rotherham, whose appointment as a member of the Central Electricity Generating Board was announced in *Nature* of January 4, p. 20. Dr. Kronberger, who is thirty-eight years of age, was chief physicist at Risley prior to his new appointment.

Mr. J. C. C. Stewart, formerly director of technical policy in the Industrial Group at Risley, becomes a deputy managing director of the Industrial Group. Mr. J. B. W. Cunningham, formerly deputy director (civil reactors), becomes director of industrial power in the Industrial Group. Dr. R. Hurst, formerly chief chemist in the Research and Development Branch of the Industrial Group at Risley, becomes director of the Dounreay Experimental Reactor Establishment. Mr. D. S. Mitchell, formerly director of administration, becomes director of personnel and administration in the Industrial Group. These appointments, which took effect on February 1, mark a first stage towards implementing recommendations made by the Committee appointed by the Prime Minister under the chairmanship of Sir Alexander Fleck to examine the organization of certain parts of the Authority. Further appointments will be announced in due course.

Mr. D. W. Fry, chief physicist at Harwell, has been appointed a deputy director of the Atomic Energy Research Establishment and took up his new post on February 17.

Prof. Heinrich Balss

Dr. J. Théodorides of the University of Paris has written to say that, in the obituary notice of Prof. Heinrich Balss, which appeared in *Nature* of December 21, 1957, p. 1391, he was surprised to find no reference to Prof. Balss's important works on the medieval naturalist, Albert the Great. Dr. Isabella Gordon wishes to add that Prof. Balss's scholarly contributions to the history of biology and medicine include the following: "Albertus Magnus als Zoologe" (Munich, 1928); "Albertus Magnus als Biologe: Werk und Ursprung", *Grosse Naturforscher*, 1 (Stuttgart, 1947) and "Aristoteles Biologische Schriften", with Greek text and German translation (Munich, 1943).

Announcements

The following medal awards have been made by the Royal Astronomical Society: *Gold Medal:* Prof. André Danjon, for his contributions to astronomical photometry, to fundamental astronomy and to the design of astronomical instruments; *Eddington Medal:* Dr. H. W. Babcock, for his work on the magnetic fields of early-type stars and of the Sun.

Dr. L. A. Jordan, director of the Research Association of British Colour and Varnish Manufacturers, has been appointed professor of chemistry at the Royal Academy of Arts in succession to Dr. H. J. Plenderleith, keeper of the Research Laboratory, British Museum.

The British Institute of Radiology has made the following awards for 1958: the Barclay Medal to Dr. G. M. Ardran (Nuffield Institute for Medical Research, Oxford); the Röntgen Award to Dr. P. R. J. Burch (Department of Medical Physics, General Infirmary, Leeds); and the Barclay Prize (posthumously) to the late Dr. Trevor Griffiths (Brook Hospital, Shooters Hill Road, London).

The Road Research Laboratory of the Department of Scientific and Industrial Research is again holding open days, this year on May 15 and 16. The Materials and Construction Division and the Colonial Section are at Harmondsworth, Middlesex, and the Traffic and Safety Division at Langley, Buckinghamshire. The Scottish Branch of the Laboratory at Thorntonhall, near Glasgow, will be open to visitors on June 4 and 5.

The third International Seaweed Symposium will be held in Galway during August 13–19. Further information can be obtained from the Secretariat, Third International Seaweed Symposium, University College, Galway, Ireland. Abstracts of communications must reach the Secretariat before April 1.

A symposium on "The Pharmacology of Phenolic Substances" is to be held at Oxford on April 10 and 11 in conjunction with the first annual general meeting of the Plant Phenolics Group. Applications to attend should be made to the secretary, Dr. T. Swain, Low Temperature Research Laboratory, Downing Street, Cambridge.

The Nutrition Society is holding a symposium on "Fish" in the Physiology Lecture Theatre, the Old Medical School, the University of Liverpool, during March 28–29. Further information can be obtained from the hon. programmes secretary of the Nutrition Society, Miss D. F. Hollingsworth, c/o Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W.1.

The 1958 International Starch Convention, organized by the German Cereals Research Association, will be held at Detmold, West Germany, during April 22–24. The programme will include papers on research and analysis; starch fractions and derivatives; starch manufacture and practice. Further information can be obtained from Dr. Eric Dux, Sichel Adhesives, Ltd., Riverside Works, 6 Friars Lane, Richmond, Surrey.

A symposium on "Numerical Approximation", sponsored by the Mathematics Research Center, U.S. Army, will be held during April 20–23 at the University of Wisconsin, Madison. The topics of the symposium include linear approximation, interpolation, Tchebycheff and other extremal approximations, expansions and algorithms. Further information can be obtained from Prof. R. E. Langer, Mathematics Research Center, U.S. Army, University of Wisconsin, 1118 W. Johnson Street, Madison 6, Wisconsin.

The spring conference of the X-ray Analysis Group of the Institute of Physics will be held in the College of Science and Technology, Manchester, during April 18–19. There is no specific topic, and papers will be presented on a wide range of subjects, including optical diffraction methods, structural investigations, and X-ray diffraction and X-ray spectrographic techniques. The conference is open to all interested persons on completion of an application form to be obtained from the honorary conference secretary, Dr. C. A. Taylor, Department of Physics, College of Science and Technology, Sackville Street, Manchester 1, to whom all inquiries should be addressed.

The Silver Jubilee Symposium on "The Physical Properties of Polymers" arranged by the Plastics and Polymer Group of the Society of Chemical Industry will be devoted to the fundamental investigation of mechanical and electrical processes in polymers and the physical testing of polymers. It will be held at the William Beveridge Hall, Senate House, University of London, London, W.C.1, during April 15–17. The proceedings will be conducted under the general chairmanship of Mr. C. E. Hollis, chairman of the Group, and Dr. V. E. Yarsley, Mr. C. G. Garton and Dr. L. R. G. Treloar will take the chair for the three daily sessions. Further information can be obtained from the Assistant Secretary (Plastics and Polymer Group), Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

In the review of "Recruitment of Skilled Trades" by Lady Williams published in *Nature* of February 8, p. 373, it is stated in the first paragraph that questionnaires were sent to 9,000 firms. This is incorrect: in fact, 1,000 firms were approached, and 550 replied.

EMPLOYMENT AND WELFARE IN 1956

IN recent years British industry has seen an expanded working population with a high demand for labour and a low rate of unemployment. The annual report of the Ministry of Labour and National Service (H.M.S.O., 6*s*.) shows that this was not the case in 1956.

The total working population (which comprises those in civil employment, in H.M. Forces and the unemployed) increased only slightly, small decreases in the numbers in civil employment and in the Armed Forces being rather more than outweighed by a rise in the number of unemployed persons. There was an increase in the number of workers on short-time and some falling-off in overtime. The number of unfilled vacancies at the end of the year was lower than at the end of 1955. The post-war trend of a falling level of employment in the basic industries and a rising level in the manufacturing industries as a whole was checked.

The total working population rose by 14,000 during the year to a total of 24,087,000 at the end of the year, with a peak in November when a new post-war record total of 24,225,000 was reached. By the end of the year the number of men and women in civil employment had decreased by 64,000 to 22,989,000 and the number of H.M. Forces was 761,000, a reduction of 18,000.

There was some easing in the demand for labour during the year, affecting mainly semi-skilled and unskilled workers. This occurred mostly in the manufacturing industries although there was a small increase in employment in some sections engaged largely on exports and capital goods. Within the basic industries, however, the general decline in man-power was arrested. The number in employment in coal mining increased by more than 3,000 and in transport and communication by 9,000 ; in the gas, electricity and water supply group the labour force remained unchanged ; there was a decrease in mining (other than coal mining) and quarrying, and agriculture again suffered a substantial decline. Other industries which increased their labour force during the year were building and contracting, the distributive trades and the chemicals and allied trades.

The average number of persons registered as unemployed during 1956 was 257,000. Although this represented an increase of 25,000 compared with 1955, it was less than in any other post-war year except 1951.

The rising trend in wages continued, although the rise in prices slowed down until late in the year when a further marked rise occurred. The post-war expansion in industrial production as a whole and in the output per man was halted in 1956, the rates remaining approximately at the 1955-level. A large measure of economy in Government expenditure was part of the Government's general disinflationary policy during 1956. By the careful choice of economy measures the Ministry succeeded in making a substantial contribution to the economies while maintaining its service to industry and the public at a high standard.

The Ministry's employment exchange and appointments services continued their primary purpose of bringing together men and women seeking employment and employers requiring workers ; they also assisted in the supply of labour to the undermanned essential industries. Employers were encouraged to offer ex-regular servicemen resettlement in civil occupations, to accept older and disabled people on their merits and to expand part-time working. In spite of some easing of the shortage of labour, there was still a high average number of unfilled vacancies on the registers of the Ministry. The changes during the year in man-power demands by a number of industries, and especially the redundancies that occurred in the motor-vehicle and other manufacturing industries, made necessary a substantial measure of redeployment of labour ; in this the Ministry, helped by a number of employers who co-operated with employment exchanges by giving early notice of labour redundancies, achieved considerable success. Following a review early in the year, the Notification of Vacancies Orders, 1952, were revoked with effect from May 7, 1956, and at the same time the arrangements for giving preference to certain classes of vacancies were discontinued. Nevertheless, the number of vacancies filled remained high, the total for the year being 2,354,000.

Vocational training was provided by the Ministry for disabled persons, for ex-regular members of H.M. Forces and for other able-bodied men and women. The total numbers of new applicants for training and those completing training during the year were fewer than in 1955. Training was given, in the main, in the Ministry's Government Training Centres.

As in previous years, special services, including industrial rehabilitation and training, were provided to assist disabled persons to obtain employment. Industrial rehabilitation was provided at the Ministry's Industrial Rehabilitation Units, and about 80 per cent of the 7,800 men and women who completed courses either obtained jobs or began courses of training within three months of leaving the units.

Although there were more stoppages of work arising from industrial disputes in 1956, there were considerably fewer working days lost than in 1955 ; the total number of days lost was, in fact, the lowest since 1952. Strikes arising from labour redundancies in the motor-vehicle and ancillary industries were a new feature.

At the end of 1956, there were sixty Wages Councils and five Catering Wages Boards, the same numbers as at the end of 1955 ; one new Council was established and one abolished during the year. Arrears of wages were paid to more than 20,000 workers following action by the Wages Inspectorate.

The increasing awareness in recent years of the need for good human relations in industry was maintained in 1956 ; the incidence of labour redundancies in some parts of the country during the year emphasized both the need for and the value of such relations. The Ministry's Personnel Management Advisory Service continued to meet requests for assistance from particular firms and to co-operate with their organizations in this field ; the value of their work is completely disproportionate to the small numbers employed.

In the international labour and social field the Ministry again made a major contribution to the work of the International Labour Organization.

DEOXYRIBONUCLEIC ACID AND GENETIC MODIFICATION IN DUCKS

IT was natural that the genetic transformation of bacteria effected by the introduction of foreign deoxyribonucleic acid should lead to speculation as to whether the phenomenon could also be induced in higher forms. That similar treatment should be capable not only of altering the racial characteristics of the growing vertebrate but that such changes would also be heritable seemed one of the least likely outcomes of such an experiment.

Recently published reports by Benoit *et al.*[1] state that they have succeeded in changing the characteristics of ducks of one breed by injections of deoxyribonucleic acid from another, and that the modifications continued to be identifiable in the progeny of the treated birds.

Because of the importance that must be attached to such revolutionary claims, and in the absence, as yet, of substantive evidence from repeat experiments, the work of Benoit and his colleagues should be subjected to critical scrutiny.

In the first place it might be suggested that, even with the most meticulous records, proof of somatic transformations of the kind described (size, weight, form of head, bill colour, carriage of body and the general aspect) would be difficult to establish in this species without an appreciation of the range of variability.

This is because there is not only considerable lack of knowledge of the genetics of the duck, but at times the development of breeds depended upon predilection for improvement by the sporadic introduction of other varieties, and this has provided many so-called pure breeds with a cryptic hereditary constitution not always to be expected from their apparent origins.

Preliminary to the experiment the birds were obtained from a reputable breeder and the weekly injections commenced when the Pekin ducklings were 8 days old. Of thirty-six ducklings, twelve (3 males, 9 females) were chosen at random for injection of deoxyribonucleic acid derived from blood and testes of Khaki Campbell drakes, and the remainder kept as controls. Total amounts of deoxyribonucleic acid injected were 5 mgm. per bird for the males and 61 mgm. for the females over a period of 5 weeks and 19 weeks respectively. One male and eight females developed the pronounced somatic modifications described. The females matured normally and laid eggs which, fertilized by treated males, produced twenty-six ducklings, 73 per cent of them having atypically coloured bills, and a good number actually showing other somatic modifications.

Bill colour in the Pekin breed is orange-yellow, and in the Khaki Campbell a greenish black. It may be of significance that a defect of the Pekin listed in British Poultry Standards is "Black marks or spots on the bill".

Although considerable time would appear to have elapsed between the end of the injection period and the discovery of the modifications, the findings, if and when substantiated, would, like the proof of vegetative hybridization, have a tremendous impact on genetic theory and practice.

For the moment it would be as well to agree with Benoit and his colleagues that "Aujourd'hui, notre meilleure conclusion sera que nous n'avons aucune conclusion à vous présenter", and await the repetition and extension of this work by them and others who will, no doubt, be stimulated by the reports.

ALAN W. GREENWOOD

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[1] Benoit, J., LeRoy, P., Vendrely, C., and Vendrely, R., *C.R. Acad. Sci. Paris*, **244**, 2320 (1957); **245**, 448 (1957); *La Presse Médicale*, 65 Année, No. 72, 1623 (1957).

UNION OBSERVATORY, JOHANNESBURG

THE annual report of the Union Observatory, Johannesburg, for 1956 (which appeared in October 1957) follows the usual lines, and it will be sufficient to refer to the main events during the period under consideration. The 26½-in. refractor was used with the interferometer by Dr. W. S. Finsen for the measurement of double stars and the discovery of new ones on 135 nights, and on 68 nights for colour photography of Mars. In addition, Mr. J. Churms and Dr. W. H. van den Bos used it on 68 nights for the measurement of known double stars. Messrs. J. A. Bruwer and Churms, with a number of amateur astronomers who are members of the Transvaal Branch of the Astronomical Society of South Africa, used the 9-in. refractor on 179 nights for observations of planets, variable stars, etc., the amateurs rendering valuable assistance to the staff on visiting evenings and in many other ways. The results of the occultation observations were communicated to H.M. Nautical Almanac Office.

The Franklin-Adams telescope at the Hartbeestport Annexe obtained 178 plates for minor planets and 23 plates for comets, and the resulting positions were regularly communicated to the respective central bureaux of the International Astronomical Union at Cincinnati and Copenhagen. Dr. Finsen devoted much of his leisure time to the preparation of composite enlargements from the colour films of Mars obtained during the favourable opposition of 1954 and 1956. The card catalogue of double stars south of − 19° dec. has been kept up to date, and information has been supplied to other astronomers on request.

With the 3-in. refractor sunspot counts were obtained on 281 days, the other days being overcast or unsuitable for reliable counts. The results have been regularly communicated to the Telecommunication Research Laboratory of the South African Council for Scientific and Industrial Research, the Magnetic Observatory at Hermanus and the Receiving

Station of the South African Broadcasting Corporation at Panorama.

Under "Time Services", reference is made to improvements to the control circuits of the Diesel generator and to the vibrator power supply units so that the quartz clock installation is now practically independent of mains interruptions. A new frequency divider employing cold-cathode valves was built, and the stability of other frequency dividers improved. The performance of the ring crystal over short periods was rather more erratic than had been expected, and from October onwards all the time and frequency equipment has been controlled by oscillator 4*A* while further tests are being made. A twelve-channel frequency recorder, designed and built by the British Post Office, was delivered in June, and this recorder has been of very great value in keeping a continuous check on the performance of all parts of the time installation. A new cathode-ray oscilloscope comparison unit was built and this measures the reception time of time signals in terms of local time to one ten-thousandth of a second.

Under "Miscellaneous Public Services" reference is made to the Wiechert horizontal seismograph which was in operation throughout the year; local earth tremors and records of ten distant earthquakes; and records of rain have been sent monthly to the Bernard Price Institute for inclusion in its monthly *Seismological Bulletin*. Reference is also made to the installation of a synchronous motor drive on the twin telescope, and to the transfer of the Leyden Southern Station from Johannesburg to Hartbeestport.

FEDERAL RESEARCH AND DEVELOPMENT EXPENDITURE IN THE UNITED STATES*

THE National Science Foundation has issued an analysis of the Federal Research and Development Budget for the fiscal years 1956, 1957 and 1958, in which latter year twenty-three agencies of the Federal Government allocated 3,400 million dollars for scientific research and development, an increase of nearly one-fourth on 1956. Actual expenditure increased from about 2,500 million dollars to almost 3,000 million dollars in 1957 and is expected to reach 3,300 million dollars in 1958. From 85 to 90 per cent of these funds are for the conduct of research and development, including the pay and allowances of personnel, actual expenditure increasing by 14 per cent in 1957, and it is expected to increase by 10 per cent in 1958 to 2,900 million dollars. Some 10–15 per cent of the total is on the expansion of plant and equipment, including the acquisition of land, and expenditure for these purposes increased from just over 200 million dollars in 1956 to an estimated 437 million dollars in 1958, mainly on plant or facilities for defence.

Of the twenty-three agencies, the Department of Defense and the Atomic Energy Commission together account for 88, 85 and 82 per cent of the total funds in 1956, 1957 and 1958, respectively, about 45 per cent of the Defense Department funds being administered by the Air Force. For 1957 and 1958, 672 million dollars were allocated by the Atomic Energy Commission, compared with 2,166 million and 2,111 million dollars, respectively, by the Defense Department. Allocations of the Department of Health, Education and Welfare for scientific research and development increased from 89 million dollars in 1956 to 200 million in 1958, and of the 182 million allocated in 1957, 175 million were primarily by the National Institutes of Health for research on the diagnosis, cause and treatment of disease. The Department of Agriculture increased its allocation from 84 million dollars in 1956 to 108 million in 1957 and 132 million dollars in 1958; for the National Advisory Committee for Aeronautics, the corresponding figures are 66 million, 80 million and 94 million dollars; for the Department of the Interior, 38 million, 47 million and 53 million dollars; for the National Science Foundation, 17 million, 48 million and 47 million dollars; and for the Department of Commerce, 18 million, 25 million and 33 million dollars, respectively, the decrease for 1958 in the allocation by the National Science Foundation being because of the International Geophysical Year.

Of the 2,231 million dollars expended on the conduct of research and development in 1956, 1,388 million was on development and 844 million on research, of which 157 million was on basic research. The corresponding figures for 1957 are estimated as 2,635 million dollars, 1,671 million, 964 million and 218 million, respectively, and for 1958, 2,782 million dollars, 1761 million, 1,021 million and 233 million, respectively. Of the expenditure on research in 1956, 198 million dollars was on the biological sciences, 616 million dollars on the physical sciences, and 30 million on the social sciences; in basic research, the corresponding distribution was 50 million, 104 million and 3 million dollars. For 1957 the corresponding distribution in total research is estimated as 281 million, 627 million and 35 million, and in basic research 70 million, 143 million and 4 million dollars; and for 1958 in total research, 317 million, 637 million and 48 million, and in basic research, 83 million, 143 million and 6 million dollars. Subdivided again, total research expenditure on the biological sciences in 1956 included 99 million dollars on medical sciences and 44 million on agricultural sciences; for 1957 the corresponding estimates are 158 million and 53 million dollars, and for 1958, 177 million and 59 million dollars. That on the physical sciences in 1956 included 6 million dollars on the mathematical sciences and 456 million dollars on the engineering sciences; corresponding estimates for 1957 are 7 million and 435 million dollars, respectively.

Of the 2,830 million dollars allocated for the conduct of research and development by the Federal Government in 1957, 48 per cent was spent on work performed by Government agencies, including pay and allowances of military personnel engaged in such work. Of the remainder, 35 per cent went to work carried out by profit organizations, about one-fourth of this going to research institutions administered by such organizations, 14 per cent went to educational institutions and the remaining 3 per cent to other institutions, including non-profit research institutions, foundations and hospitals.

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* National Science Foundation. Federal Funds for Science 6: The Federal Research and Development Budget, Fiscal Years 1956, 1957 and 1958. Pp. iii+60. (Washington, D.C.: Government Printing Office, 1957.) 40 cents.

Since the 1948 low level of just over 850 million dollars, Federal Government expenditure on scientific research and development has risen steadily, except in 1954, to 2,800 million dollars in 1957, or just over 4 per cent of the total budget expenditure compared with just over 2 per cent, and it is estimated that expenditure on basic research has increased by more than 85 per cent since 1952, although still amounting to only 8 per cent of the total funds for the conduct of research and development, exclusive of the pay and allowances of military personnel. In the same period, allocations for research in the biological sciences also increased by more than 83 per cent. It is estimated that the increases have been greater than the rate of increase in costs for salaries and equipment for scientific work and that accordingly when due account is taken of such rising costs the long-term trend still reflects a steady increase in the provision of Government funds for scientific research and development. Besides the statistical tables, the report includes technical notes on the limitations of the data and definitions and a list of research centres.

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PHOTOPERIODISM IN PLANTS AND ANIMALS

AN international symposium on "Photoperiodism in Plants and Animals", sponsored by the Photobiology Committee of the National Research Council of the United States, was held at Gatlinburg, Tennessee, during October 29–November 2.

In an introductory session the reversible photochemical properties of certain dyes were described by Dr. G. Oster (Polytechnic Institute of Brooklyn) and problems of energy transfer in photochemical systems were discussed by Dr. Gordon Tollin (University of California, Berkeley). Dr. Stacey French (Carnegie Institution, Stanford) discussed the difficulties of determining action and absorption spectra in living systems.

One session was devoted to the various photoperiodic effects observed in growth and dormancy of plants. Dr. J. L. Liverman (Texas Agricultural Experiment Station) and Dr. W. H. Klein (Smithsonian Institution, Washington) dealt with the interaction between red light and various other factors in the growth of bean leaf disks, and the uncoiling of the bean epicotyl hook, respectively. Both speakers reported that the effects of indole-acetic acid, kinetin, gibberellic acid and the cobaltous ion seem to be independent of those of red light. There appears, however, to be an interaction between adenine and red light in the growth of bean leaf disks. Dr. E. H. Toole (U.S. Dept. of Agriculture, Beltsville) described the responses of various light-sensitive seeds and Dr. P. F. Wareing (University of Manchester) dealt with the photoperiodic control of germination, with special reference to the action of various spectral regions and the possible role of growth inhibitors. Dr. R. J. Downs (U.S. Dept. of Agriculture, Beltsville) discussed the interaction between red and infra-red radiation in relation to various aspects of vegetative growth. The effects of red irradiation on the activity of indole-acetic acid oxidase were shown by Dr. A. W. Galston (Yale University) to be due to the formation of an inhibitor of this enzyme by red light.

Dr. R. van den Veen (Philips' Research Laboratories, Eindhoven) described experiments which involved growing various species entirely under high-intensity monochromatic light. It was found that there are marked differences between species with respect to growth responses, under the various spectral regions. There are complex interactions between blue and red, especially in relation to the control of flowering. Prof. E. C. Wassink (Agricultural University, Wageningen) also described the responses of various species grown under high-intensity radiation in narrow spectral regions.

Two sessions were devoted to the photoperiodic control of flowering. Dr. Ralph Wetmore (Harvard University) and Dr. E. M. Gifford (University of California, Davis) described the structural changes occurring in shoot-apices of *Xanthium* and other species in the transition from the vegetative to the flowering condition. The interaction of red and far-red radiation in the flowering of various species, including *Hyoscyamus*, was dealt with by Dr. H. A. Borthwick (U.S. Dept. of Agriculture, Beltsville). Dr. Roy Sachs (University of California, Los Angeles) discussed the implications of 'long-short' day plants, such as *Cestrum nocturnum*, for general theories of photoperiodism.

Dr. A. Lang (University of California, Los Angeles) read a paper dealing with the general problem of the role of auxin and gibberellins in flowering. Auxin tends to be inhibitory of flowering in short-day plants and promotive in long-day plants, but it appears only to modify the responses. Both gibberellic acid and gibberellin-like fractions from *Cucurbita* endosperm are capable of inducing flowering in some long-day plants, but cannot replace photo-induction in short-day plants. Photo-induction in long-day plants appears to involve reactions other than gibberellin-controlled processes, which may be concerned primarily with stem elongation. The interactions between gibberellic acid and photoperiodic responses were discussed by Prof. Fausto Lona (University of Parma) for a wide variety of species.

The effects of certain synthetic hormones on flowering of *Xanthium* were described by Dr. A. Naylor (Duke University), and Dr. F. Salisbury (Colorado State University) described the interaction between various applied growth substances and the critical dark period in *Xanthium*. Dr. W. Jacobs (Princeton University) discussed the relations between auxin, day-length and compensatory growth in *Coleus*.

In a general paper on the nature of the photo-inductive processes in photoperiodism, Dr. James Bonner (California Institute of Technology) outlined the present state of knowledge of the various partial processes involved, and discussed the possible reasons why the 'flower-hormone' has not yet been isolated. Dr. R. B. Withrow (Smithsonian Institution, Washington) gave a general account of the kinetic aspects of the photoreactions. He distinguished between 'graded' responses (for example, of light-sensitive seeds) and 'threshold' responses (for example, photoperiodic phenomena). Dr. S. B. Hendricks (U.S. Dept. of Agriculture, Beltsville) also dealt with kinetic aspects of the photo-reactions of photoperiodism and showed how certain kinetic parameters of the photo-receptor system can be derived. He also described a second photo-receptor system which appears to be involved in anthocyanin synthesis.

A series of papers dealt with photoperiodism in animals. Dr. A. D. Lees (A.R.C. Unit of Insect Physiology, Cambridge) reviewed the phenomena of photoperiodism in insects and mites, particularly in relation to the onset of diapause. Photoperiodic responses appear to be widespread in Lepidoptera. Dr. C. E. Jenner (University of North Carolina) dealt with photoperiodism in an aquatic midge, the larval stage of which is found in the 'pitchers' of pitcher plants. Reproduction in certain snails and freshwater shrimps appears to require long-day conditions. Photoperiodism is also of importance in many marine invertebrates, including crustaceans, molluscs and echinoderms, as was shown by Dr. A. C. Giese (Stanford University).

The general problem of the seasonal control of reproductive cycles in vertebrates was discussed by Dr. W. S. Bullough (University of London), who emphasized that photoperiodism constitutes only one aspect of a highly complex system. In vertebrates, photoperiodic perception appears generally to be mediated through the eyes. In carp and related fishes, courtship and breeding appear to be induced by increasing day-length in the spring, as shown by Dr. R. W. Harrington (Florida State Board of Health). Photoperiodic effects have also been reported in certain reptiles, including the pond-turtle, the American chameleon and certain lizards. Dr. G. A. Bartholomew (University of California, Los Angeles) emphasized, however, that in the latter the importance of photoperiodic responses is probably over-ridden by behavioural patterns in relation to diurnal temperature changes.

Endogenous rhythms in the ovulation cycle of hens were described by Dr. R. M. Fraps (U.S. Dept. of Agriculture, Beltsville). Dr. D. S. Farner (State College of Washington) showed that in certain birds day-length controls a variety of physiological responses including the male gonadal cycle, fat metabolism, vernal migration and probably moulting. In the white-crowned sparrow the most effective spectral region controlling development of the testes appears to be in the red. Dr. A. Wolfson (North Western University, Evanston) described photoperiodic control of migration in the juncos of Alberta, in which fat deposition appears to be an important factor. The responses in these birds appear to be determined by the duration of the daily dark period. Photo-periodic responses in other bird species were described by W. L. Engels (University of North Carolina), Dr. C. M. Kirkpatrick (Purdue University) and Dr. W. O. Wilson (University of California, Davis).

A further series of papers was devoted to endogenous rhythms in plants and animals. Dr. E. Bünning (University of Tübingen) gave a general account of endogenous rhythms, and discussed some general properties of the 'timing mechanism' in such rhythms. Dr. K. C. Hamner (University of California, Los Angeles) described the results of experiments with 'Biloxi' soybean, in which it was found that flowering occurred with cycle-lengths of 24 hours or of multiples thereof, whereas with cycles of intermediate duration flowering was partially or completely inhibited. These results are held to indicate an endogenous rhythm in photoperiodic sensitivity. Dr. F. W. Went (California Institute of Technology) showed that certain species, notably the tomato, made favourable growth on 24-hour cycles but showed reduced growth and other adverse symptoms on other lengths of cycle. These effects are exhibited in both photoperiodic and thermoperiodic phenomena.

Dr. C. S. Pittendrigh (Princeton University) discussed the possible nature of the clock mechanism in endogenous rhythms and postulated that two types of 'oscillator' may be involved, namely: (1) a primary light-sensitive oscillator which is temperature-independent, and the phase of which is determined by external light conditions; (2) a temperature-sensitive oscillator which can 'entrain' oscillator (1). Endogenous rhythms of activity in the hamster, and of bioluminescence in *Gonyaulax polyedra*, were described by Dr. K. S. Rawson (University of Wisconsin) and Dr. J. W. Hastings (Northwestern University) respectively.

Three evening sessions were devoted to sixteen short papers, including seven dealing with interactions between gibberellic acid and various light-controlled processes.

This highly successful meeting is believed to have constituted the first international symposium devoted specifically to photoperiodism in plants and animals. Biologists working in this field are indebted to the Photobiology Committee for organizing the meeting and especially to Dr. R. B. Withrow and Dr. N. E. Tolbert, chairman and secretary of the Committee respectively.

P. F. WAREING

FARMING HISTORY

THE joint annual conference of the British Agricultural History Society and the Association of Agriculture was held on December 7 at the Institute of Education, University of London. Three papers were read. Mr. George Ordish discussed the "History of Crop Pests, and the Measures taken to overcome them". After lunch, two papers on horticultural history were presented. Dr. L. G. Bennett, Department of Agricultural Economics, University of Reading, spoke on the "History of the Development of Market Gardening", and Mr. Eric Hobbis, of Long Ashton Research Station, University of Bristol, on the "History of Soft Fruit Growing".

Pests and diseases of plants are as ancient as the cultivation of crops for food, and the uncultivated flora that flourished before man was probably also afflicted. Mr. Ordish showed by exhaustive references to Pliny that pests and diseases were well known in classical times. Apples and pears were affected, and the olive fly was prevalent. It is still a trouble. There were cereal pests, wireworm and the cabbage flea beetle, but there was no phylloxera, nor the two mildews that were introduced from America much later.

Methods of protection were then of four kinds: religious, superstitious, mechanical and chemical. Though some of the first two were peculiar, it is not advisable to dismiss them out of hand. The superstition of yesterday often turns out to be the science of to-day. Achilles barley, presumably an immune variety, was recommended by Pliny when rust was very bad. Treating with burnt ash, steeping seed in wine and the dregs from the oil presses were other preventive measures. Greasebands were fixed on the vines, and indeed are still used in Turkey.

No doubt the prevalence of pests and diseases, and the lack of knowledge of how to destroy or cure them, was a factor, among others, that kept yields at a low level for a thousand years or more.

Mr. Ordish proceeded to a discussion of the work of the sixteenth- and seventeenth-century botanists, more particularly that of Thomas Mouffett and Topsell. He said that Worlidge in 1669 had set out a method of dealing with hop mildew that would effectively control one type. The belief in the spontaneous generation of bugs, lice and other insects "out of corruption" was widely held by writers of that date, and was not disposed of until later scientists had shown that these pests were born out of eggs. New material had become available in the eighteenth century, and Richard Weston and others suggested the use of tobacco dust, spraying with a nicotine solution, and fumigating with tobacco smoke. Steeps of brine and urine had continued to be used to control cereal rusts, but there was some dispute about their efficacy. Some remarkable randomized experiments were made by Tilly in France about 1750 to test controls.

Necessarily, Mr. Ordish's paper was an outline of a vast subject, and, as was then said, it is to be hoped that he will make and publish an exhaustive study of the subject. The only existing treatise is a very brief American publication.

Dr. Bennett traced the development of commercial market gardening from the sixteenth to the nineteenth century. Before 1500 he thinks there was little. The use of vegetables is said to have declined between the eleventh and the sixteenth centuries, and to have been revived only with the new methods of cultivation introduced to Great Britain by French and Dutch refugees from religious persecution. It is, however, a little difficult to accept this conclusion, because, if it is true, some other food must have taken the place of the onion, garlic, leek, cabbage, peas and beans, worts and other herbs that all went into the pottage commonly consumed by the generality of the people. Be that as it may, Dr. Bennett made it quite clear that there was a great extension of market gardening in the sixteenth century. The refugees settled in the Sandwich area and elsewhere in Kent, around Norwich, and eventually in the immediate environs of London, where a part of Covent Garden was set aside for a vegetable and fruit market held three days a week. The Worshipful Company of Gardeners was organized by the growers to exercise control over malpractices and to look after their interests. From this time market gardening increased in importance, especially in the nineteenth century, when the growth of population in large aggregations, some rise in the standard of living, and changes in dietetic taste led to an immensely increased demand for fruit and vegetables.

Mr. Hobbis indicated no such decline in the use of soft fruits during the Middle Ages as there may have been in vegetables and herbs. Strawberries, raspberries and gooseberries were known to our remote ancestors, but the raspberries were not very well liked until the sixteenth century. They were thought sour. Red currants were then regarded as a small kind of red gooseberry. From such small beginnings a very large soft-fruit growing industry had developed by the nineteenth century, and it expanded widely during that century, though it had not then spread to the eastern counties. The two wars had a bad effect, but the soft-fruit growing industry under modern influences—factory jam-making, canning, deep freezing, and so on—is reviving, while the results of research are providing growers with advantages unknown to their predecessors.

Such subjects are not simple, and it is difficult to make a summary of all the important points raised in these two lectures and the discussion that followed them. All three lecturers demonstrated that there are large areas in the history of agriculture and horticulture that still require exploration.

The headquarters of the British Agricultural History Society have now been moved to the Department of Agriculture, Parks Road, Oxford, and anyone interested should make inquiries of the Hon. Secretary at that address. G. E. Fussell

GELATINE AND GLUE

At the fourteenth meeting of the Research Panel of the British Gelatine and Glue Research Association, held on December 12, Dr. S. M. Partridge (Low Temperature Research Station) took the chair for the morning session and Mr. S. G. Hudson (Richard Hodgson and Sons, Ltd.) for the afternoon session. The first paper was by Mr. G. Russell (Ilford, Ltd.) with the title "Chemically Distinct Major Components of Gelatin"[1]. He outlined previous views on the level of impurities (other than inorganic ions) in high-grade gelatines. Methods such as heat coagulation, or adsorption on charcoal, suggest a protein impurity-level of not more than 0·5 per cent. In an attempt to separate these impurities from gelatin, experiments were carried out, in which chromatographic column technique was applied, using a finely divided form of the resin, '*I.R.C.50*'. Elution was effected with a buffer previously used for equilibrating the column, so that the whole operation took place at the same *p*H. Protein in the fractions was estimated, after hydrolysis, by reaction with ninhydrin.

Whereas at *p*H 6 the whole of the gelatin sample is eluted, giving a curve of concentration against eluant volume with a twin peak, at *p*H 5·5 only a portion of the sample (15 per cent) is eluted, the remainder (85 per cent) being firmly adsorbed on the resin. The latter fraction can be removed by raising the *p*H. Paper chromatograms show the smaller component to have a higher tyrosine content than ordinary gelatin, no detectable hydroxyproline, and other characteristics giving it an amino-acid composition broadly similar to the serum albumins. The major component is similar to gelatin. Quantitative results for tyrosine, using ultra-violet absorption, show the major component to have zero or only a trace of tyrosine, whereas the minor component has about 3 per cent. Assuming the tyrosine to be entirely present in the minor component, the content of this component in a series of gelatins ranges from 10 to 20 per cent. Mr. Russell considered some of the implications of his work, and a keen discussion showed the interest aroused. Dr. G. R. Tristram (University of St. Andrews) reported a separation, presumably of the same two components, on a modified cellulose column. It was clear from many comments that the future course of research on gelatin may be very much modified by Mr. Russell's work.

The second paper, "Some Aspects of Connective Tissue in Relation to Age", by Dr. R. Consden and Dr. P. C. Brown, of the Special Unit for Juvenile Rheumatism of the Canadian Red Cross Memorial Hospital, Maidenhead, discussed the chemical make-up of connective tissue. Recent work, both on collagen and on the polysaccharides of connective tissue, has revealed the complexity of the problems requiring solution. Whereas certain polysaccharides are readily removed by very mild processes, others are so firmly held that their association with the collagen must be very intimate. This applies in particular to the neutral polysaccharides. The course of fibrogenesis was outlined, and the contrast between young tissues, whether in young animals or in freshly formed tissue in wounds, and mature tissues was emphasized. The inertness of collagenous tissue was illustrated from Glynn's experiments on embedding dead tissue in living animals to study their rate of destruction. Collagen appears to persist indefinitely, whereas liver or muscle is metabolized fairly quickly. If, however, the collagen is heat-shrunk, it then is attacked fairly rapidly. The collagen of the uterus, which Harkness has studied, shows unusual features in being able to undergo rapid growth during pregnancy and rapid reabsorption at parturition. The increased stability of collagen with age, which can be demonstrated also as an increase in the force to inhibit contraction under thermal shrinkage conditions, is related to greater orientation and crystallinity. Keech has shown that a greater resistance to collagenase develops. A survey of human collagenous tissue shows that there is a significant increase of shrinkage temperature with age, and older tissue is more resistant than young to the action of hydrogen-bond breaking reagents. Uterine collagen has a significantly lower shrinkage temperature than adult collagen from elsewhere.

The third paper, "An Approach to the Non-Gelatin Constituents of Gelatines and Glues", was given by Mr. A. A. Leach, of the Association staff. Using bone glue as the starting material, it is possible to separate from it a component, present in substantial amount, which partially coagulates at about *p*H 4 and can be centrifuged off. This component is made up of a complex of lipid, polysaccharide, non-collagenous protein and a gelatin-like substance. The lipid is derived from the bone fat, and the analytical evidence suggests that the polysaccharide and non-collagen protein have their origin in the 'osseomucoid' isolated from compact bone and analysed by Eastoe and Eastoe. It is not certain to what extent the links between gelatin and the complex are formed during processing in bone glue manufacture, or are already present in the tissue. Attempts to separate the gelatin from the complex, using either heat coagulation of the second protein or differential trypsin attack on the gelatin, although partially successful, were not quantitative.

Bone glue from which the complex had been removed was fractionated by the alcohol method of Stainsby. It was then shown that the bulk of the non-gelatin components, other than the complex, remain in solution at the end of fractionation. They include substantial amounts of polysaccharide. It must be presumed that a further separation of the 'gelatin-like' fractions into the two components of Russell above would still be possible using the resin column technique.

A. G. Ward

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PIGMENTATION OF INTESTINAL MUSCLE IN STEATORRHŒA

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AND

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INTESTINAL biopsy has proved of little value in the diagnosis of idiopathic steatorrhœa. Paulley[1] has described changes in the mucosa which cannot be regarded as specific.

The object of this communication is to report a hitherto undescribed association between a lipoprotein pigment in intestinal smooth muscle and steatorrhœa.

The material was obtained from necropsies on a variety of intestinal disorders (Table 1). Four of the cases of steatorrhœa were diagnosed in life on the basis of high content of fat in the stool, high proportion of unsplit fat, low serum calcium-level and megaloblastic anæmia. The percentage of fat absorbed was found to be abnormally low in three cases, using a 'fat balance' test. In two other cases, in which pigment was found, the diagnosis of steatorrhœa was not confirmed during life. In one of these cases a diagnosis of Whipple's disease[2] rested upon histological findings alone.

Pieces for histogical examination were fixed in 10 per cent formal–saline or in corrosive formal. Paraffin sections were prepared and stained by Harris's hæmatoxylin and eosin; preliminary treatment with Lugol's iodine and sodium thiosulphate was given to those fixed in corrosive formal.

Those sections which showed pigment in the smooth muscle of the small intestine were stained by histochemical methods. Sections were stained for protein by the tetrazo method of Danielli following the technique described by Dixon[3]. This method detects tyrosine, tryptophan and histidine groups in the protein molecule. The Feulgen method[4] for deoxyribonucleic acid and pyronin G[5] for ribonucleic acid were applied. The periodic acid–Schiff method[6] and the permanganate–paraldehyde–fuchsin method[7] were used for detecting carbohydrates. Sudan black was employed for detecting lipids.

The presence of an unusual pigment was suggested in the case of Whipple's disease by a brown coloration

Table 1. ILLUSTRATING THE TYPE OF CASE INVESTIGATED AND THE OCCURRENCE OF PIGMENT

Clinical diagnosis	No. of cases examined	Stomach	Jejunum	Ileum	Colon
Whipple's disease	1	*N.E.*	+	+	*N.E.*
Idio. steatorrhœa (3 yr.)	1	*N.E.*	+	+	+
Idio. steatorrhœa (10 yr.)	1	+	+	+	+
Idio. steatorrhœa (4 yr.)	1	*N.E.*	+	+	*N.E.*
Idio. steatorrhœa (5 yr.)	1	*N.E.*	+	*N.E.*	*N.E.*
Steatorrhœa (not proved in life)	1	*N.E.*	+	*N.E.*	*N.E.*
Reticulo-sarcoma	4	*N.E.*	—	—	*N.E.*
Tuberculosis	8	*N.E.*	—	—	*N.E.*
Secondary carcinoma	2	*N.E.*	—	—	—
Leukæmia	5	*N.E.*	—	—	*N.E.*
Gastro-enteritis	14	—	—	—	—
Paralytic ileus	4	*N.E.*	—	—	—
Typhoid	2	*N.E.*	—	—	*N.E.*
Uræmia	1	*N.E.*	—	—	*N.E.*
Regional ileitis	3	*N.E.*	*N.E.*	—	—
Jejunal ulcers	1	*N.E.*	—	*N.E.*	*N.E.*

N.E., not examined; +, pigment present; —, no pigment present

of the muscular layers visible to the naked eye. In the five cases of steatorrhœa a delicate grey brown pigment was found in the hæmatoxylin and eosin preparations almost filling the cytoplasm of the smooth muscle cells of both the longitudinal and circular layers (Fig. 1). A remarkable feature was the total absence of pigment from the cells of the muscularis mucosæ. In the case in which stomach was examined and in the two cases in which colon was examined pigment was found in the same layers. Pigment was not found in any of the other examples of intestinal disease which were examined.

The histochemical reactions of the pigment were, in every case, the same. It stained bright red with the tetrazo method, purple with permanganate–paraldehyde–fuchsin and black with Sudan black. The findings suggested that it is a lipoprotein. No reaction was obtained with the other methods employed.

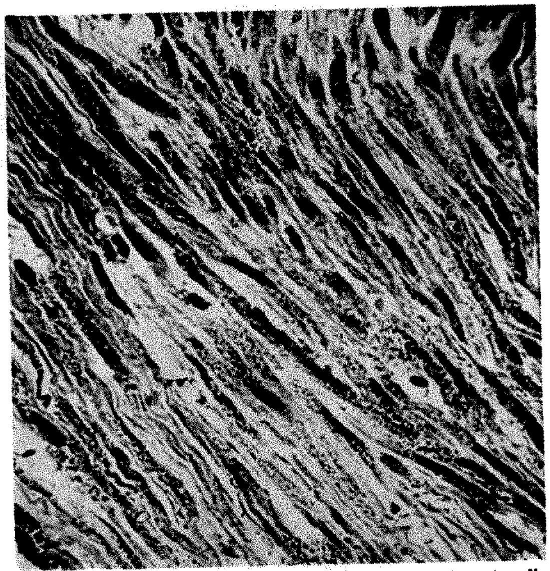

Fig. 1. Pigment in smooth muscle of jejunum. (Hæmatoxylin and eosin. × 450)

The presence of smooth-muscle pigment in cases of idiopathic steatorrhœa and Whipple's disease is of interest, first because of its diagnostic value and secondly because it may provide a clue to the etiology.

Paulley[1] saw pigmentation in the muscle coat in one case of idiopathic steatorrhœa, but did not consider it to be of any significance. Laparotomy was done in this case for subacute intestinal obstruction and consequently the full thickness of the gut was available for histological examination. He did not remark upon such pigmentation in his other cases. Further examples of idiopathic steatorrhœa need to be examined before the association of muscle pigment and the disease can be clearly established. Such an association is of little diagnostic value except in those cases in which the full thickness of gut-wall can be obtained. Since the pigment was not seen in the muscularis mucosæ, intestinal biopsy by Wood's tube[8] would be of little value since mucosa and muscularis only can be taken.

The histochemical properties of this pigment closely resemble those of lipofuscin (wear and tear pigment) commonly seen in cardiac muscle and in the olivary and dentate neurones. The pigment in the latter differs only in that it stains with paraldehyde-fuchsin without previous oxidation with permanganate. Scott and Clayton[9] consider that this property indicates the presence of 'highly sulphated mucopolysaccharides'. Staining with paraldehyde-fuchsin following permanganate oxidation was a feature of the pigment in the small gut and of brown atrophy pigment in the heart. This property, when the periodic acid–Schiff test is negative, suggests the presence of either cystine or highly sulphated mucopolysaccharides.

The origin of lipofuscin is debatable[10]. Marinesco[11] considers that it may arise from mitochondrial remnants. This would only seem likely if the ribonucleic acid content of mitochondria had previously been destroyed, since lipofuscin does not stain with pyronin *G*, which is considered to be a specific stain for this nucleic acid[12].

It is tempting to suppose a mitochondrial origin for the pigment in the intestinal smooth muscle in cases of steatorrhœa. Mitochondrial surfaces are sites of enzymic activity[13] which may be concerned with the absorption of fat through the intestinal wall. This hypothesis would seem more probable if the pigment was situated in the mucosa rather than in the muscle. However, the mechanism of fat absorption is still obscure[14] and such a hypothesis is worthy of consideration.

We are grateful to Dr. A. M. Barrett for his encouragement and permission to use the necropsy reports and material.

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ENZYMIC SYNTHESIS OF COENZYME I IN RELATION TO CHEMICAL CONTROL OF CELL GROWTH

By Prof. R. K. MORTON

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IT is generally accepted that the cell nucleus carries the genetic determinants of cell behaviour. It must therefore exercise control of cell division, growth and differentiation, probably by means of a compound, or compounds, synthesized exclusively in the nucleus but essential for cytoplasmic reactions. Such a compound is coenzyme I (nicotinamide adenine dinucleotide, or so-called 'diphosphopyridine nucleotide'). It is required for more enzymic reactions than any other known coenzyme and is as essential for the aerobic and anaerobic mechanism for provision of energy for the cell as adenosine triphosphate.

In animal cells, coenzyme I is synthesized from nicotinamide, according to the following reactions which are catalysed by the enzymes nicotinamide mononucleotide–pyrophosphorylase (equation 1)[1], and coenzyme I–diphosphopyridine nucleotide–pyrophosphorylase (equation 2)[2,3].

$$1.\ \text{Nicotinamide} + \begin{array}{c}\text{5-phosphoribo-1-}\\ \text{pyrophosphate}\end{array} \rightleftharpoons \begin{array}{c}\text{nicotinamide}\\ \text{mononucleotide}\end{array} + \begin{array}{c}\text{inorganic}\\ \text{pyrophos-}\\ \text{phate}\end{array}$$

$$2.\ \begin{array}{c}\text{Nicotinamide}\\ \text{mononucleotide}\end{array} + \begin{array}{c}\text{adenosine}\\ \text{triphosphate}\end{array} \rightleftharpoons \begin{array}{c}\text{nicotinamide}\\ \text{adenine}\\ \text{dinucleotide}\end{array} + \begin{array}{c}\text{inorganic}\\ \text{pyrophos-}\\ \text{phate}\end{array}$$

By a tissue-fractionation method, Hogeboom and Schneider[4] showed that coenzyme I–pyrophosphorylase was mostly localized in the cell nucleus in mouse liver. Branster and Morton[5] confirmed and extended this important finding by showing that the activity per nucleus is the same in isolated nuclei as in isolated intact liver cells[6,7]. The enzyme is also found in the nucleus in normal and tumour cells from mouse mammary gland[8] and in avian erythrocytes[9]. As yet it is the only enzyme known to occur exclusively in the cell nucleus.

The coenzyme I produced in the nucleus, where it may occur in relatively high concentration[10], is supplied to the cytoplasm wherein it participates in the reactions catalysed by numerous dehydrogenases. However, it also may be degraded relatively rapidly by cytoplasmic nucleosidases[11] and pyrophosphatases[12]. Provided that the dietary vitamin (nicotinamide or nicotinic acid) intake is adequate, therefore, the amount of coenzyme I available for cytoplasmic dehydrogenation reactions depends on the relative rates of the synthetic reactions (equations 1 and 2) as compared with the degradative reactions. Synthesis of new compounds by exchange reactions *in vivo*[13] and studies with intact whole cells[5] established that degradation *in vivo* is rapid and thus there must be a relatively high turnover-rate of coenzyme I in the cell.

Branster and Morton[8] therefore tested the hypothesis that a sufficient change in the rate of synthesis of coenzyme I by the nucleus would modify normal cell division and differentiation and thus lead to malignant growth. It was assumed that the activity of the coenzyme I–pyrophosphorylase (equation 2) would limit synthesis. In comparative studies, a unit of activity was taken as the synthesis from nicotinamide mononucleotide of 1 μmole of coenzyme I per hr. per 10^9 nuclei at 38°. With C_3H mice they found that the activity of spontaneous mammary gland carcinoma (2·8 units) was about 20 per cent of that of normal lactating mammary gland (13 units)[8]. With strain *A* mice, the activity of hepatoma (9 units) induced by feeding aminoazotoluene was about 20 per cent of that of normal liver (42 units) of control animals[5]. Very low rates of synthesis were also found[5] with Ehrlich ascite cells (2 units) from mice, and with post-operative human tumours. In the latter cases, however, no suitable normal tissues were available for comparison.

Branster and Morton[8] also found that the activity of normal liver of C_3H mice markedly increases during growth, being 2 units for fœtal, 12 units for young (7 and 17 days old) and 42 units for adult mice. Thus both tumour cells, and rapidly growing fœtal cells, have low activities as compared with suitable normal cells. On the basis of the rate of synthesis of coenzyme I per nucleus, therefore, the tumour cell represents a change from an adult-type to an embryonic-type of cell, and this is consistent with the general morphological and behavioural characteristics of tumour cells.

A low content of coenzyme I (and of coenzyme II) in tumour as compared with normal tissue has been established[14,15]. When expressed as μgm. of coenzyme per gm. of tissue, dye-induced hepatomas contain 48 per cent of the total coenzyme I and 14 per cent of the total coenzyme II of normal rat liver[15]. Hepatoma and normal rat liver contain the same amount of deoxyribonucleic acid phosphorus per nucleus[16] but 546 and 249 μgm. of deoxyribonucleic acid phosphorus per gm. of tissue, respectively[17]. Thus there are about 2·2 times as many nuclei per gm. of tissue in hepatoma as compared with normal liver. Expressed on the preferable basis of amount per nucleus[8,18,19], therefore, the results of Glock and McLean[15] indicate that hepatomas contain about 20 per cent of the coenzyme I of normal rat liver. Thus there is good agreement between the relative amounts of coenzyme I and the relative coenzyme I–pyrophosphorylase activities in hepatoma and normal liver. Also in agreement with the finding of a similar amount of coenzyme I in the two tissues[15], there was no significant difference between the coenzyme I–pyrophosphorylase activity of liver in hepatoma-bearing mice and in the controls[5]. The low content of coenzymes I and II cannot be attributed to increased cytoplasmic degradation which is no greater[20], and frequently less[5], than that of comparable normal tissues. A decreased activity of nicotinamide mononucleotide–pyrophosphorylase (equation 1) may occur in tumours and thus potentiate the effect of a decreased activity of coenzyme I–pyrophosphorylase. It appears, however, that this latter effect largely accounts for the low content of coenzyme I in tumours as compared with normal tissues. A low coenzyme I–pyrophosphorylase activity would also account for the synthesis of only 25 per cent of the coenzyme I in regenerating (48 hr.), as compared with normal, mouse liver in animals injected with large amounts of nicotinamide[21].

Weinhouse and his colleagues found that coenzyme I is a limiting factor in the respiration of homogenates and isolated mitochondria from tumours. This 'coenzyme I-effect'[22] would be expected from the low content of coenzyme I in tumour mitochondria[15], but it also may be due to the rapid dissociation of the so-called 'bound' coenzyme I from the tumour mitochondria and consequent rapid hydrolysis of the coenzyme[23]. Structural imperfection of the tumour mitochondria[24] could account for this rapid loss of coenzyme I, especially since a pronounced requirement for coenzyme I may also be shown by damaged mitochondria from normal tissues[22]. Swelling and consequent damage to isolated respiring liver mitochondria is prevented and even reversed by addition of adenosine triphosphate and coenzyme I [25], and it is likely, therefore, that the addition of coenzyme I prevents similar changes in isolated tumour mitochondria.

The 'coenzyme I-effect' observed by Weinhouse in the respiration of tumour mitochondria, therefore, reflects the low rate of coenzyme I synthesis in the tumour cell. Furthermore, the high fermentative activity of tumour cells[26,27] and of embryonic cells[22] may also be a consequence of the low rate of coenzyme I synthesis causing a kinetic imbalance of cytoplasmic enzyme systems and thus structural abnormalities in the cytoplasm.

Modification of the Rate of Synthesis of CoenzymeI as a Basis for Chemotherapy of Cancer

The findings already discussed show that in rapidly growing cells synthesis of new cell material occurs against a limiting rate of supply of coenzyme I from the nucleus. Continued cell growth immediately after cell division will cause the concentration of cytoplasmic coenzyme I to fall. It is assumed that when this declines to some critically low level, consequent interaction between the nucleus and cytoplasm causes the cells to divide again, thus providing more nuclear enzyme in relation to the amount of cytoplasm. The interaction which induces division probably involves a 'feed-back'[28] mechanism, since the synthesis of adenosine triphosphate in the cytoplasm is dependent on the supply of coenzyme I from the nucleus (for oxidative reactions), and synthesis of coenzyme I in the nucleus on supply of adenosine triphosphate from the cytoplasm. If each cell division leads to a net increase of coenzyme I–pyrophosphorylase in the nucleus, the concentration of coenzyme I will increase and thus permit of greater production of cytoplasm before another cell division is induced. In normal embryonic tissues which have no permanent lesion of coenzyme I synthesis, this will lead to a continual decline with time in the rate of cell division and so permit of normal differentiation and stabilization of the adult tissue. This interpretation is consistent with observations on fœtal, young, and adult mouse liver[8] and on regenerating mouse liver[21].

However, if there is a genetic lesion which prevents an increase in the activity of the coenzyme I-synthesizing enzyme, then cell division will not correct the limitation in the supply of coenzyme I, and synthesis of new cell material will rapidly lead to the interaction between the nucleus and cytoplasm which induces renewed cell division. The cells so formed would have the relatively high ratio of nuclear volume to cytoplasmic volume characteristic of many tumours, and cell division would remain uncontrolled. It is therefore considered that tumour cells differ from normal embryonic cells in lacking the inherited potential for increasing the amount of coenzyme I–pyrophosphorylase in response to the stimulus of cell division. Tumour cells may arise from normal adult cells by depletion of the enzyme system associated with synthesis of coenzyme I–pyrophosphorylase. Other factors which follow this primary defect may account for the invasiveness and other distinguishing features of malignant tissues.

Since the activity of the coenzyme I–pyrophosphorylase is very low in the tumour as compared with the normal adult cell[5,8], and is probably close to the critical level for cell survival, inhibition of this enzymic activity would probably be lethal to the tumour cell. However, the much greater activity (about five-fold) in the comparable normal cell ensures that a similar percentage inhibition would probably have little serious effect on the metabolism of the normal tissue, especially if the inhibition is relieved soon after death of the malignant cells. For chemotherapy, the characteristics required of the compound are as follows. (1) It should specifically inhibit the coenzyme I–pyrophosphorylase. (2) Desirably, it should be taken up preferentially by the tumour cells, which may have surface properties differing from those of normal adult cells[29]. Moreover, it should not be excluded by nuclear or cellular membranes. (3) It should not react with other enzyme systems which may modify or destroy it.

No organic inhibitors of the coenzyme I–pyrophosphorylase have yet been described. The anti-tumour agent, acetyl podophyllotoxin ω-pyridinium chloride, apparently causes a marked fall in this activity of tumour tissue in treated animals, but has no effect on the tissue *in vitro*[30]. In this Department, therefore, inhibitors are being sought which will interfere with the area of attachment of nicotinamine mononucleotide to the enzyme (see equation 2), since compounds which would react with other sites would probably inhibit also other essential pyrophosphorylases. Pyridinium compounds are being studied initially with purified enzyme from pig liver[31]. It is hoped to be able to reduce the number of compounds to be synthesized and evaluated by prediction of the relative effectiveness of substituents on the pyridine ring[32].

The powerful growth inhibitor and anti-leukæmic agent 2 : 4 : 6-triethyleneimino-1 : 3 : 5-triazine causes a marked decrease of coenzyme I in tumour cells, apparently by accelerating degradation rather than by inhibiting synthesis[33]. This and similar compounds may therefore be valuable for potentiating the action of an inhibitor of coenzyme I–pyrophosphorylase. As a long-range approach, investigation of the synthesis of the nuclear coenzyme I–pyrophosphorylase may also be of value in that activation of this system could possibly lead to production of sufficient coenzyme I to prevent division of tumour cells.

This new approach involving specific inhibitors and activators of coenzyme I synthesis would appear to deserve consideration alongside other biochemical approaches to cancer chemotherapy which were recently discussed in *Nature*[34]. The malignant cell has been cited here as a special example of uncontrolled growth. However, it is believed that active compounds of the type envisaged here may have wide application for control of growth and differentiation of normal cells, especially of plants. The problem of chemical control of coenzyme I synthesis is therefore being actively investigated in this Department.

Most of the ideas expressed here were formulated while I was on the staff of the Department of Biochemistry of the University of Melbourne, where in 1953 I initiated a programme of investigation of the biochemistry of tumours. I wish to thank Prof. V. M. Trikojus, professor of biochemistry, and Prof. S. Sunderland, dean of the faculty of medicine, University of Melbourne, for their encouragement. I am grateful to the Anti-Cancer Council of Victoria for financial assistance for the work carried out with the collaboration of Miss M. Branster.

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A REMARKABLE SOLAR RADIO EVENT

By STAFF OF THE IONOSPHERE AND RADIO ASTRONOMY SECTION OF THE NETHERLANDS TELECOMMUNICATIONS SERVICES, THE HAGUE

On November 4, 1957, a large increase in solar radio noise was observed on a frequency of 200 Mc./s. at the receiving station 'Nera' of the Netherlands Telecommunications Services. The increase started rather abruptly at 0848 U.T. and lasted for more than 5 hr., the greatest intensity being reached at about 0930 U.T., when it amounted to approximately 900 times the noise level of the quiet Sun. The smoothed intensity level showed considerable fluctuations with periods of the order of a few minutes. No solar flare has been reported as occurring near the onset of the radio event, nor was a sudden ionospheric disturbance observed. The phenomenon manifested itself over a considerable frequency-range in the metre wave-length band. It was also observed at 169 Mc./s. by the observatories at Humain (Belgium) and Nançay (France), but it was altogether absent on the decimetre–centimetre wave-length range and on a wave-length near 6 metres. The radiation was 100 per cent left-handed circularly polarized. The position of its source, as determined at 1125 U.T. with a two-element interferometer operating on a frequency of 250 Mc./s., was about 0·1 solar radius east of the centre of the solar disk. During a period of 2 hr., centred around local noon, no systematic displacement of the source of enhanced radiation was observed.

The lack of correlation with a solar flare or associated effects, and the absence of disturbances on the decimetre–centimetre wave-lengths, must be considered as rather exceptional for so large a 200-Mc./s. event. However, the extraordinary character of this great radio phenomenon was particularly apparent from records obtained with a negligible time-constant. Some were recorded with a high-speed recording paper (5 mm./sec.). These records revealed short-period fluctuations of intensity, with a period of some 0·2–0·3 sec., of a type not observed before at the Nera Observatory, altogether different from the kind ordinarily occurring during a noise storm. Part of this variability, strongly reminiscent of the ionospheric scintillations of radio sources (Fig. 1, 1), showed an oscillatory type of intensity fluctuation (Fig. 1, 2). In other parts of the record there was a preponderance of decreases in intensity, short dips of a fading character, which were also present on records obtained by the Nançay Observatory on 169 Mc./s. (for copies of which we are indebted to M. A. Boischot). During the later stages of the radio event dips and oscillations of a longer duration, of the order of 0·1 min., occurred. These could also be identified on slow-speed records obtained at 200 Mc./s. simultaneously at Nera and at Paramaribo (Surinam) with time-constants of, respectively, 1 sec. and 0·3 sec. This proves that the latter variability (which was also of a very uncommon type) certainly cannot be ascribed to ionospheric effects. No ionospheric scintillation of radio sources of any importance was observed at the Jodrell Bank Experimental Station or at the Mullard Radio Astronomy Observatory on November 4. Ionospheric scintillations of so short a period have never, in fact, been observed in Cambridge (Dr. A. Hewish, private communication). The very short-period fluctuations of intensity must also, therefore, be ascribed to solar conditions.

All these facts together justify the conclusion that the radio phenomenon which occurred on November 4 is of a new, so far unknown type of great rarity. It should be noted that this peculiar type of variability is revealed only by a recording instrument

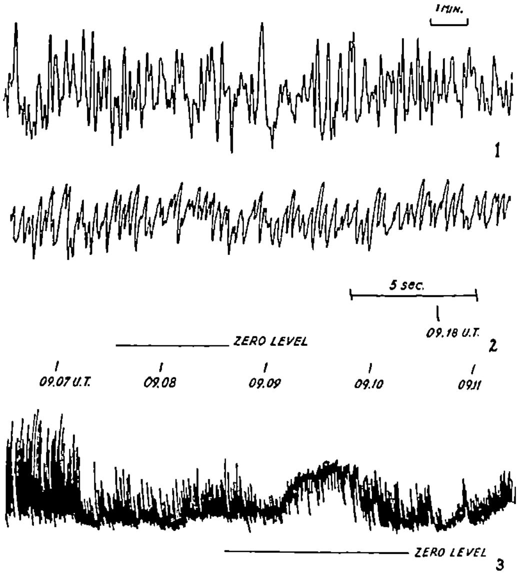

Fig. 1. 1. Scintillations of the radio source Cas *A* on 200 Mc./s.
2. High-speed record of solar radio emission on 200 Mc./s.
3. Slow-speed record of solar radio emission on 200 Mc./s.

with a time-constant no greater than a very small fraction of a second. With slow-speed recording paper one then simply obtains a very blurred record (see Fig. 1, 3), which might suggest some kind of interference. In the present case, however, the possibility of interference is ruled out, both by the confirmation from the other observatories, and by the regular pattern of the interferometer curve. The true nature of the intensity fluctuations can only be ascertained by high-speed recording. This is perhaps the reason, together with its extreme rarity, why this type of radio event has not been reported before. It differs from the so-called 'non-selective fading', observed by Payne-Scott and Little[1] on 62 and 98 Mc./s., in that the intensity fluctuations have a much shorter period.

The occurrence of fluctuations in intensity of the type shown in Fig. 1, 1, suggests that, in special circumstances, solar coronal gas may give rise to scintillation effects, possibly analogous in mechanism to ionospheric scintillations, but more varied in character. Irregularities in the solar corona may be responsible for focusing and defocusing effects and perhaps to absorption effects. It is of interest to consider the possibility that the occurrence of storm-bursts during an ordinary noise storm may be due to a focusing mechanism.

The radio event of November 4 occurred quite unexpectedly. The importance of observing such rare phenomena as completely as possible makes it very desirable that solar radio instruments should be operated on a routine basis, however specialized in type.

We are indebted to Dr. R. Coutrez of the Humain Observatory and to Dr. Boischot of the Nançay Observatory for providing us with copies of their records; and to the Jodrell Bank and Mullard Radio Observatories for information on the scintillation of radio sources on November 4.

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SOLAR ACTIVITY AND THE IONOSPHERE

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THE recent unprecedented high levels of solar activity, as indicated by sunspot numbers and described by Dr. M. A. Ellison[1], have been accompanied by equally exceptional conditions in the ionosphere. During the sunspot cycle there is no appreciable change in the amount of visible light or heat radiation emitted by the Sun, but in other parts of the spectrum this is no longer true. As compared with June 1954, when solar activity was at a very low level, the intensity of the ultra-violet and X-radiation which is responsible for the existence of the *E*-layer of the ionosphere had increased by a factor of 3·2 in September 1957, 3·6 in October and 3·1 in November. These values all exceed the previous maximum of 3·0 in May 1948 and are the highest recorded values since ionospheric measurements were begun at Slough in 1931.

The figures quoted above are based on the critical frequency of the *E*-layer. Unfortunately there is, as yet, no adequate theory on which similar estimates of the intensity of the *F*2-layer ionizing radiation could be based. However, in November 1957 at Slough, the mean value of the electron density at the peak of the *F*2-layer rose to $2 \cdot 6 \times 10^6$ cm.$^{-3}$, a value which exceeds the previous highest value, for November 1947, by 9 per cent. In October 1957 the density was much lower than in November but, after making an appropriate allowance for the normal seasonal changes in the *F*2-layer, it may be concluded that the mean intensity of the ionizing radiation in October exceeded that in November, thus confirming the conclusion reached using the *E*-layer results.

The large changes in the intensity of the ionizing radiation which are associated with the sunspot cycle lead to corresponding variations in the structure and the electron density of the layers of the ionosphere. The complicated ways in which these layers change are of great importance during investigations into the chemical constituents and the atomic processes which determine the electrical properties of the upper atmosphere. These changes are not, however, solely of academic interest, because the electron density controls the critical frequencies of the layers which are responsible for the reflexion of radio waves; a wave which is normally incident on an ionospheric layer will not be reflected for frequencies greater than the critical frequency. At very oblique angles of incidence, the greatest frequency at which a wave will be reflected will be 3–3·5 times the critical frequency for reflexion at the *F*2-layer and 5 times for the *E*-layer.

Reports from the B.B.C. receiving station at Tatsfield show that during October 1957 radio stations in the United States could, on the average, be received at frequencies of 37·5 Mc./s. in the early afternoon; in November this figure had risen to 46·9 Mc./s. On individual days even higher frequencies could be received: 50·7 Mc./s. in October and 55·3 Mc./s. in November. These observations are consistent with the reception, when propagation conditions are favourable, of B.B.C. television signals on 45 Mc./s. in the United States and in South Africa. An even more spectacular achievement, which has recently been reported in the Press, was the reception of B.B.C. television pictures in Australia at the end of November.

The mean value of the critical frequency of the $F2$-layer at Slough at noon was 13·4 Mc./s. in October and 14·6 Mc./s. in November; on individual days, values of more than 16 Mc./s. were fairly common. In the light of these figures, it is not difficult to account for reports, such as those mentioned above, of the propagation of radio waves in the very-high-frequency band over distances far in excess of those expected in normal circumstances.

It may be recalled that even near sunspot minimum in 1954 it was not uncommon to find instances where European radio stations operating in the very-high-frequency band interfered with television and other radio services in southern England. The propagation in such circumstances must be attributed, not to reflexions from the $F2$-layer, but from the sporadic E-layer or, alternatively, to effects associated with the refractive properties of the troposphere during certain meteorological conditions. Fortunately, such interference is not sufficiently frequent to cause serious difficulties in planning radio networks in the very-high-frequency band. On the other hand, the occurrence of fairly regular reception of distant very-high-frequency stations as a result of $F2$-layer propagation may prove to be embarrassing to some radio services for most of this winter. Although the seasonal fall in $F2$-layer ionization during the first month or two of 1958 may give some respite from such difficulties, the seasonal rise in February and March 1958 will probably lead to a recurrence of interference problems except in the unlikely event of a very rapid fall in solar activity over the next few months.

An examination of the twenty sunspot cycles which have occurred since 1749 shows that the present one and its predecessor must be regarded as having maxima which are well above the average. Communication engineers would certainly not be justified either in making long-term plans based on experience gained in 1947–48 or 1957–58, or in assuming that the steady rise in the level of the three consecutive maxima beginning with that of 1927 is part of a long-term trend.

Peaks in solar activity which are in any way comparable to the present one seem to occur only about once in a hundred years. Such an event may produce problems for radio engineers, but from the point of view of those engaged in upper atmosphere research, it may be said of the fortunate coincidence of the 1957–58 peak with the I.G.Y.: "never had mortal man such opportunity . . .".

The work described above was carried out as part of the programme of the Radio Research Board, and is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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FOSSIL ALGAE IN INDIA

By Prof. L. RAMA RAO

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TWENTY-FIVE years ago, I reported in *Nature* the discovery of abundant fossil algae in the Cretaceous rocks of South India, especially in one of the limestones belonging to the youngest division, the Niniyur group (Danian), of the Trichinopoly area. (The Cretaceous of the Trichinopoly Dt., South India, is divided into four groups. Starting from the oldest, these are: (*a*) the Utatur; (*b*) the Garudamangalam (Trichinopoly); (*c*) the Ariyalur; (*d*) the Niniyur. The entire succession ranges in age from the upper Albian to the Danian of the European stratigraphical scale. A full description of these rocks has been recently given by me elsewhere[1].) Further examination of all the limestones of this group and the associated flints and cherts which are their silicified representatives yielded a rich harvest of fossil algae of various kinds; these were studied and described by me in collaboration with Dr. Julius Pia, of Vienna[2]. Prior to this discovery, our knowledge of fossil algae in India was confined to casual references and brief descriptions of a few stray and solitary occurrences here and there.

The finding for the first time in India of a rich assemblage of fossil algae in the beds of the Niniyur group was therefore an event of considerable interest, and the fact that this collection included several new genera and species of the three main families, Solenoporaceae, Corallinaceae and Dasycladaceae, made it particularly noteworthy. Many of these forms show features of significant phylogenetic and evolutionary importance, the entire collection constituting, according to Pia, "the most interesting algal flora" he had ever studied.

The publication of the memoir in 1936 dealing with the Niniyur algae thus opened out a whole field of research, and it is gratifying to note that many valuable contributions to our knowledge of fossil algae in India, especially from the Cretaceous and Eocene rocks, have since been made by a number of workers. The object of this article is to give a summary of these contributions and indicate their scope; for fuller details and descriptions, the reader may refer to the original papers published from time to time, of which the more important are given at the end of this article.

In the rocks of the Niniyur group itself, more algae have since been noticed, including *Neomeris*, *Acicularia*[8], *Clypeina*[3,7] and *Piania*; along with these there is also the 'unexpected' occurrence of a primitive form like *Holosporella*. The coral-reef limestones (Upper Albian) at the base of the Trichinopoly

Cretaceous succession have also revealed a rich algal flora, indicating that the algae played quite an important part in the building up of these reefs. Of outstanding significance is the occurrence in several rocks of this area, including the Niniyurs, of species of *Solenopora*[3], thus showing that the time-range of this genus extended up into the late Cretaceous, where it existed side by side with *Archaeolithothamnium*. Such an association of these two genera in the Cretaceous also provides valuable material for the study of the mutual chronological and evolutionary inter-relationships of the two important families of fossil algae which they represent. In the year 1937, J. Pia, S. R. N. Rao and K. S. Rao described fossil algae, including *Terquemella*, *Acicularia*, *Acetabularia* (?), and four species of *Neomeris* from the intertrappean beds near Rajahmundry[4]. This assemblage, which shows a distinct Tertiary aspect, is important not only in itself but also in throwing light on the age of the associated traps. A more recent examination of some of these intertrappeans which I have made shows that there are more of these Dasycladaceae here, probably including several other forms in addition to those mentioned above.

From the Lockhart limestone (Palæocene) of the Samana Range (now in Pakistan) S. R. N. Rao described in 1941 a rich algal flora belonging to the Melobesieae[5]. This includes several new species belonging to the genera *Archaeolithothamnium*, *Lithophyllum*, *Mesophyllum* and *Melobesia*. It may be noted that one of these species of *Archaeolithothamnium* (*A. samanensis*) found here shows "a concentric arrangement of the hypothallial rows"—a character which is considered as a distinctive feature of the genus *Lithophyllum*. Associated with these algae here, the solitary occurrence of a *Neomeris* (*Larvaria* ?) has also been noticed. From a limestone in Sind (Pakistan) probably also of Palæocene age, S. R. N. Rao and K. P. Vimal have quite recently (1955) described certain species of *Acicularia* and *Indopolia* representing the Dasycladaceae, together with the form *Boueina* belonging to the Codiaceae.

The occurrence of an abundant algal flora including both the Corallinaceae and Dasycladaceae in some of the limestones of doubtful Cretaceous or Eocene age of Assam was noticed in the year 1940; the Corallinaceae in this material have been studied in detail by K. S. Rao and the results embodied in a paper which he published in 1943[6]. Both the sub-families Melobesieae and Corallinae are represented here; of the former, which are by far the more abundant, he has described five species of *Archaeolithothamnium*, five of *Lithothamnium*, and one each of *Mesophyllum*, *Melobesia* and *Distichoplax*; and of the latter there is a new species of *Corallina*. The entire assemblage clearly indicates that the containing rocks are of early Tertiary age—a conclusion also supported by recent stratigraphical studies. The Dasycladaceae found in this material are yet to be described. These Assam limestones evidently constitute a rich storehouse of a varied and well-preserved algal flora, worthy of further attention.

Another important area where numerous fossil algae have been recently noticed is the Salt Range. The first report of this occurrence in the Eocene beds of this area (now in Pakistan) was made by me and K. S. Rao in 1939, recording the presence of *Dissocladella*, *Acicularia* and *Neomeris*, together with some surviving primitive forms like *Oligoporella* and *Diplopora*. More recently (1953) a rich algal flora from the lower Eocene limestones (of the Nammal gorge) of this region has been described by C. P. Varma[8]. He has recognized here some new species—three of *Archaeolithothamnium*, two of *Mesophyllum* and one of *Lithophyllum*; in this connexion he has also contributed a valuable discussion on the affinities of these and allied genera, especially in regard to *Mesophyllum*, where we can observe "a complete gradation from the *Lithothamnium* type to the *Lithophyllum* type of tissue among the various species of *Mesophyllum*". The same material also contains the remains of an alga very similar to the interesting form *Solenomeris*. Attention may also be directed to the three species of *Gymnocodium* recently described (1953) from the Permian beds of the same area.

The following classified list gives an idea of the variety and abundance of fossil algae described so far from the above areas: Dasycladaceae: *Holosporella* (2), *Triploporella* (1), *Oligoporella*, *Diplopora*, *Dissocladella* (1), *Indopolia* (2), *Acicularia* (4), *Orioporella* (1), *Neomeris* (9), *Clypeina* (3), *Terquemella* (1), *Acetabularia* (?) and *Piania* (1); Corallinaceae: (Melobesieae) *Archaeolithothamnium* (14), *Mesophyllum* (5), *Lithophyllum* (2), *Lithothamnium* (6), *Melobesia* (2), *Solenomeris* (1) and *Distichoplax*; (Corallinae) *Corallina* (1); Solenoporaceae: *Parachaetetes* (1) and *Solenopora* (3); Chaetophoraceae: *Palaeachlya*; Codiaceae: *Gymnocodium* (1) and *Boueina*. (The figures within brackets indicate the number of new species recognized.)

From the above brief review of the results of work done in India since the occurrence of abundant algae was first reported in 1931, it becomes clear that these algal remains "offer a vast field of research of which only the fringe has yet been touched". Apart from the Cretaceous and Eocene rocks which have yielded most of the forms mentioned above and will no doubt reveal many more on further examination in due course, we have a whole series of marine sedimentary rocks in India of earlier ages which are still 'untouched' from the point of view of their fossil algae. The farther back we go in time in this sedimentary succession, the more interesting will be their algal contents; and when we go down to the Precambrian rocks, of which we have such a good development in India, the search for fossil algae becomes positively exciting. A beginning in the study of the Precambrian algae in India has just been made by the record of a few remains by R. C. Misra in the rocks of the Vindhyan system, and of some algal (?) structures in the even older Cuddapah formations by M. R. S. Rao. The scope and opportunities for further explorations in India in the study of Precambrian algae are practically unlimited.

It is thus evident that a most promising field dealing with the study of fossil algae from rocks of various ages in India is still awaiting attention. It is earnestly hoped that this fruitful and fascinating line of research will be taken up and pursued in earnest before long; the results of these studies will undoubtedly be of the greatest value alike to the stratigraphical geologist and to the palæobotanist.

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LETTERS TO THE EDITORS

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Presence of Triiodothyronine in Fowl

THE observation of an unknown iodinated compound as a regular constituent of plasma and thyroid tissue of mice and rats[1-3] led to the discovery of 3-5 : 3′-triiodo-L-thyronine[4-7]. It has been established that triiodothyronine possesses all the thyroid hormone qualities of thyroxine when tested in a large number of species[8] and is more potent than thyroxine when tested by a variety of methods *in vivo* in mammals and amphibians[9]. Thus triiodothyronine has come to be recognized as being of physiological importance in laboratory mammals and man. However, little is known of the distribution of triiodothyronine in other classes of vertebrates, beyond the fact that it has been found in reptiles[10]. It seemed of interest to ascertain whether birds have the capacity to synthesize this compound.

Light Sussex cockerels, 100 days old, were given 250 μc. of iodine-131 by the subcutaneous route. 24 hr. later they were killed while under light ether anæsthesia, and the thyroid glands removed, minced and placed in ammonium-chloride ammonia : urea buffer (*p*H 8·6). Trypsin (1 mgm.) was added, and the glands were allowed to incubate for 24 hr. at 35° C. with a further addition of trypsin after 12 hr. After acidification with hydrochloric acid, the hydrolysate (*p*H 2·6) was extracted three times with butanol and the combined butanol extracts reduced to dryness under diminished pressure. The residue was taken up in methanol : ammonia (3 : 1) and applied to Whatman No. 1 filter paper for ascending chromatography in *n*-butanol–acetic acid–water (78 : 10 : 12 v/v) or *n*-butanol–dioxane (80 : 20 v/v) saturated with 2 *N* ammonium hydroxide systems. Thyroxine, triiodothyronine, diiodotyrosine, monoiodotyrosine and iodide were added as carriers. The positions of the carriers were visualized in ultra-violet light, and the triiodothyronine and/or thyroxine areas of the paper cut out, eluted with methanol–ammonia and re-chromatographed in a single dimension in *n*-butanol–dioxane–ammonia or in two dimensions in both solvent systems together with the appropriate carriers. The radioactivity of the paper was localized by radioautography and/or scanning with an automatic recording β-counter. The carriers were localized with diazotized sulphanilic acid and palladium chloride.

The results of two such experiments are shown in Fig. 1, and in both cases radioactivity was noted in the area of triiodothyronine. Other experiments, carried out on both males and females, from a cross between Light Sussex and Rhode Island Reds, in some cases following stimulation of the thyroid gland with thyroid-stimulating hormone, have confirmed these observations, but in no case was the percentage of radioactivity ascribed to triiodothyronine higher than 1 per cent of the total radioactivity extractable with butanol from the gland, or more than 5 per cent of the thyroxine radioactivity.

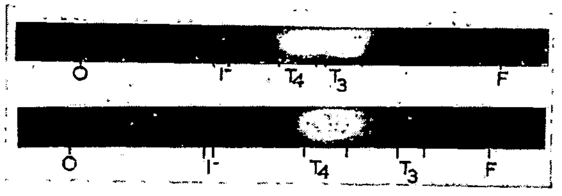

Fig. 1. Autoradio chromatograms of hydrolysed, butanol-extracted bird thyroid glands rechromatographed in butanol–dioxane–ammonia system. Bottom: elution of T_4–T_3 spot from a butanol–acetic acid–water chromatogram. Top: elution of T_3 spot from a butanol–dioxane–ammonia chromatogram. O, origin; I^- iodide; T_4 thyroxine; T_3, 3 : 5 : 3′-triiodothyronine

It may be concluded from the present experiments that the thyroid gland of the bird possesses the capacity to synthesize triiodothyronine, and that triiodothyronine presumably has a role in thyroid physiology in this class of vertebrates. This finding may take on added interest in the light of two curious findings, that birds have a low plasma protein-bound iodine value[11] and that triiodothyronine is no more potent than thyroxine in various biological tests done in birds[12,13].

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Enzymes of the Tricarboxylic Acid Cycle and Cytochrome Oxidase in the Fat Body of the Desert Locust

VARIOUS workers have shown the presence of some or all of the enzymes of the tricarboxylic acid cycle in insect muscle sarcosomes (for example, in *Musca domestica*[1], *Phormia regina*[2], *Apis mellifera*[3]) or in particulate fractions prepared from whole insects (for example, from *Aedes aegypti*[4]); but other specific insect tissues have received little attention. The insect fat body is often one of the most conspicuous organs and is known to carry out many reactions involving nitrogen metabolism[5]; but almost nothing has been recorded of other oxidative capabilities. As the biochemical function of the fat body is probably not primarily concerned with energy production (unlike muscle sarcosomes), it appeared of interest to examine this tissue.

The desert locust, *Schistocerca gregaria* Forsk., was used as a source of the fat body tissue which was carefully dissected out and gently homogenized in a Potter–Elvehjem blender. Fifth instar nymphs were used for most of the work. The presence of a number of enzymes associated with the tricarboxylic acid cycle was demonstrated in this tissue for the first

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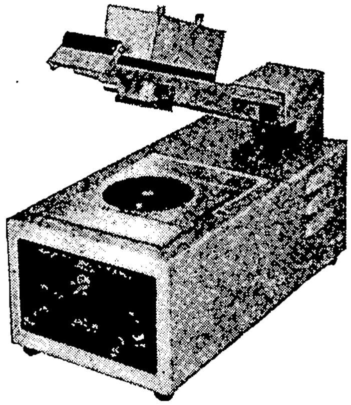

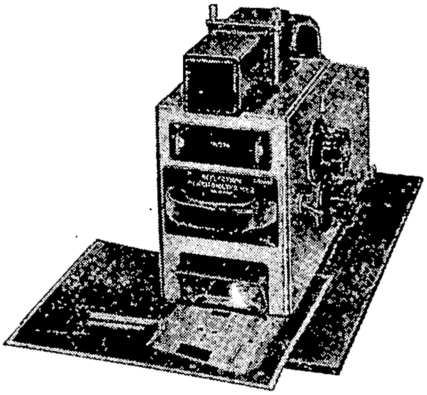

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time. Using spectrophotometric assay methods, the presence was shown of a specific triphosphopyridine nucleotide-linked *iso*citric dehydrogenase, aconitase and fumarase. A diphosphopyridine nucleotide-linked malic dehydrogenase was demonstrated both by optical observation of the reduction of oxidized cytochrome *c* in the presence of cyanide, and manometrically by measurement of oxygen uptake in a Warburg apparatus. Cytochrome oxidase was present in the fat body, and was completely inhibited by $7\cdot5 \times 10^{-5}$ *M* cyanide and 94 per cent inhibited by 1×10^{-3} *M* azide. The cytochrome oxidase activity of the fat body showed a striking variation with age in the fifth stadium. It fell from a relatively high value at the beginning to about one-thirtieth towards the end of the stadium (that is, about 160 hr. after the fourth moult), and then rose sharply at the time of the fifth and final moult, and was at a high level in the young adult.

All efforts to demonstrate the presence of the condensing enzyme, succinic dehydrogenase and α-ketoglutarate oxidase were unsuccessful, both by optical and manometric methods. The apparent absence (or presence at a very low level below the sensitivity of the assay methods) of these key enzymes of the tricarboxylic acid cycle (although other enzymes which can take part in the operation of the cycle could readily be assayed), suggests that the cycle may not play an important part in the intermediary metabolism of the fat body of the locust.

We are indebted to the Anti-Locust Research Centre for financial support and encouragement in this work.

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Phosphorylase Activity of Primary Rat Liver Cancer

THE level of glycogen in the majority of tumours is considerably lower than in the normal homologous tissues[1]. According to Dickens and Weil-Malherbe[2] the glycogen content of primary rat hepatoma is lower than that of normal rat liver. As found recently by Goranson *et al.*[3], the phosphorylase activity of a transplantable rat hepatoma is very low. According to these authors, the addition of adenosine 5-phosphate greatly increases the phosphorylase activity of hepatoma tissue, up to the values found with normal rat liver. Hence the low content of glycogen in hepatoma might be due to a lack of adenosine 5-phosphate, rather than a deficiency in the amount of the phosphorylase itself. On the other hand, Le Page[5] found that rat hepatoma contains approximately twice as much adenosine 5-phosphate as normal rat liver. We have therefore studied the phosphorylase activity of primary rat liver carcinoma and the activating effect of adenosine 5-phosphate on it.

Discrete rat liver tumour nodes were selected for our experiments. The tumours were induced by feeding rats for 5 months with a semi-synthetic diet containing 0·6 per cent 4-dimethylaminoazobenzene[4]. Experimental and control animals were fasted for 24 hr. before killing; the tumour nodes were separated from the adjacent parenchyma, necrotic areas being carefully removed, and were homogenized at 0° with isotonic potassium chloride in a Potter–Elvehjem glass homogenizer. As it was found that the degree of homogenization is of importance for the phosphorylase activity, all experiments were made with homogenizers having an optimal clearance according to Potter[6].

Phosphorylase activity was determined by Sutherland's method[7], slightly modified according to the conditions of our experiments: the reaction was started by the addition of 0·5 ml. enzyme mixture to 1·0 ml. substrate solution (*p*H 6·1, glass electrode) containing glucose-1-phosphate (0·05 *M*), glycogen (5·7 mgm./ml.) and sodium fluoride (0·05 *M*). The enzyme mixture had the following composition: 0·5 ml. 2 per cent homogenate, 0·3 ml. *M* sodium fluoride, 0·2 ml. distilled water. When the activating effect of adenosine 5-phosphate was to be studied, 0·2 ml. of a solution of adenosine 5-phosphate (Pabst) was added, instead of water (final, 0·04 *M*). Test-tubes were incubated at 30°. At 0, 10 and 20 min., samples were taken, deproteinized with an aliquot of 5 per cent trichloracetic acid, and centrifuged. Inorganic phosphorus was determined in the supernatant by the method of Fiske–SubbaRow as adapted to a photoelectric colorimeter.

The phosphorylase activity of homogenates from normal rat liver (5 animals) and from primary rat liver cancer (7 animals) was studied. The effect of adenosine 5-phosphate (0·04 *M*), adenosine (0·04 *M*) and guanosine (0·02 *M*) was also investigated. In all experiments only fresh homogenates were used. The results of our experiments (Fig. 1) show that the phosphorylase activity of primary rat liver cancer is considerably lower (about one-third) than that of normal rat liver. The inorganic phosphorus released has the following average values: for tumour tissue,

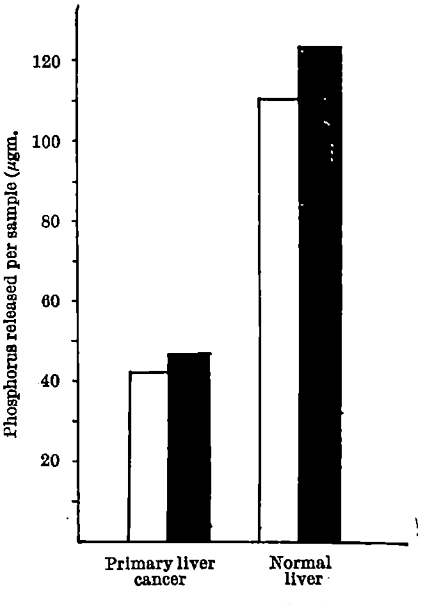

Fig. 1. Phosphorylase activity of normal rat liver and primary rat liver cancer. White, without adenosine 5-phosphate; black, with adenosine 5-phosphate

42·0 μgm. phosphorus, and for normal liver tissue, 109·8 μgm. phosphorus per sample in the conditions of our experiment. The adding of adenosine 5-phosphate in the above-mentioned concentrations increased the phosphorylase activity by 11 per cent for the primary rat liver carcinoma and by 11·2 per cent for normal rat liver. Adenosine and guanosine have no marked effect on phosphorylase activity.

The results of our experiments suggest that the low glycogen content in hepatic tumours could well be explained by the low phosphorylase activity of these tumours. Contrary to the data of Goranson *et al.*[3], our experiments indicate that rat liver tumours are characterized by a real decrease in the enzyme protein and not by a lack of adenosine 5-phosphate, the phosphorylase in tumour and normal liver homogenates being activated to the same degree by adenosine 5-phosphate.

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Occurrence of Independent Systems for the Cleavage of Folic Acid and Citrovorum Factor in Rat Liver

RECENT work has demonstrated that extracts from animal tissues can actively degrade folic acid[1,2] and citrovorum factor[3] at the C_9—N_{10} linkage with the liberation of a diazotizable amine. Whether the same enzyme systems are involved in the cleavage of the two substrates is, however, not established. The horse-liver fraction which has been shown to degrade citrovorum factor was inactive towards folic acid[3]. In a recent paper, Dinning *et al.*[4] have suggested that the transformation of folic acid into a diazotizable amine by slices and homogenates of rat livers takes place with the intermediate formation of citrovorum factor. In the course of studies on folic acid degradation by purified fractions from rat liver, we prepared extracts which degrade folic acid but not citrovorum factor. Furthermore, *A*-methopterin has been found to inhibit selectively the cleavage of folid acid in acetone-dried powder extracts, but the citrovorum factor remains unaffected.

Three kinds of rat liver extracts were used. Fresh liver extracts were prepared by extraction of the liver in 0·15 *M* phosphate buffer, *p*H 5·5 and dialysis in water (0–4° C.) for 20 hr.; acetone–powder extracts were made in the usual way and phosphate buffer *p*H 5·5 added to give 10 per cent extracts.

Extracts of acetone–powders of liver prepared as above were treated with solid ammonium sulphate (30–70 per cent) in the cold, and the precipitate suspended in water and dialysed for 20 hr. in distilled water (0–4° C.).

Enzyme activity was determined by following the liberation of the aromatic amine, according to Bratton and Marshall[5]. Non-substrate blanks were determined by incubating tubes with all constituents of the reaction mixture except folic acid. The latter was added at the end of the incubation period.

Table 1. CO-FACTOR REQUIREMENTS

The complete system consisted of 150 μgm. of folic acid or citrovorum factor, 0·06 *M* phosphate buffer, $1·5 \times 10^{-3}$ *M* adenosine triphosphate, $1·0 \times 10^{-3}$ *M* manganese chloride, $1·0 \times 10^{-3}$ *M* sodium citrate. $1·0 \times 10^{-4}$ *M* coenzyme I, 1 ml. acetone powder extract. Total volume = 2 ml.; time of incubation, 3 hr.; temperature of incubation, 37° C. (The values given have been corrected for the non-substrate blank)

Sample No.	System	Folic acid degraded at *p*H 5·5 (μgm.)	Citrovorum factor degraded at *p*H 6 (μgm.)
1	Complete system	110·70	36·50
2	Adenosine triphosphate omitted	73·30	8·85
3	Manganese chloride omitted	75·30	17·30
4	Sodium citrate omitted	12·70	12·90
5	Coenzyme I omitted	8·50	9·90
6	All the above omitted	nil	5·5

Table 2. EFFECT OF SOME SUBSTANCES ON ENZYMES DEGRADING FOLIC ACID AND CITROVORUM FACTOR

Complete system as in Table 1. Total volume = 2 ml.; time of incubation, 3 hr.; temperature of incubation, 37° C. (The values given have been corrected for the non-substrate blank.)

Sample No.	Supplements added to the complete system	Folic acid degraded at *p*H 5·5 (μgm.)	Citrovorum factor degraded at *p*H 6 (μgm.)
1	Nil	92·7	35·7
2	*A*-methopterin (10 μgm.)	2·0	35·0
3	L-Glutamic acid (10^{-2} mole)	96·3	35·0
4	N-Formylglutamic acid* (10^{-3} mole)	80·3	31·2

* N-Formylglutamic acid was a gift from Dr. H. R. V. Arnstein.

Table 3. COMPARATIVE DEGRADATION OF FOLIC ACID AND CITROVORUM FACTOR BY DIFFERENT RAT LIVER PREPARATIONS

The incubation mixture consisted of 150 μgm. folic acid or citrovorum factor, same co-factors as in Table 1, and enzyme extract as specified. Buffer, 0·06 *M* phosphate, *p*H 6; time of incubation, 3 hr.; temperature of incubation, 37° C. (The results have been corrected for the non-substrate blank)

Source of enzyme	Folic acid degraded (μgm.)	Citrovorum factor degraded (μgm.)	Ratio of citrovorum factor degraded to folic acid
Dialysed fresh liver extract (1 ml.)	54·3	12·7	0·233
Acetone-powder extract (1 ml.)	79·3	35·4	0·446
30–70 per cent ammonium sulphate fraction from acetone powder extract (0·5 ml.)	87·7	8·5	0·097

Dialysed extracts of acetone-dried powders from rat livers catalyse the liberation of a diazotizable amine from folic acid and citrovorum factor. The activity in presence of either substrate is dependent on coenzyme I, adenosine triphosphate, manganese ions, and citrate. These co-factors have also been found to be necessary for the cleavage of folic acid by chicken liver extracts[2]. Results of experiments given in Table 1 show that omission of any one of the supplements causes a considerable reduction in activity in presence of either substrate. In a publication, which has reached us while this communication was in preparation, Silverman *et al.*[6] report the purification of an enzyme system from hog liver which cleaves citrovorum factor. The latter enzyme differs in some of its properties from the rat liver preparations described here. It is activated by

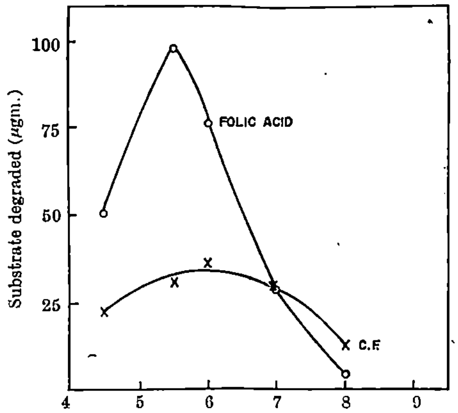

Fig. 1

L-glutamic acid, inhibited by N-formylglutamic acid and apparently does not need any of the above co-factors required by the rat liver system. Results in Table 2 show that L-glutamic acid and N-formylglutamic acid produce negligible effects on the system cleaving folic acid or citrovorum factor in rat liver. *A*-methopterin selectively inhibits the folic acid degradation but citrovorum factor is still unaffected. Furthermore, the folic acid degrading system can be largely separated from the activity towards citrovorum factor by ammonium sulphate fractionation of extracts made from acetone-dried powder (Table 3). The relation of *p*H to activity in presence of the two substrates is illustrated in Fig. 1. The two curves show marked differences. The *p*H optimum for folic acid is at *p*H 5·5 and for citrovorum factor at *p*H 6. Above *p*H 6 the activity in presence of folic acid falls rapidly. This may be a possible explanation for the higher rate of degradation of citrovorum factor obtained by Dinning *et al.*[4] in rat liver homogenates, for their experiments were carried out at *p*H 7·4.

The findings reported here indicate that, in rat liver, separate enzyme systems catalyse the conversion of folic acid and citrovorum factor into a diazotizable amine. The present results do not show whether these conversions proceed through the formation of tetrahydrofolic acid, as has been demonstrated for the system reacting with citrovorum factor in hog liver[6]. Differences between the co-factor requirements and the lack of effect produced by L-glutamic acid indicate, however, that the enzymes catalysing the cleavage of citrovorum factor in the two animal species may not be identical.

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A Possible Intermediate in the Biosynthesis of Tryptophan : 1-Deoxy-1-N-o-Carboxyphenyl-Ribulose

DURING an investigation of compounds formed by washed cell suspensions of mutant strains of *Aerobacter aerogenes* blocked at various stages in tryptophan synthesis, two strains (*N*3–33 and *N*2–18) were found to form a compound which showed an intense blue-violet fluorescence under ultra-violet light, but the absorption spectrum of which did not correspond to any known compound. Neither strain of *A. aerogenes* would grow in the minimal medium described by Davis and Mingioli[1] unless either tryptophan or indole was added and they were therefore presumably unable to convert anthranilic acid to indole.

Cell suspensions were incubated with a mixture of glucose (0·1 *M*), ammonium chloride (0·005 *M*), magnesium sulphate (10^{-4} *M*) and phosphate buffer (0·1 *M*, *p*H 7·7) as described by Gibson, Jones and Teltscher[2]. After removal of the cells, spectrophotometric examination of the supernatant fluid showed the presence of a compound with a spectrum similar in some respects to that of anthranilic acid (Fig. 1). The compound was readily extracted by ethyl acetate after the supernatants had been acidified, but concentration of these extracts to dryness resulted

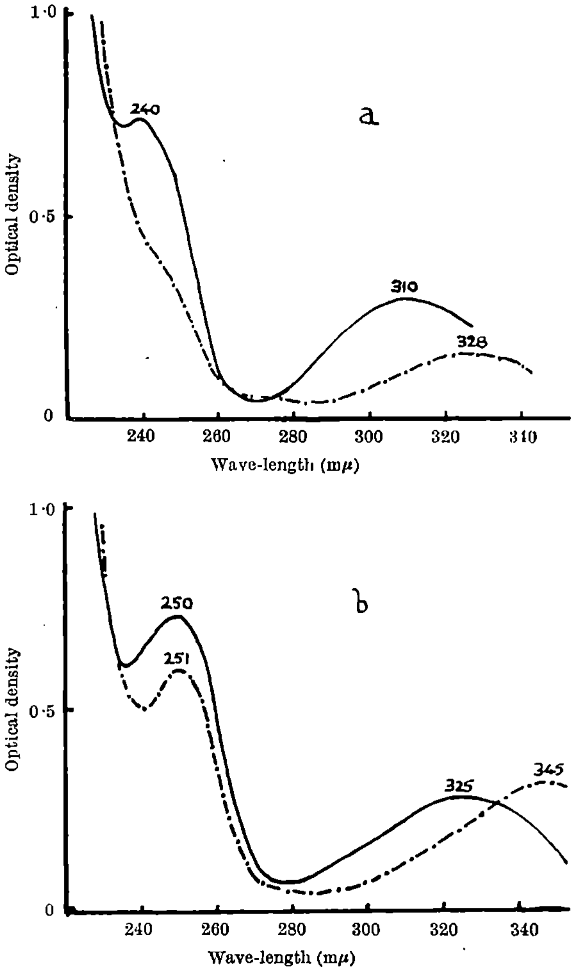
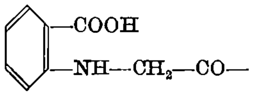
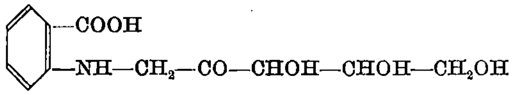


Fig. 1. Ultra-violet absorption spectra of: (*a*) anthranilic acid (10^{-4} *M*) 0·1 *M* phosphate; (*b*) experimental sample with 0·1 *M* phosphate as blank. ———, Spectrum at *p*H 7·7; —·—·—, spectrum at *p*H ∼ 2

in decomposition of the compound. It has not been found possible to isolate the pure compound, but its identity has been established by the absorption spectrum, paper chromatography and by the formation of the crystalline 2,4-dinitrophenylhydrazone. The examination of the absorption spectra of a number of anthranilic acid derivatives indicated that the spectrum was consistent with the structure



The compound appears to be 1-deoxy-1-N-*o*-carboxyphenyl-ribulose.



This compound was suggested[3] as a possible intermediate in the conversion of anthranilic acid to indole and is the Amadori rearrangement product of the riboside or arabinoside of anthranilic acid. It has been prepared from both the D-riboside and D-arabinoside and although not yet isolated was readily detected on paper chromatograms by reagents such as 2,3,5-triphenyltetrazolium chloride. Concentrates of the natural and synthetic compounds readily reduced alkaline methylene blue at room temperature, a property of Amadori rearrangement products[4]. The natural and synthetic products had the same R_F value in two solvent systems and gave the same colour reactions on paper chromatograms (Table 1). The absorption spectra of the natural and synthetic compounds in ethanol and in phosphate buffer at various *p*H levels were identical.

Table 1. TESTS ON PAPER CHROMATOGRAMS SHOWING IDENTICAL RESULTS WITH THE NATURAL AND SYNTHETIC PRODUCT

Reagent	Result	Inference	Ref.
Ammonium molybdate	green-blue changing rapidly to dark blue	sugar present	6
Aniline-acetate	purple-brown	pentose	7
Phloroglucinol	dark green	keto-pentose	8
Anthrone	purple	keto-pentose	9
Alkaline 2,3,5,-triphenyl tetrazolium chloride	immediate intense red colour without heating	evidence for Amadori rearrangement products	10 4

The 2,4-dinitrophenylhydrazone of the natural product was obtained by extraction of the original compound first into ethyl acetate and then into phosphate buffer (0·1 *M*, *p*H 7·7). An acid solution of 2,4-dinitrophenylhydrazine was then added and allowed to react overnight at room temperature. The product was recrystallized from alcohol and acetone. The 2,4-dinitrophenylhydrazones of the synthetic compound and of the natural product had the same melting point (213–215°) separately and mixed. The derivatives also seemed identical on paper chromatograms. Analysis of the 2,4-dinitrophenylhydrazone of the natural product gave values for carbon, hydrogen, nitrogen and oxygen consistent with the structure proposed.

Concentrates of deoxy-carboxyphenyl-ribulose when added to minimal medium supported the growth of various mutant strains of *A. aerogenes* and *Escherichia coli* which would utilize anthranilic acid and such strains were cross-fed by strains *N*3–33 and *N*2–18 when tested by the technique described by Gibson and Jones[5]. The formation of the compound by cell suspensions was stimulated by aeration and was detectable at 1 hr. by measurement of the absorption peak at 325 mμ. For the isolation of the compound, the cell suspensions and substrates were incubated with aeration for 24 hr. Cell suspensions of *A. aerogenes N*3–33 in phosphate buffer (0·1 *M*, *p*H 7·7) readily converted anthranilic acid to deoxy-carboxyphenyl-ribulose in the presence of glucose. Details of the experiments establishing the identity of the compound will be published elsewhere.

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Mode of Action of Chelates in protecting against *Clostridium perfringens* Toxin

IT was reported previously that ethylenediamine tetraacetic acid was capable of protecting mice against the toxin of *Clostridium perfringens*[1]. The protection thus afforded was shown to be probably due to the removal of a metallic ion or ions necessary for the activity of the toxin from the area where the toxin was acting. Inasmuch as the metallic ion or ions necessary for the action of the toxin apparently were higher in the preferential chelation series than calcium, the calcium chelate was shown to be able to protect when given systemically[2]. In this report, studies on the duration of the protection afforded by calcium ethylenediamine tetraacetic acid are presented and their implications are discussed.

The toxin, calcium ethylenediamine tetraacetic acid, and methods of administration of both of these were the same as described previously[2]. 2·5, 5 and 30 per cent solutions of calcium ethylenediamine tetraacetic acid were injected intradermally into mice; at various time-intervals thereafter the mice were injected at a different site with toxin and the deaths occurring within a 48-hr. period were recorded. The results of three typical experiments are presented in Table 1.

Table 1. DURATION OF EFFECT OF CALCIUM ETHYLENEDIAMINE TETRA-ACETIC ACID IN PROTECTING MICE AGAINST *Cl. perfringens* TOXIN

Calcium ethylenediamine tetraacetic acid injected (per cent)	Time (hr.) after injection of calcium ethylenediamine tetraacetic acid that toxin was injected. Groups of ten mice were used for each time-interval and the number that died is recorded									
	0	½	1	2	3	4	6	9	12	15
2·5	0	5	9	10	—	—	—	—	—	—
5	0	—	—	5	—	10	10	—	—	—
30	0	—	—	—	0	—	3	6	9	10

It can be seen that the protective effects of 2·5 per cent calcium ethylenediamine tetraacetic acid lasted about 30 min., that of 5 per cent about 2 hr., and that of 30 per cent about 9 hr. Inasmuch as 2·5 per cent calcium ethylenediamine tetraacetic acid is capable of completely protecting mice against the toxin and this protection lasts for but about ½ hr., it indicates that once the *Cl. perfringens* toxin is inhibited by calcium ethylenediamine tetraacetic acid there is some mechanism present in the body to inactivate it. This ability of calcium ethylenediamine tetraacetic acid to protect against the toxin is certainly not due to the inactivation of the toxin inasmuch as it has been demonstrated that the protection can be reversed by either zinc, cobalt or manganese ions[1]. These results also may explain why it was possible to render the toxin inactive in mice simply by mixing it with a small quantity of ethylenediamine tetraacetic acid[1]. If it is necessary to inhibit the action of the toxin for a short interval of time to render it non-toxic in the body, the period of time that the ethylenediamine tetraacetic acid remained at the injection site was sufficient to allow the inactivating mechanism in the body to come into play.

It was previously suggested that calcium ethylenediamine tetraacetic acid protected against the toxin when given systemically by binding the 'free' trace metals that were available in the body[2]. If this interpretation obtains, the data presented here would indicate that, although the level of 'free' trace metals is reduced to the point where the toxin is inactive with 2·5 per cent ethylenediamine tetraacetic acid, the trace metal equilibrium is restored within ½ hr. by the release of metals from depots in the body. The fact that higher concentrations of calcium ethylenediamine tetraacetic acid protect for proportionately longer periods of time suggests that sufficient calcium ethylenediamine tetraacetic acid remains in the circulation during the respective time-intervals to bind the metals that are released. An implication of these findings is that in attempts to use chelating compounds as detoxifying or therapeutic agents in other diseases a mode of administration other than that used with *Cl. perfringens* toxin will probably be necessary. In order to inhibit the growth of micro-organisms *in vivo* with agents such as antibiotics it is necessary to maintain the inhibitory level of the antibiotic until the micro-organisms are no longer active. In instances where the removal of 'free' trace metals may be inhibitory to the activities of a micro-organism *in vivo*, this condition probably would have to be maintained until the activities of the micro-organisms are suppressed to the point where they are no longer harmful to the body. A mode of administration of a chelating compound such that the level in the body is maintained sufficiently high to keep the 'free' trace metals at the requisite low level would be indicated in such instances.

In another series of experiments toxin was injected into groups of 10 mice, and at intervals of 2 hr. thereafter 5 per cent calcium ethylenediamine tetraacetic acid was injected at another site. The results of these experiments can be summarized as follows: If calcium ethylenediamine tetraacetic acid was given within 6 hr. after the injection of toxin, the mice survived; if it was given at 8 or 10 hr., the majority of mice, and all of them in some experiments, died. The median death time for the dose of toxin used was about 10 hr.; after 6 hr. all the mice were severely ill with a small percentage of deaths occurring by this time. It would appear that the action of the toxin is cumulative, and if its activity is inhibited by calcium ethylenediamine tetraacetic acid before it reaches the lethal level the mice are able to recover.

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Adherence and Viscosity of Blood Contacting Foreign Surfaces, and the Plasmatic Zone in Blood Circulation

THE cell-free marginal zone of plasma in vessels of living animals, due to the axial accumulation of red blood cells, was already known to Haller and Spallanzani in the eighteenth century[1]. The formation of this zone was later studied by Poiseuille[1] in arteries, veins and capillaries in various species of the living animal. He found that, with increased velocity, the thickness of this layer was augmented. Recently, in the course of investigations on the flow of blood columns using a tilting viscometer (Scott Blair, G. W., personal communication), we made the following observation. If an index of human or rabbit blood, containing 0·01 mgm. heparin/ml. as anticoagulant, be permitted to flow down a large capillary tube held at varying angles from the vertical, then films of blood of varying thickness can usually be seen macroscopically on the wall after the column has passed. This finding led to investigations on the flow of varying indexes of blood, plasma and serum in glass tubes 0·5–1·4 mm. in diameter, where the Reynolds number is so small that turbulence is out of the question. We found that the adherence of fluids from moving indices in such capillary tubes can be determined by simply measuring the reduction in the length of the index after it has travelled a certain distance, and then calculating the thickness of the adherent layer. By this method, we found that this phenomenon is not limited to blood, but can also be detected when cell-free plasma or serum is used instead. Moreover, this adherence is not dependent on glass surfaces, as we found it in tubes coated with silicone, 'Lusteroid', 'Perspex' and paraffin as well.

The question now arises whether the plasmatic zone in the living blood vessels can be related to this phenomenon of adherence in tubes lined with various surfaces, and also whether adherence of fluids in capillary tubes can be found to be a general physical phenomenon. In examining how the nature of the surface affected the adherence of blood, we discovered that the velocity of flow differed markedly with all surfaces at various angles of tilt. With higher velocities, more blood adhered to glass and other surfaces.

Table 1 shows the effect of various surfaces on the velocity of flow and the adherence of blood and plasma in capillary tubes of radii ranging from 507μ to 492μ. Rabbit's heart blood and plasma from the same blood withdrawal was used in all tests. Indexes 100 mm. long were run in duplicate and triplicate along lengths ranging from 441 mm. to 426 mm. and at 20° tilt of the tube; the same glass tube being used throughout the entire series of experiments, comparative tests were run with coatings of

Table 1. FLOW AND ADHERENCE VALUES OF INDEXES. 100 MM. LONG, OF BLOOD AND PLASMA OF SAME RABBIT HEART BLOOD (0·01 MGM. HEPARIN/ML.) SAMPLE CONTACTING VARIOUS SURFACES AT 20° C. AND AT 20° ANGLE OF TILT. LENGTH OF RUN VARYING FROM 426 TO 441 MM.

Surface	Calculated radius of tube (μ)	Fluid	Flow		Adherence	
			Time (sec.)	Velocity (mm./sec.)	Vol. of index adherent (per cent)	Calculated thickness of layer (μ)
Glass	507	Blood	54·0	8·1	9·5	5·6
		Plasma	25·4	16·8	1·8	1·1
'Perspex'	492	Blood	44·8	9·6	3·8	2·2
		Plasma	23·7	18·0	2·5	1·4
'Lusteroid'	498	Blood	68·7	6·2	2·8	1·6
		Plasma	43·1	9·9	1·3	0·7
Paraffin	498	Blood	410·6	1·1	16·3	9·2
		Plasma	193·0	2·3	9·0	5·2
Silicone	498	Blood	41·0	10·4	1·5	0·8
		Plasma	21·8	19·6	0·5	0·3

'Lusteroid', paraffin wax, 'Perspex' and silicone, after control runs against the uncoated glass surface. Table 1 shows clearly that both blood and plasma indexes from the same blood withdrawal have widely varying velocities of flow depending on the surfaces with which they are in contact. For any particular surface, plasma always flowed faster than blood. As can be seen, variations in diameter of the tube due to the coatings being of different thickness cannot be made responsible for these wide divergencies in the velocity of plasma and blood indexes from the same blood sample. Nor do the anomalous flow properties of blood entirely explain these phenomena, since plasma behaves like a Newtonian fluid[2]. Table 1 also demonstrates that the amount of adherence, rather than being directly related to the velocity of the index *per se*, depends on the nature of the surface as well, with silicone exhibiting least adherence and paraffin the most in spite of the very low velocity of flow with the latter. For each surface, plasma gave relatively lower values of adherence than those of blood. The above phenomena occurred with blood–air interfaces. However, similar findings were obtained in a system without air through capillary tubes, 600 mm. long, maintained horizontally. A column of oil was merely used to act as a piston without coming in contact with the blood over the measured region of the tube.

Our results appear to be significant because: (1) Measurements of the adherence of blood and plasma have not been made thus far. The fact that blood and plasma adhere to the silicone and paraffin suggests that the well-known physical anticoagulant effect of these surfaces may be independent of the phenomenon of adherence. (2) Observations on a marginal layer in living blood vessels as well as in capillary tubes have always been related to whole blood or to suspensions of red cells in different fluids[3,4] but have never been considered for plasma without suspended red cells. It appears from our observations that the immobile layer of plasma at the blood vessel wall, as established by Poiseuille[1], is not necessarily due to a suspension of red cells, but may as well exist when plasma alone flows through a living blood capillary, for example, in plasma skimming. (3) Viscosity studies of blood and plasma have been made in the past only in glass tubes. Hence, until the nature and physical properties of the surface lining the blood vessel[5] have been established, the widely divergent values we report for blood and plasma in contact with various surfaces make it seem doubtful whether the results of all previous studies on viscosity of shed blood and plasma in glass tubes can be applied to blood and plasma circulating in living blood vessels.

Nevertheless, our observations invite new rheological studies with blood and plasma from different subjects of various species in health and disease. These findings on adherence of blood and plasma could explain why arteries and veins may differ outside of their morphological structures, because, due to the various velocities in vessels of varying diameters, one should then expect various degrees of thickness of adherent layers. Finally, our observations may throw a new light on a number of problems related to the physiology of blood circulation as well as on certain vascular disorders associated with changes in the structure of the inner or endo-endothelial lining[5] facing the lumen of the vessel.

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Isolation of Reserpine from *Vinca rosea* Linn.

IN recent years considerable interest has been aroused in the use of the alkaloid reserpine in the treatment of hypertension and various mental disorders. Various plants in the family of Apocynaceae other than *Rauwolfia* have been investigated, and among them the isolation of reserpine from *Alstonia constricta*[1] is noteworthy. With the view of detecting the presence of reserpine in the plants of the Apocynaceae family we have studied the plant *Vinca rosea*. Several alkaloids have been reported from this plant: vinceine (melting point, 259–260° C.)[2], and vincaine (melting point, 250–252° C.)[3], which appears to be identical or stereoisomeric with δ-yohimbine. According to Beereboom *et al.*[4], vinceine and vincaine are indeed identical with ajmalicine, and the same authors have reported[4] the presence of serpentine (melting point, 156° C., with decomposition) and a new alkaloid, $C_{20-21}H_{26-28}N_2O_2$ (melting point, 200–201° C.) which they propose to name 'lochnerine'. Recently, ursolic acid (melting point, 280° C.)[5] has been reported present in *Vinca rosea*.

We have been able to isolate an alkaloid (melting point, 265–266° C.) from the ether-insoluble weakly basic resin of the roots of *Vinca rosea* grown in West Bengal. This is now confirmed to be reserpine by determination of the mixed melting point with authentic reserpine, as well as by the R_F values of the sample isolated, authentic reserpine and the mixture of the two. Whatman paper No. 1 and a

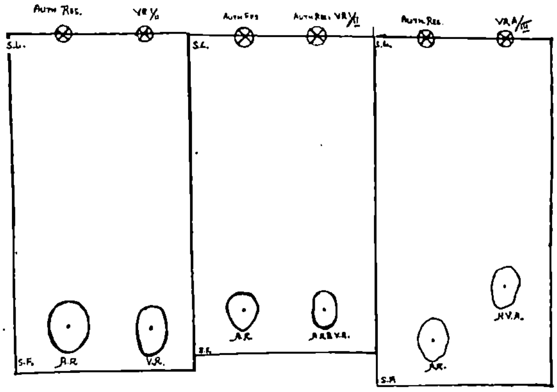

Fig. 1. *A.R.*, Authentic reserpine; *V.R.*, reserpine isolated from *Vinca rosea*; *N.V.A.*, a new alkaloid isolated from *Vinca rosea*

n-butanol/hydrochloric acid/water system were employed for chromatography.

Another alkaloidal base (melting point, 242° C., with decomposition) with R_F 0·70 (R_F reserpine 0·86) has been isolated from the same fraction. Further work on this alkaloid is in progress. Experimental details of the isolation and further work on this plant will be published elsewhere.

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Auxins in Immature Maize Kernels

Ether extracts of maize-kernel pulp at *p*H 6 contain only part of the growth-promoting activity of the kernels. The juice expressed from the ether-extracted kernels is still highly active in the straight-growth test. In Table 1 the activity of the expressed juice from ether-extracted maize kernels is compared with that of an equivalent concentration of ether-extractable material.

At first, it seemed possible that these results were due to incomplete extraction of indole-3-acetic acid. To test this, ether-extracted juice was partly purified by ethanol (4 vol.) precipitation of inactive material. After removal of ethanol, the juice was acidified to *p*H 3·6 with sulphuric acid, exhaustively extracted with ether and then neutralized with barium hydroxide solution.

The activity remaining in the acid/ether-extracted juice is compared with that of the acid/ether extract in Table 2. In this experiment and the subsequent ones activity was tested by the *Avena* straight-growth test of Bentley and Housley[1].

Table 1. Effect of Maize Extracts on Wheat Coleoptiles

	Final length sections (mm.)		
	Original solution	× 10 dilution	× 100 dilution
Ether extractable fraction	11·9	19·4	14·1
Juice after ether extraction	11·2	19·2	16·5
	1 mgm./l.	0·1 mgm./l.	0·01 mgm./l.
Indole-3-acetic acid	19·2	16·5	14·1
Water controls	14·5		

Initial length of sections, 10 mm.

Table 2

	Final length of sections (mm.)		
	Original solution	× 10 dilution	× 100 dilution
Acid/ether extractable fraction	12·9	16·1	14·4
Juice after acid/ether extraction	16·2	18·7	15·8
	1 mgm./l.	0·1 mgm./l.	0·01 mgm./l.
Indole-3-acetic acid	17·3	15·8	14·3
Water controls	13·4		

Initial length of sections, 10 mm.
In this experiment, oat coleoptiles were used, as in the straight-growth test of Bentley and Housley (ref. 1).

Table 2 shows that approximately only a further 10 per cent of the activity of the ether-extracted juice can be obtained under these conditions. Indole-3-acetic acid would be completely removed by this treatment. The activity of the juice is due, therefore, to some constituent which is not indole-3-acetic acid. For an investigation of this unknown active constituent, the juice was first purified as before by ethanol precipitation. It was then evaporated to a syrup and exhaustively extracted with ether at *p*H 6.

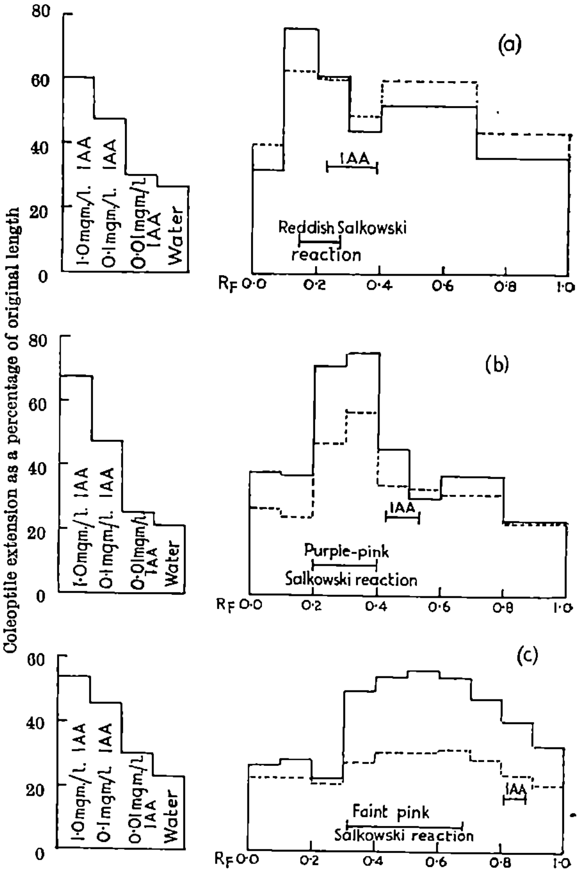

Fig. 1. Histograms of ether-extracted maize juice chromatographed in: (*a*) *n*-butanol saturated with *N* ammonium hydroxide solution; (*b*) *iso*propanol : water (4 : 1) containing a trace of ammonia; (*c*) acetone : water (1 : 1). Broken lines show activity extractable by ether after chromatography, while full lines show activity not extractable under these conditions. Assay was by the *Avena* coleoptile straight-growth test

The results in each histogram in Fig. 1 were obtained from material equivalent to 4 gm. of maize-kernel pulp. Fig. 1 shows that the activity of the juice appears at lower R_F values than does indole-3-acetic acid.

From strips of paper chromatograms run in the presence of ammonia some activity can be extracted by ether. The activity coincides with a Salkowski-reacting region on the paper. In the three chromatograms in Fig. 1, the colour of the Salkowski reaction was rather patchy and in the case of the paper run in acetone/water, very faint and indistinct. The other two papers, run in the presence of ammonia, appeared to show that a substance with a purple Salkowski reaction was present. At slightly greater R_F values, though not completely separated from the purple zone, there was a reddish Salkowski reaction.

The general impression obtained was that in ammoniacal solvents a substance with a purple Salkowski reaction was giving rise to a substance with a red Salkowski reaction and a greater R_F value. The indistinctness of the spots was thought to be due to the effect of large amounts of other constituents present.

A further concentration of the juice was made. Juice equivalent to about 200 gm. pulped maize kernels was partly purified by ethanol precipitation followed by exhaustive ether extraction as previously described. The syrup (25 ml.) obtained after evaporation of the ethanol was mixed with anhydrous sodium sulphate (100 gm.) and the mixture stirred with absolute ethanol. The ethanolic extract was filtered off and the process repeated three more times. The combined ethanolic extracts were evaporated to a small volume. Fig. 2 shows the histogram obtained when one-eighth of the syrup was chromatographed in *n*-butanol saturated with water. A tank completely free from ammonia was used.

The peak of activity corresponded to a region with a purple Salkowski reaction. After treatment of the paper with *N* sodium hydroxide solution, the same region no longer gave a purple Salkowski reaction. Instead, there was a red Salkowski reaction exactly like that given by indole-3-acetic acid. This red colour was more intense than the original purple, and had a greater spread of R_F value. Before sodium hydroxide treatment, no zone of the paper gave any trace at all of a red Salkowski reaction.

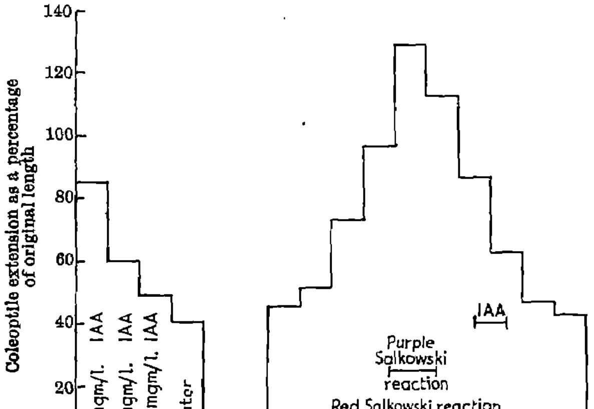

Fig. 2. Histogram of maize juice concentrate chromatographed in water-saturated *n*-butanol and tested by the *Avena* coleoptile straight growth test

Both the red and the purple Salkowski reactions appeared to be given by two overlapping spots, indicating that the activity is not due to one compound only. A purple Ehrlich reaction given by the same region of the chromatogram also appeared to result from two overlapping spots.

The high activity relative to the indole-3-acetic acid controls shown in Fig. 2 has been noted in other experiments, but is not always reproducible.

These results were obtained with extracts from a Himalayan strain of maize, and also from a commercial variety, Northern Cross. The Salkowski and Ehrlich tests were carried out by the methods of Stowe and Thimann[2]. This work is continuing, and a further report will appear later. We wish to thank Profs. S. C. Harland and E. R. H. Jones for facilities and also Mrs. V. Shaw for carrying out biological tests.

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Influence of Introduction of a Fructosyl Group into Galactosylglucoses on their β-Galactosidase-inducing Activity

INTRODUCTION of a fructose group at the reducing carbon position of melibiose (to form raffinose) is known to abolish the β-galactosidase-inducing capacity of this α-galactoside in *Escherichia coli*[1,2]. The question arises whether this effect of the fructose group applies also to induction effected by β-galactosides. A study was therefore made of the β-galactosidase-inducing capacity of an homologous β-galactosidic oligosaccharide pair, namely, the pair lactose and α-lactosyl-β-fructofuranoside[3]. This last sugar, which will be referred to as 'lactsucrose', has a terminal β-galactosidic linkage, and is readily cleaved to galactose and sucrose both by *E. coli K*–12 β-galactosidase in solution and by a washed suspension of lactose-induced cells of this strain (Table 1). It proved, however, to be a negligible inducer of the β-galactosidase. Thus, the relative behaviour of lactose and lactsucrose resembles that of melibiose and raffinose in respect of the capacity to induce β-galactosidase in *E. coli K*–12. Moreover, it has also been shown recently that raffinose can be metabolized by melibiose-induced cells[6]. This indicates that raffinose is able to penetrate such cells. The cleavage of lactsucrose by lactose-induced cells indicates similarly that lactsucrose can enter these cells.

It is thus evident that the introduction of a fructosyl group at the reducing carbon of lactose results, as with melibiose, in a marked diminution of the ability of the disaccharide to serve as inducer of the β-galactosidase system. Such behaviour can be

Table 1. ACTIVITY OF *E. coli* β-GALACTOSIDASE TOWARDS LACTSUCROSE

Sugar in growth medium*	Inducer†	β-Galactosidase activity‡		Hydrolysis of the β-galactosidic linkage‖	
		Washed cells	Cell extract§	Lactose	Lactsucrose
Glucose	—	0·0	0·5	–	–
Glucose	lactsucrose	0·1	1·1	–	–
Glucose	lactose	9·8	182·5	+	+
Lactose	—	12·4	240·0	+	+

* Growth was conducted for 24 hr. in '56' synthetic medium containing 2 per cent sugar (ref. 1).

† Washed cells (in a concentration equivalent to 5 mgm. dry weight/ml.) were incubated 5 hr. at 37° C. in an induction medium (ref. 4) containing 0·02 *M* inducer.

‡ Expressed in terms of units of hydrolysis of *o*-nitrophenyl-β-galactoside (ref. 5) per mgm. dry weight.

§ Cells were mechanically disintegrated with glass beads in a Mickle vibrator. The supernatant solution given by centrifuging for 15 min. at 8,000*g* served as the enzyme solution.

‖ (+) indicates > 50 per cent and (–) < 2 per cent hydrolysis of substrate, both by cells and by their extract. The reaction mixture contained 0·1 *M* sugar, 0·05 *M* phosphate buffer *p*H 7·0 and fresh cells (5 mgm. dry weight/ml.) or enzyme solution (1 mgm. dry weight/ml.). After incubation at 37° C. for 6 hr. products of hydrolysis and decrease in the initial amount of substrate were observed by methods of paper chromatography and reducing sugar determination (ref. 3).

attributed to inability of the trisaccharide to reach the site of β-galactosidase induction, and/or a lack of inductive capacity proper. The permeation step is known to be controlled by a specific inductive system[7-9]. It is conceivable that raffinose and lactsucrose are incapable of inducing the permeation system, whereas cells induced by lactose possess it and hence are also penetrated by trisaccharides.

I wish to thank Prof. S. Hestrin for helpful advice.

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Demonstration of Some 'Masked' Lipids in the Oocytes of *Chrotogonus trachypterus* with Sudan Black *B* and Phenol 'Unmasking' Techniques

SUDAN black *B*, in spite of being the most specific and vigorous dye for the demonstration of lipids in tissue sections[1,2], has its limitations[3,4]. The cell inclusion believed to be lipid may not be coloured with sudan black *B*, because: (1) some lipids (like phospholipids) may escape from the tissue into the fixative by the process of emulsification[2,3]; (2) the lipids present have a high melting point and thus remain 'solid' in tissue sections[3]; or (3) the lipids present are 'masked' by proteins or other substances.

All these difficulties have been experienced in this laboratory during the histochemical investigation of the lipids in the oocytes of a number of animals[5]. The first one can always be eliminated by fixing the tissue in fluids containing free calcium ions[3] (like formaldehyde–calcium of Baker[2]), and by post-chroming; while the second difficulty can be overcome to a great extent by using the dye at 60° C. for longer periods (say 30 min.). But the lipids still remaining uncoloured have either a melting point much higher than 60° C. (for example, cholesterols and cholesteryl esters), or they may be 'masked'. The cholesterols and cholesteryl esters can always be detected by using specific histochemical tests[1,4,6]. It is the presence of 'masked' lipids which has troubled many previous workers.

Although the 'masked' lipids may be 'unmasked' and thus coloured with sudan black *B* by a simple treatment of the tissue sections with the various fat-solvents like acetone, ether, etc., which 'unmask' the lipids not removed by these solvents[5,7,8], yet such treatments are inadequate to 'unmask' the lipids in larger lipid bodies for which some special unmasking techniques recommended by Ciaccio[9] must be employed.

In the oocytes of *Chrotogonus* it has been found that a large number of sudanophil lipid spheres constantly give a 'ringed' or 'crescentic' appearance (that is, a dark sudanophil sheath enclosing a completely non-sudanophil core of various sizes) even when the sections of the material fixed according to the formaldehyde–calcium/postchroming technique[2] are coloured with sudan black *B* in propylene glycol[10] at 60° C. for 1 hr. These bodies give a completely negative reaction to all the tests for cholesterol and its esters[1,4,6], in spite of repeated attempts. This shows that if lipids are present in the core they must be 'masked'.

Ciaccio's[9] various techniques were tried to 'unmask' them. The methods, which include an 'unmasking' fixative, namely, Da Fano, Ramon y Cajal with or without potassium dichromate, did not prove successful. Of the two special 'unmasking' agents recommended, trypsin also was not so successful, but phenol gave excellent results. The material fixed in formaldehyde–calcium for 6 hr. was treated with 1 per cent phenol solution at 37° C. for 24 hr. The gelatin sections of this material when coloured with sudan black *B* did not reveal any 'ringed' or 'crescentic' appearance of the lipid bodies, which now coloured uniformly blue-black. This shows clearly that the lipids present in the uncoloured cores of the 'crescentic' and 'ringed' lipid spheres in the oocytes of *Chrotogonus* were 'masked' ordinarily by proteins; the presence of the latter is shown by the stainability of these lipid bodies with mercuric–bromophenol blue[11].

The kindness of Dr. S. Bradbury, Cytological Laboratory, Department of Zoology, University of Oxford, for sending the details of Ciaccio's techniques not available here, is gratefully acknowledged.

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Influence of Time on the Reversible Association between Large Molecules: the Collagen System

It is increasingly evident that reversible interactions between macromolecules underlie many important biological functions; the actomyosin system is a classical example. Time-related changes in association between large molecules, which give rise to altered solubility and tensile strength (often associated with increased order), are well known to polymer chemists. It is suggested here that biological systems which rely on controlled intermittent association between specific macromolecules may, by increasingly long periods of association, become fixed in an irreversible or very slowly reversible state, resulting in impaired or lost function.

This communication reports an example of time-related changes in solubility of fibrils formed in relatively homogeneous solutions of collagen. Cold neutral salt extracts of fresh skin from growing animals contain collagen in solution which may be precipitated as an opaque gel composed of cross-striated fibrils, characteristic of the native tissue, by warming to 37° C.[1]. Purified collagen isolated from such extracts behaves in like manner[2]. Dilute acetic-acid extracts of collagen dialysed against neutral buffers can be gelled in a similar way. The effect of certain electrolytes and non-electrolytes on the rate of heat gelation has been briefly described[3].

It was observed in the course of these studies that the opaque collagen gels would occasionally be re-dissolved on cooling in the refrigerator. Fessler[4] has independently reported that one fraction of purified collagen obtained from rabbit skin by neutral salt extraction would, after precipitation by warming, redissolve on cooling. The investigations reported here revealed that one factor determining whether or not a gel would dissolve on cooling was the time it remained at the higher temperature.

Clear viscous solutions of collagen were prepared from calf dermis by extraction with 0·5 *M* acetic acid and dialysis consecutively against phosphate buffer, *p*H 7·6, $\Gamma/2 = 0{\cdot}4$, and sodium chloride, $\Gamma/2 = 0{\cdot}45$. Other samples were similarly prepared at physiological ionic strength and *p*H. These solutions are 'homogeneous' electrophoretically and in the ultracentrifuge. Partial composition of the dissolved collagen was reported earlier[3].

When warmed to 37° C. the opacity of the rapidly formed gel increased with time along a sigmoid curve as observed in a 'Klett' photoelectric colorimeter (No. 540 filter). Opacity, in this system, was a direct function of precipitated protein sedimentable at 80,000*g* for 1 hr. This was demonstrated by analysis of the supernatant solution and weighing of the dried, salt-free precipitates. Series of samples of the two neutral solutions described above were allowed to stand in a water-bath at 37° C. for varying time-intervals ranging from 10 min. to 48 hr. after reaching maximum opacity. At the end of each period the tubes were transferred to an ice-bath and the fall in opacity was measured at 1-min. intervals in the colorimeter. After the rate of decrease in opacity had diminished nearly to zero the samples were centrifuged cold at 80,000*g* for 1 hr. and the collagen-content of the supernatant solutions was determined by hydroxyproline analysis, and the dry salt-free precipitates were weighed. Results of a typical experiment using a collagen solution, sodium chloride 0·14 ionic strength buffered to *p*H 7·4 with 0·008 *M* phosphate, are shown in Fig. 1. On cooling a gel for 10 min. after it had reached maximum opacity at 37° C., there was a fairly prompt fall in opacity, levelling off at about 40 per cent of the control value. After 48 hr. of incubation, less than 10 per cent reduction in opacity was observed on cooling. The same phenomenon in a greater degree occurred in solutions of 0·45 ionic strength. The loss in opacity on cooling after 10-min. incubation was 100 per cent and after 48 hr. of incubation was less than 10 per cent.

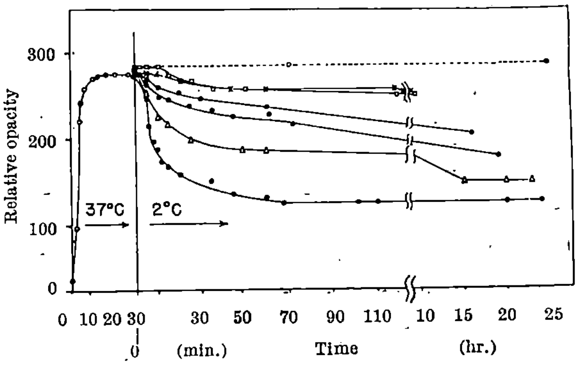

Fig. 1. Effect of cooling to 2° C. on the opacity of collagen gels incubated at 37° C. for different periods of time. Reading from the lowest curve upward: ●, 10 min.; △, 1 hr.; ◒, 3 hr.; ◓, 6 hr.; □, 24 hr.; ×, 48 hr.; ○ - - - - ○, 56 hr. (control, not cooled). Starting solution contained about 0·2 per cent calf-skin collagen dissolved in cold 0·14 *M* sodium chloride buffered with phosphate to *p*H 7·6

This phenomenon was also observed in cold saline extracts of fresh guinea pig skin which contained relatively high concentrations of a collagen fraction thought to be the precursor of the characteristic tissue fibrils.

Changes in solubility of the gels at acid *p*H as a function of time of previous incubation at neutral *p*H were also investigated. Between one and two weeks of incubation at 37° C. were required for the collagen gels to become almost completely insoluble in cold citrate buffer at *p*H 3·5.

It is improbable that the system reported here required interaction with non-collagenous components or enzymes. It is suggested that the increasing degree of irreversibility may result from the action of Brownian movement, allowing the associated molecules to find their most stable and sterically matched fit, thus permitting the establishment of more intermolecular cross-links.

The results of this study suggest the possibility that increasing time of association between biological high polymers may, at least in some instances, be contributing factors to ageing changes in structure and function in the organism.

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Isomorphous Replacement in the Kaolin Group of Minerals

It has been customary to classify the groups of layer silicate minerals as trioctahedral or dioctahedral according as all the octahedral ion sites in the lattice are occupied, or only two sites out of three. Virtually all minerals in the layer silicate groups fall clearly into one of these two divisions, the number of octahedral sites per unit cell occupied being usually nearly round numbers.

In the kaolin group the purely aluminous minerals, kaolinite, dickite and nacrite are dioctahedral members. Hallimond[1,2], Brindley[3,4] and Brindley and Youell[5] have shown that the chamosite present in sedimentary ironstones is a member of the kaolin group and that its molecular formula is very close to a trioctahedral structure, typically 2·9 octahedral sites out of every 3 being occupied by iron, magnesium or aluminium. There has been considerable recent evidence from microradiography[6], and chemical analysis and X-ray diffraction[7] that the composition of chamosite can vary between wider limits than had been supposed originally. Previous attempts to classify chamosite[2] have considered the Pauling structure for the kaolin and chlorite groups, trioctahedral members of which have a common empirical formula $X_3(\mathrm{SiAl})_2\mathrm{O}_5(\mathrm{OH})_4$ [X = Fe,Mg,Al....] representing half the unit-cell content of kaolin, and a quarter of the unit cell of chlorite. Agreement with this structure has not, in general, been very good. Other methods of classification[2,8] have used the oxide ratios in the formula of chamosite originally suggested by Zalinski[9]. This method has no justification from a structural point of view, but has indicated that for most chamosites derived from sedimentary ironstones the numbers of silicon and aluminium atoms in the structure are very nearly equal, although RO (where R = Fe or Mg) is often substantially lower than in Zalinski's formula.

It has recently been possible[10] to obtain a complete analysis of a chamosite from the chamosite–kaolinite (top) beds of the Northampton sand ironstone formation at Wellingborough. There were strong indications[6,7] that this specimen was particularly low in iron content, and analysis has confirmed these. The low iron content could not be accounted for by simple admixture of kaolinite. The structural formula, evaluated on a basis of 9(O + OH) ions in the formula, was :

$$\underbrace{\mathrm{Al}_{1\cdot09}\,\mathrm{Fe}^{2+}_{1\cdot30}\,\mathrm{Fe}^{3+}_{0\cdot12}\,\mathrm{Mg}_{0\cdot16}}_{2\cdot67}\,(\mathrm{Si}_{1\cdot59}\,\mathrm{Al}_{0\cdot41})\,\mathrm{O}_{5\cdot15}\,(\mathrm{OH})_{3\cdot85}$$

This compares with the formula of a chamosite from the Main Ironstone beds of the same formation[5] at Corby :

$$\underbrace{\mathrm{Al}_{0\cdot85}\,\mathrm{Fe}^{3+}_{0\cdot01}\,\mathrm{Fe}^{2+}_{1\cdot83}\,\mathrm{Mg}_{0\cdot23}}_{2\cdot92}\,(\mathrm{Si}_{1\cdot33}\,\mathrm{Al}_{0\cdot67})\,\mathrm{O}_{5\cdot02}\,(\mathrm{OH})_{3\cdot98}$$

It is clear that (*a*) the RO value is much lower than for the main ironstone chamosite, even when all iron is included as RO (1·58 against 2·07) ; (*b*) the occupation of octahedral sites is so low (2·67 against 2·92) that the Wellingborough specimen can scarcely be regarded as properly trioctahedral ; and (*c*) the Si/Al ratio is still nearly 1. Replacement of tetrahedral silicon by aluminium is low, whereas the amount of octahedral aluminium is high ; this represents a deviation towards the kaolinite composition.

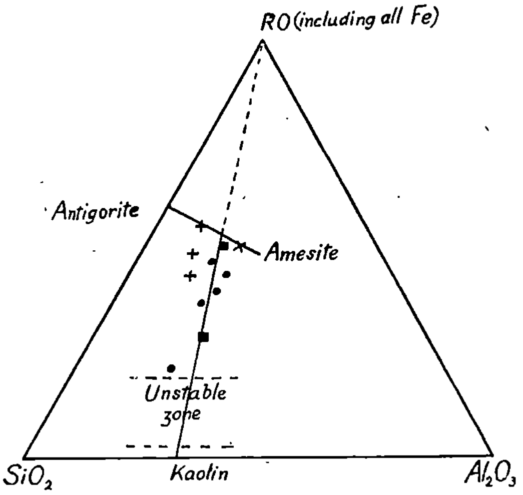

Fig. 1. Chamosite analyses: ■, present work; ●, Taylor; +, acid-extraction method (low aluminium); ×, lateritic origin (high aluminium)

This formula is so far from the Pauling structure composition that it seems necessary to seek some other method of classifying chamosite. It would appear that isomorphous replacement of iron and aluminium occurs between chamosite and kaolinite over a wide range of compositions, and that structures intermediate between dioctahedral kaolinite and the trioctahedral 'normal' chamosite are possible. Following Taylor[8], it is useful to present chamosite analyses as a triangular composition diagram (Fig. 1) based on $\mathrm{SiO_2}$, $\mathrm{Al_2O_3}$, and RO (the latter including all iron calculated as ferrous). On the basis that the silicon–aluminium ratios in chamosite are nearly 1, a line joining RO with the kaolinite formula ($2\mathrm{SiO_2}$, $\mathrm{Al_2O_3}$) should include all possible intermediates between chamosite and kaolinite. The chamosites from Wellingborough[10] and Corby[5] lie very close to this line and five analyses by Taylor[8] (although in some cases obtained by difference from materials containing only 30 per cent chamosite) are also in reasonable agreement with this line. Analyses quoted by Hallimond[2] and Taylor[8] made by the acid-extraction method (which tends to give low values for the aluminium content of the mineral) are well on the silica-rich side of the line, whereas a chamosite of lateritic origin[4] is, as may be expected, divergent in the aluminium-rich direction. Work by Grimshaw *et al.*, and Brindley, Robertson and Mackenzie has shown that a very small amount of substitution in the kaolinite lattice produces considerable disorder in the mineral. Very small amounts of iron present in place of aluminium produce a highly disordered fireclay and not a well-ordered kaolinite. This is in agreement with the much larger size of the ferric ion compared with the aluminium ion.

At the other end of the series, an iron-rich chamosite agreeing fairly well with the Pauling structure (as represented by the amesite–antigorite line) contains a high proportion of large ferrous and magnesium ions. Considerable substitution of small aluminium ions in the octahedral positions may occur without disrupting the lattice, although appreciable disorder is apparent in X-ray photographs of chamosites with high octahedral aluminium values.

There appears to be a zone which is structurally unstable for which no specimens have yet been found. A substantial part of the chamosite–kaolin series is, however, represented by actual specimens, and it is suggested that this series forms a sounder basis for classification than the Pauling formula composition or Zalinski's oxide-ratios.

Thanks are due to Dr. E. Cohen, of the British Iron and Steel Research Association, and Prof. J. H. Taylor for specimens. A full account of this work will be published later.

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Dynamics of Chain Molecules in Dilute Solutions, with Special Reference to Non-Newtonian Viscosity

SEVERAL aspects of the phenomena appearing when chain molecules in dilute solutions are subjected to a velocity field seem to be satisfactorily explained by the theory which I have recently proposed[1]. In particular, the correct shape of the curve giving tan α (initial slope of extinction angle curve, as resulting from flow birefringence measurements) as a function of η_0 (viscosity of solvent) has been obtained; quantitative agreement has been observed between the calculated and the measured slope of the asymptote to the preceding curve, in the case of polystyrene; the correct dependence on molecular weight of the internal viscosity term B in tan α has been obtained (proportionality of B to the molecular weight, as established experimentally by Leray for polystyrene[2]); and finally it has become possible to understand some of the characteristics of non-Newtonian viscosity.

Furthermore, an expression of the intrinsic viscosity for molecules of low internal viscosity, valid in a wide range of velocity gradients, has recently been obtained[3]; this expression contains three molecular parameters which can all be determined experimentally: the molecular weight M, the zero gradient intrinsic viscosity $[\eta]_0$, and the ratio, B/M, which is characteristic of each kind of polymer.

These last results have been compared with the non-Newtonian viscosity measurements of Čopič[4] on a series of polystyrene fractions. The theoretical curves giving the intrinsic viscosity $[\eta]$ as a function of the velocity gradient G were computed, using the values of M and $[\eta]_0$ given by Čopič and the value of B/M deduced from flow birefringence measurements of Leray[2]. The agreement, though not perfect, is quite significant[3].

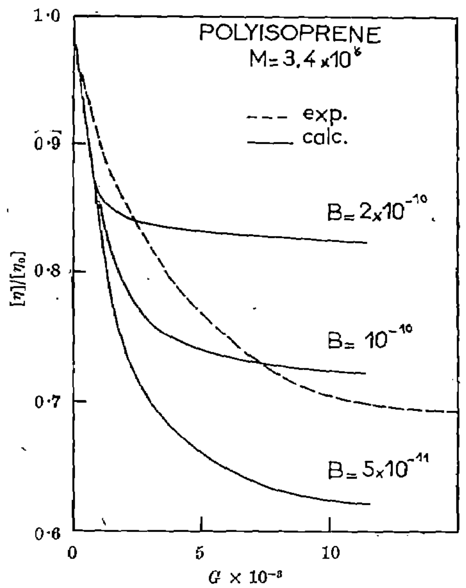

Fig. 1

Here, I wish to make the comparison with the measurements of Golub on a series of polyisoprene fractions[5]. No flow birefringence data are available in this case; therefore it is not possible, as in the case of polystyrene, to compute the $[\eta]$ versus G curves from the theory, not using any adjustable parameter.

I have first computed three theoretical curves for polyisoprene 1c, giving B/M respectively the values 5×10^{-11}, 10^{-10}, 2×10^{-10}. In Fig. 1 it can be seen that a reasonable agreement with the experimental curve is obtained taking $B/M = 10^{-10}$.

The theoretical curves for the samples 1a, 3a and 3b have then been computed (taking B/M as a constant). The comparison with the experimental curves is made in Fig. 2 for the samples 3a and 3b: the agreement is quite good. For sample 1a the agreement is of the same type as for 1c; the curves relative to 1a are not represented here.

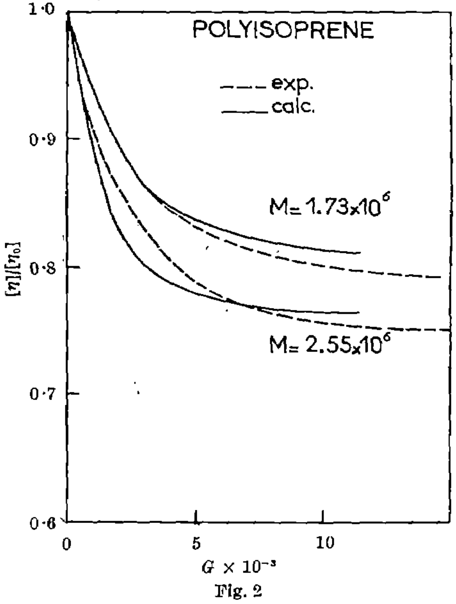

Fig. 2

Deviations like those observed on Fig. 1 are not surprising, since the conditions of validity of the theory are not rigorously fulfilled (the internal viscosity of polyisoprene is a little too high), and since the theory becomes insufficient when G approaches infinity.

Thus the theory explains a large number of facts, and is well suited to describe many essential features in non-infinitely small gradients. It is hoped that new possibilities of the hydrodynamic methods will follow; it is already possible to obtain the parameter B, and therefore the internal viscosity of the molecule, from one single $[\eta]$ versus G curve.

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A Survey of Terrestrial Craters

The domination of the Moon's surface by circular crater-like features raises the question as to whether this is a phenomenon peculiar to the Moon or whether it has significance for the solar system as a whole, including the Earth. The latter view has been urged by Baldwin[1] and others[2,3], who conclude that the lunar craters are due to meteorite impact and that the Earth has suffered a similar bombardment of which known meteorite craters are the residual evidence.

Baldwin's correlations are on the whole rather convincing, but the data on terrestrial meteorite craters available at the time his work was done were statistically less impressive than might be desired. Although widely distributed over the Earth, specimens being found in Europe, Asia, Africa, Australia and North and South America, only 17 craters or clusters of craters were known prior to 1950. While some of the clusters contained many pits, they were for the most part small, and only ten individual craters were known to be more than 100 metres (330 ft.) in diameter, the limit of size which can be observed on the Moon (Kuiper, G. P., private communication). In addition, all these craters belong to a recent geological epoch, whereas there is evidence pointing to a wide distribution of ages among lunar features.

Discoveries made during the past seven years have provided appreciable extensions to the data in the directions of numbers, diameters and ages of craters. These include the Chubb or New Quebec Crater, 3·4 km. diameter (Recent)[4], the Talemzane Crater, 1·8 km. diameter (Late Pliocene or early Quaternary)[5], the Brent Crater, 3·7 km. diameter (Early Paleozoic)[6], the Holleford Crater, 2·4 km. diameter (Early Paleozoic)[7] and the crater at Deep Bay, Saskatchewan, diameter 13·7 km. (Late Mesozoic)[8]. In addition, two large circular arcs have been noted in Canada, the Belcher Islands arc in Hudson Bay, 400 km. diameter, and the arc containing Prince Edward Island and outlined by the neighbouring coasts of Nova Scotia and New Brunswick[9], 300 km. diameter, both of which may be due to meteorite impact.

Most of the more recent crater discoveries have been made as a result of systematic studies of aerial photographs, and it seems reasonably certain that some of the most interesting objects would have remained in obscurity for a long time if these photographs had not been available. It is the purpose of this communication to suggest that the wide aerial photographic coverage which now exists throughout the world represents an opportunity to make what could be a decisive contribution to this branch of astronomical and geophysical science. The equipment necessary for studying aerial photographs is very modest, and a determined worker can cover a relatively large area of country in a short time. If systematic searches could be initiated in many countries, it would be reasonable to expect a trend to emerge which would go far to settle the still unsolved problem of the relationship between terrestrial meteorite craters and the astonishing array of circular objects covering the surface of the Moon.

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Etch Figures on Sodium Chloride Crystals

GYULAI and his co-workers have for some years been investigating the properties of alkali halide crystals. In the course of etching sodium chloride and rock salt crystals I have made some observations which may throw light on the dislocations supposed to exist in real crystals.

Cleaved crystals of sodium chloride were etched in alcohol mixed with a small quantity of formaldehyde. After etching for a few minutes, that part of the sample which was in contact with the container revealed etch-figures, shown in Figs. 1 and 2. The examination and photography of these samples was carried out in transmitted light, with an '*L*-Stative' Zeiss microscope. The etch-figures are most instructive. The growth layers, and the lamellar structure of the crystals show up clearly. On the single growth steps right- and left-handed spirals and their various combinations have become visible. The single spirals are squares with rounded corners, their orientation corresponding with the cubic edges of the crystal. The direction of observation was (001).

The photomicrographs give a detailed picture of the etched (001) plane. The etch-figures are similar to those obtained by A. R. Verma[1] on silicon carbide. Voltava and Amelinckx[2] obtained spiral figures on the surfaces of sodium chloride crystals by thermal etching. The spirals and their combinations obtained by the use of etching reagents are, however, clearer,

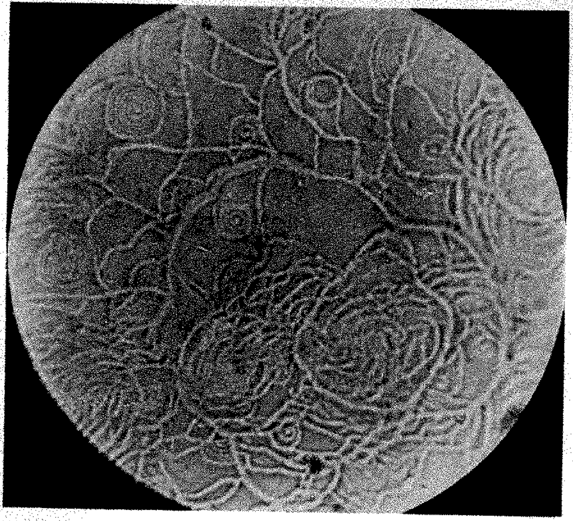

Fig. 1. Surface of a sodium chloride crystal after etching in alcohol +formaldehyde for 30 min. × 500

more easily obtained and are durable in dry air. The etching method described here may be applied to synthetic as well as to natural crystals, and with appropriate modification may also be used for potassium chloride crystals. Investigations in this direction are being carried out.

Another observation has been made on deformed crystals of sodium chloride. Synthetic blocks of sodium chloride a few millimetres in length and diameter were slightly deformed by bending. After etching a deformed crystal for 0·1 sec. in glacial acetic acid very regular etch-pits were obtained on every side of the sample. The etch-pits are regular, square-shaped concave pyramids. These observations were also made with a Zeiss '*L*-Stative' microscope, with a magnification of about 100, in transmitted light. The etch-pits are located on the (001) plane as seen from the direction of the bending axes on the (110) slip planes. The etch-figures are grouped in more or less dense strips. It is, however, unnecessary to deform the sample, because cleavage itself initiates slips, which seems to be unavoidable. When preparing the sample by cleaving it on six sides, deformations are produced in the crystals. Thus every surface examined contained systems of two perpendicular bands and two bands inclined at an angle of 45° to the (100) direction. These bands consist of square etch-pits and in some cases they may be observed individually. According to the observations of W. Dekeyser, J. J. Gilman and W. G. Johnston[3] and others, such etch-pits originate at the ends of dislocations emerging on the surface. Taking into consideration the potential mobility of the dislocations, the network of the 45°-bands may be interpreted as containing edge-dislocations, and the 90°-orthogonal network as containing screw-dislocations. Etching in glacial acetic acid provides a very quick method for investigating grain boundaries. After a short etching time, the grain boundary becomes readily visible as a region densely packed with distorted etch-pits.

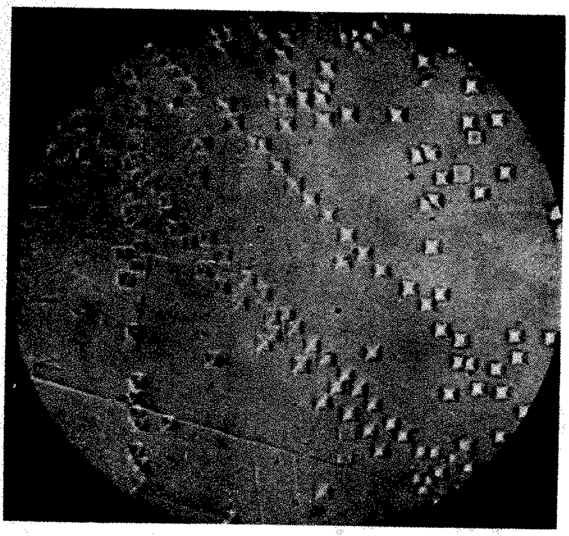

Fig. 2. Cleaved surface after etching for 0·1 sec. in glacial acetic acid. × 350

It is interesting to observe that the edges of the cleavage lamellæ are attacked by the reagent only after a considerably longer period.

Further investigations are in progress.

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Relativistic Aberration Formula

It has been stated that "the relativistic aberration formula, $\tan\theta' = \sin\theta(1 - v^2/c^2)^{1/2}/(\cos\theta + v/c)$ . . . deviates from the equation . . . of the ether theory by quantities of second order only, a deviation which is negligible compared with the present accuracy of the measurements"[1]. The aberration is also referred to as a "displacement, $\theta - \theta'$"[2].

The angles θ, θ', however, which appear in the formula, are measures in different frames of reference, and subtraction of them is meaningless observationally. The 'displacement', as measured by the observer, would be $\theta - \theta''$, where θ, θ'' give, respectively, the apparent and actual directions of the source in the frame of the observer, simultaneously for him. But in that frame, since the source has moved vt while the ray has moved ct, t being the time of transit from source to observer, we have $\tan\theta'' = \sin\theta/(\cos\theta + v/c)$, exactly as in the classical theory for an observer at rest in the ether. It is obvious, in fact, that there would be no deviation between the classical and relativity theories for such an observer, since no transformation of co-ordinates is involved.

If it is the source which is at rest in the ether, the classical theory requires us to superpose on the picture relative to the observer an ether drift of v in the direction of the source's velocity. The velocity of the light-ray being now approximately $(c + v\cos\theta)$ relative to the observer, by the same argument we find $\tan\theta'' = \sin\theta/\{\cos\theta + v/(c + v\cos\theta)\}$, which gives a second-order deviation between the theories amounting to twice the deviation now accepted. In general, with an ether drift of V (not commensurate with c) away from the observer, the deviation is $(vV/c^2)\tan\theta$ instead of $\frac{1}{2}(v^2/c^2)\tan\theta$, as given by the accepted formula.

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Random Time

If the point of the hand of a clock moves along the circumference of the unit circle with constant angular velocity ω, then the time measured is determined by the position:

$$\exp i\omega t \tag{1}$$

This formulation depends, however, on the abstraction of a 'uniform time', a concept which, after Mach's critique, fails to be meaningful and cannot be made legitimate even if a built clock is replaced by a clock determined by the gyrations of the Earth (or, for that matter, of a galaxy). Clearly, the conceptual difficulty remains unaltered if, instead of astronomical clocks, recourse is had to electron clocks—those supplied by electromagnetic or spectroscopic measurements.

Actually, the irreducibility of the vague notion of what is the 'uniformity' of the independent variable t (classical or relativistic) is not merely an epistemological issue. For 'time' can be defined only by measurements, and the measurements can be carried out only on the movements of instruments (clocks, planets, electrons), whereas every physical object and its observations are necessarily subject to imperfections or, at best, to statistical fluctuations. What is more, the same holds for every physical law as well (by physical law we understand here differential equations in which t is an independent variable). The object of this communication is the harmonic analysis of the simplest (and, in a certain mathematical sense, uniquely determined) model of the statistical fluctuations of 'time' itself.

If $\mathrm{f}(t)$ is defined for $-\infty < t < \infty$ as a function for which the auto-correlation:

$$F(t) = \lim_{T\to\infty} \frac{1}{2T}\int_{-T}^{T} \mathrm{f}(t+s)\bar{\mathrm{f}}(s)ds \tag{2}$$

exists as a continuous function for $-\infty < t < \infty$ (the bar refers to complex conjugation), then $F(t)$ is necessarily of the form[1]

$$F(t) = \int_{-\infty}^{\infty} \exp itu d\varphi(u) \tag{3}$$

where $\varphi(u)$ is a certain bounded function satisfying $d\varphi(u) \geqq 0$.

If $\mathrm{f}(t)$ is chosen to be the function (1), then it is identical with $\mathrm{f}(t+s)\bar{\mathrm{f}}(s)$ for every s. Hence (2) shows that $F(t) = \mathrm{f}(t)$ if $\mathrm{f}(t) = \exp i\omega t$, which means, by (3), that the distribution function φ (representing the spectral energy) is a Dirac distribution, consisting of a single saltus: $\varphi(u) = 0$ for $-\infty < u < \omega$ and $\varphi(u) = 1$ for $\omega < u < \infty$. Clearly, the statistical fluctuations of time, referred to above, will have to dissolve the resulting infinite concentration (represented by a discrete, sharp spectral line) at $u = \omega$. Let the fluctuations be realized as follows:

Add to the t of (1) the function $ax(t, \alpha)$, where a denotes a positive constant and $x(t, \alpha)$ is a normalized function as defined in the theory of differential space[2]. Then, since (1) or $\mathrm{f}(t) = \exp(i\omega t)$ is replaced by:

$$\mathrm{f}(t, \alpha) = \exp(i\omega\{t + ax(t, \alpha)\}) \tag{4}$$

where x is real-valued and α is a parameter (to be averaged over the interval $0 \leqq \alpha \leqq 1$), the function (2) becomes:

$$F(t, \alpha) =$$

$$\exp i\omega t \lim_{T\to\infty} \frac{1}{2T}\int_{-T}^{T} \exp(i\omega a\{x(t+s, \alpha) - x(s,\alpha)\})ds \tag{5}$$

Here α is a point (not contained in a set of measure zero) on the integration-range of differential space.

In view of the Gaussian definition of measure in differential space, it can readily be concluded from the ergodic theorem[3] that, for almost all values of α, the time-average which multiplies $\exp i\omega t$ in (5) is identical with the corresponding space-average in differential space, and, therefore, with the integral

$$\int_{-\infty}^{\infty} \exp(i\omega av)(2\pi|t|)^{-1/2}\exp(-\tfrac{1}{2}v^2/|t|)dv$$

But this is Laplace's integral, the value of which is known to be $\exp(-\frac{1}{2}\omega^2a^2|t|)$. If this evaluation is substituted in the representation (5) of the function $F(t, \alpha)$, a function which, being independent of α (for almost all α), can now be denoted by $F(t)$, and if the result is compared with (3), it follows that:

$$\int_{-\infty}^{\infty} \exp itu\, d\varphi(u) = \exp i\omega t \exp(-\tfrac{1}{2}\omega^2a^2|t|)$$

This can be written in the form

$$\int_{-\infty}^{\infty} \exp itu\, d\varphi(u - \omega) = \exp(-\rho|t|) \tag{7}$$

where

$$1/\rho = 2/(\omega a)^2 \tag{8}$$

Finally, the integral of $\exp(itu)/(1 + u^2)$ over $-\infty < u < \infty$ is known to be $\pi\exp(-|t|)$. Hence it is clear from (7) that the spectral distribution, instead of being concentrated (as for (1) above) at the single frequency $u = \omega$ of infinite density, is spread out continuously over the entire range $-\infty < u < \infty$. In fact, the density of probability in the resulting distribution is seen to be

$$\frac{d\varphi(u)}{du} = \frac{1}{\pi}\,\frac{1}{1 + (u - \omega)^2} \tag{9}$$

if either the value of a in (4) or the unit of length on the u-axis is so chosen that the constant (8) becomes 1.

It should be mentioned that the result (9) is precisely the *elementary* distribution of Cauchy, a stable distribution of infinite standard deviation, already encountered by P. Lévy in his work on normal stochastic processes[4].

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Contraction of Time and Protoplasm

IN recent discussions concerning the clock paradox, biological time is mentioned but dismissed as of little consequence in the matter[1]. Contrary to this view and regardless of the solution finally found acceptable in the clock paradox, the entire problem really centres in biological time. Whether we accept or reject a completely mechanistic view of protoplasmic processes and therein compare them to an actual clock in the sense of their mechanical workings, or believe in other processes, in addition to the mechanistic view, the statement that biological time is the centre of the matter still holds. No one has ever shown that biological processes are identical in their functional attributes to the mechanical universe envisaged by the physicists. If biological time is not identical to the physicists' time then asymmetrical ageing is meaningless, so far as biological phenomena are concerned. One of the most outstanding physicists, upon analysing the meaning of life, gives an opposite view. Schrödinger[2] states: "from all that we have learnt about the structure of living matter we must be prepared to find it working in a manner that cannot be reduced to the ordinary laws of physics". I take it from this statement, and my own experience of more than twenty-five years of working with living materials, that the laws which control protoplasm are of a different order of integration from those of ordinary physics. This is not surprising in view of its functional complexity.

If we admit the postulates of the relativity theory apply to time–space factors, using a mechanical clock to reveal the asymmetry of the result, this is one thing; if we use a human or other living organism to reveal the result, the effects may predictably be an entirely different matter. The space–time dilatation is most profoundly related to biological processes in two obvious aspects: (1) all primary data upon which the concept is based are biologically sensorially derived; (2) if time–space factors are to show asymmetrical age differences in the stay-at-home versus the space traveller, then the biological processes of growth and ageing are involved.

Aspect (1), of course, looks directly into the whole problem of reality and causality. If as Russell[3] and others think, namely, that causality originates in perception, we can scarcely escape the implication of this in our reasoning about time dilatation and biological time. The two are closely linked. While the final status of biological time is probably in as confused a state[4] as is the clock paradox, we can, in a sense, deal with it in a more direct experimental manner.

The involvement of biological factors of ageing and growth processes in the relativistic contraction of time is very real. Biological matter has to exist not only in a physical inertial frame, of some sort, but also in some kind of time continuum. The problem here is whether or not biological material (protoplasm to be specific) is in any way affected as a function of velocity, or if it is affected in any way, or if the narrow bios zone which is an absolute necessity for survival of protoplasm also includes absolute velocity. (The discussion disregards acceleration, deceleration effects upon the intact animal which are in part understood.)

McCrea[5] mentions biological time but denies its importance through the route of making the difference between biological time and clock time arbitrarily small. He says that biological processes need not be standardized with a standard clock accompanying the system. This is the heart of the problem: is not our entire interpretation of time sense biologically conditioned? The question must be asked whether all the biological processes depend upon rate of travel of protoplasm The supposition is that growth processes will be retarded or actually reversed, yet everything we know about protoplasmic processes denies that this is possible. Living processes may be temporarily suspended under certain conditions, or slowed down, but the range of this is extremely narrow. Since all other factors, which maintain protoplasmic integrity, are of a narrow limited range, may not the same be true of the function of velocity? The interesting thing is that it does not seem to have occurred to anyone that experiments might well be performed in this connexion.

The implication in the work on asymmetric ageing is astounding since the physicists predict that increased velocity will slow up or reverse what are major biological functions, namely, the ageing and growth functions. It is as though they believe both of these are simply physical models of systems identical in final analysis to a clock. Without getting into the idea of entelechy, it suffices to state that while we may accept the physicist's view of biological materials we cannot deny that the order of organization of protoplasmic processes may be such that the ultimate upper integrative level of biological processes may function in a manner entirely different from the materials thus far tested on the electron–proton level.

Taking the other facet of the argument, assuming that the physicists are correct, and that growth and ageing processes are connected with velocity in the fashion they assume, it would be of extreme importance to determine this, since by utilization of the velocity factor we could modify living processes almost at will. Again an experimental approach is called for in order to secure the answer.

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Propagation of Ultrasonic Waves in Liquids

We had observed[1] that the heat generated by ultrasonic waves in carbon disulphide and in other liquids, such as toluene and xylene, is not in conformity with their widely divergent absorption coefficients as measured by other (acoustic) methods. To clarify the point further, we have made a set of measurements with the type of apparatus described in ref. 1.

Working at about 32° C., it was observed with a particular apparatus that the total power generated by a vibrating quartz crystal, placed inside a container with kerosene oil or xylene, was 9 watts, as obtained from the steady temperature difference between the container and the circulating water outside. Energies were also measured in a trap-vessel, placed at a definite distance from the quartz; on both sides of it when the quartz was in the middle of the container, and on one side only when the quartz was near the end. It was observed that the energy propagated forward from the quartz placed near one end was 25 per cent higher than from the other position, where it was propagated equally on both sides. The energy propagated forward was thus found to be 5·6 watts only.

Measurements were taken with trap-vessels of different sizes, placed at different distances from the quartz, which was near the end of the container. The liquids outside and inside the trap vessels were varied. It will be seen from Table 1 that α/f^2, obtained from the variation of power with distance, drops from a comparatively large value near the quartz to a value of approximately the same order as that obtained by other methods.

Table 1

Liquids (*a*) outside (*b*) in trap	Distance from quartz (cm.)	Trap vessel size (cm.)	Power in traps (watts)	Incident power at 5 cm. (watts)	$\frac{a}{f^2}\times 10^{17}$ from displacement, liquid (*a*)	$\frac{a}{f^2}\times 10^{17}$ from incident energy, liquid (*b*)
(*a*) Kerosene (*b*) Kerosene	2	1	1·5	4·5		
	5	1	1·2		408	1,722
		5	2·0			666
		15	3·0		200	400
	10	1	1·0			
	15	1	0·85		180	
(*a*) Xylene (*b*) Xylene	2	1	1·4	4·5		
	5	1	1·02		583	1,444
		5	1·9			600
		15	2·3		255	270
	10	1	0·81			
	15	1	0·70		166	
(*a*) Kerosene (*b*) Carbon disulphide	5	1	2·0	4·5		3,330
		5	2·3			800
		15	2·4			325

A direct measure of the energy incident on a trap-vessel, passing through kerosene oil and out on the farther side, was obtained by placing the trap in a closely fitting glass container, 5 cm. from the quartz. The container was thus virtually partitioned into three thermostatic chambers, except for the communicating mica windows. It was cooled by water circulating outside. The power on the farther side of the trap-vessel was measured from the temperature difference between it and the circulating water. This is a measure of the vibrational and turbulent energy as well as of the heat passing out of the trap, having regard to the temperatures on the two sides. We obtained a value of 4·5 watts, incident on the trap-vessel transmitted through the windows, irrespective of the liquid inside.

The variation of the measured power with distance has already been noted. It shows that when the incident energy at 5 cm. from the quartz is 4·5 watts, the power output at the quartz is not less than 5·6 watts. It accounts for the energy that was found to be propagated from the quartz, and it appears that the mica windows do not reflect any detectable energy.

The power measured in the different vessels, placed at 5 cm. from the quartz, gives, having regard to the incident energy, a very high absorption coefficient for liquids known to have low absorbing power.

The coefficients, in the form α/f^2, so derived are shown in Table 1 (column 7).

The higher absorption of ultrasonic waves near the source as determined by energy variation with displacement is to be associated with the inharmonic character of the waves observed by Hubbard[2]. Moreover, the excessively high absorption in the 1-cm. trap-vessel, for low-absorption type liquids, was not caused by reflexion from the mica. It has also been confirmed that diffraction by the aperture does not account for this effect. The observations appear capable of explanation on the basis of a phase retardation of the components of the inharmonic wave-form, introduced by the first mica window. They become progressively out of step and are thus prevented from being fully transmitted by the second mica window. Even in unobstructed liquids, this mechanism appears to operate to a small extent and to account for the larger loss of energy at smaller distances. It supports the conclusion that the excessive absorption of ultrasonic waves noted in carbon disulphide and benzene (and possibly also the discrepancy from the Stokes absorption coefficient in other liquids) is due to a mechanism which produces more or less effectively a confusion in phase relationship during propagation, in the same way that the mica window does for low-absorption liquids such as xylene. It thus appears that wave trains in liquids can lose energy, as if by scattering, in a manner similar to that noted by Richardson[3] in the case of gases.

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Protection of Fœtuses against Radiation Injury

The protection against a lethal dose of radiation, conferred on mice by grafts of hæmopoietic tissue, is being attributed to repopulation of homologous tissues of the host by cells from the graft[1]. This does not, however, exclude the possibility that such grafts might also be supplying a subcellular factor able to contribute to the recovery of the host.

To test the latter possibility, female mice of strain *A* were given, on the fourteenth day of pregnancy, a dose of X-rays amounting to 275 r. Immediately following this, and always under ether anæsthesia, they were splenectomized. One group was treated no further, while each animal of a second group was

Table 1. Weights (gm.) of Surviving Young at the Age of 37 Days

Young from 'ungrafted' mothers		Young from 'grafted' mothers	
Litter	Weight	Litter	Weight
A 1	5·0 4·0	*B* 1	13·6 15·5 14·0
A 2	6·0 5·5 4·9 5·2	*B* 2	11·6 11·1 12·3 8·0 6·4
A 3	5·9 4·0	*B* 3	11·6 13·9 12·9 15·0
A 4	4·2 12·4	*B* 4	11·8 14·0 14·0 12·5 12·5
Mean	5·7±2·3	Mean	12·4±2·2

given an intraperitoneal graft of six macerated livers from 18-day old fœtuses of the same strain.

Only six out of ten animals of the first ('ungrafted') group gave birth to litters. Dissection showed that resorption of fœtuses had occurred in the others. The six litters born included several still-born as well as twenty-six live young. Of the latter, twelve died within a week and another four died before weaning, having reached a weight of no more than 2–4 gm. each. The weights of the remaining ten at the age of 37 days are given in Table 1.

In contrast, all four females of the second ('grafted') group gave birth to litters, with a total of twenty-two live young and six still-born. Another five died before weaning; but the remaining seventeen developed to normal adult weight.

It would appear from these observations that the grafting of fœtal livers into the peritoneal cavity of pregnant mice subjected to irradiation improves the chances of the fœtuses to survive and enables those actually surviving to reach an adult weight twice as great as that of young from irradiated but ungrafted mothers. Experiments are being continued, based on the hypothesis that the effect of the graft is due to a humoral factor from it reaching the fœtuses *in utero*.

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Oct. 30.

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Hæmoglobin Types in Ox and Buffalo

Studies of ox and buffalo hæmoglobins by the technique of electrophoresis have been made by several workers. Geiger[1], using a technique of cataphoresis, resolved ox hæmoglobin into a component moving anodally and a component moving cathodally at a neutral reaction, and noticed that the two components had different oxygen-dissociation properties. Reiner, Moore, Lang and Green[2] and Munro and Munro[3], using the moving-boundary technique, resolved ox hæmoglobin into two components at an acid reaction. Using paper electrophoresis, Cabannes and Serain[4] found two varieties of hæmoglobin (which they called α and β) in 270 samples of North African oxen (α alone in 76·3 per cent, α plus β in 20·7 per cent, α alone in 4·0 per cent). Giri and Pillai[5] studied buffalo hæmoglobin on agar electrophoresis and resolved it into two components.

In the course of an investigation of human and animal hæmoglobin by the silicone-treated glass-plate electrophoresis technique[6] using veronal buffer *p*H 8·6 (ionic strength 0·06) and citrate buffer *p*H 6·5 (ionic strength 0·05), it became possible to study the hæmoglobin patterns in 27 oxen (*Bos banteng*) and 28 buffaloes (*Bubalus bubalis*) imported into Singapore from Bali.

In the ox, three types of hæmoglobin were detected (*A*, *B* and *C*, Fig. 1) and five patterns were obtained: *A* alone (nine cases, 33·3 per cent), *B* alone (eight cases, 29·6 per cent), *C* alone (one case, 3·7 per cent). *A* plus *B* (four cases, 14·8 per cent), and *A* plus *C* (five cases, 18·4 per cent). *A* was found in eighteen cases (66·6 per cent), migrated at a faster rate than normal adult hæmoglobin and is probably identical with Cabannes and Serain's β. *B* moved more slowly than *A*, very similar to normal adult hæmoglobin, and is probably identical with Cabannes and Serain's α. *C* moved faster than *A*. All three types moved anodally at *p*H 8·6, *A* and *B* being well separated, *A* and *C* less so. At *p*H 6·5 all three types moved cathodally, their relative migrations being reversed.

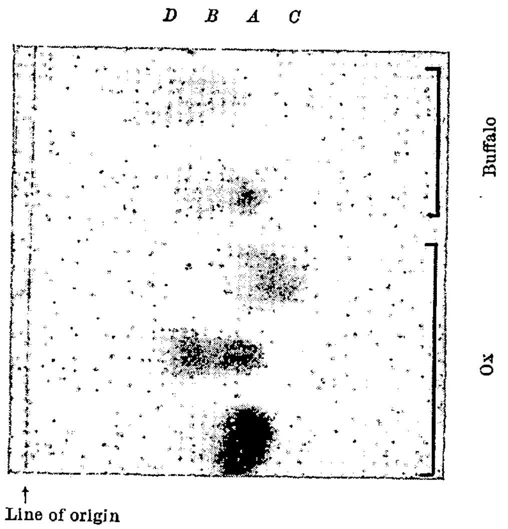

Fig. 1. Electrophoresis (Whatman 3*MM* filter paper) at *p*H 8·6 (ionic strength, 0·06), 360 V., 20 mA., 5–6 hr.

In the buffalo two components with mobilities identical with those of ox *A* and *B* were found in 27 cases (96·4 per cent), while in one case a small amount of a third component, moving more slowly than *B*, was noticed.

The one-minute alkali denaturation values[6] for the ox bloods varied between 70–90 per cent (average 75·2 per cent) and for buffalo bloods 64–90 per cent (average 79 per cent). Alkali denaturation patterns over 4 hr. were indistinguishable when ox *A*, *B*, *C*, *AB*, *AC* or buffalo bloods were used, indicating that several alkali-resistant hæmoglobins may occur in the same species.

Absorption spectra for ox *A*, *B* and *C* were determined between 2000–5000 A. They were found to be identical in all three cases.

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Some Nutritional Requirements of *Colletotrichum coffeanum* Noack

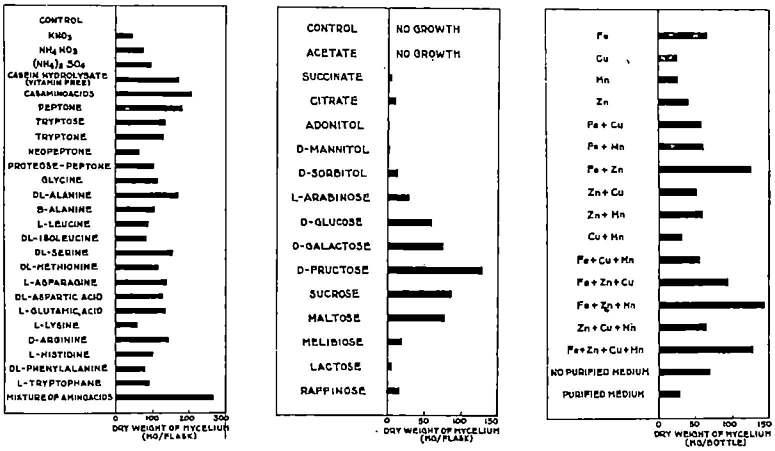
In the course of the studies on the physiology of plant pathogenic fungi causing diseases in tropical crops of Mexico, several strains of *Colletotrichum coffeanum* Noack were isolated from coffee plants (*Coffea arabica*) showing typical signs of leaf spotting and die-back. Very little is known about the nutritional requirements of this fungus, although observations concerning the taxonomy and pathogenicity have been reported from time to time[1]. However, some previous reports have made reference to various aspects of the physiological behaviour of the conidial stage of *Glomerella cingulata*[2], which is identified as *C. coffeanum*[3]. The purpose of this communication is to summarize our observations on one of the isolated strains.

A stock culture of *C. coffeanum* (*CF*–2) was maintained by serial transfers on potato–dextrose–agar slants. In all the experiments the fungus was grown in submerged culture using rotary shakers at 25° C. for 72 hr. The extent of growth was determined by weighing the previously washed and dried mycelium. Preliminary experiments revealed that the organism could grow in a wide range of *p*H values, from 2 to 9·5; 3·8 being the optimum. A basal medium was selected consisting of KH_2PO_4, 1·00 gm.; K_2HPO_4, 1·30 gm.; KCl, 0·50 gm.; $MgSO_4.7H_2O$, 0·50 gm.; $(NH_4)_2SO_4$, 2·0 gm.; distilled water, 1 litre and the *p*H adjusted to 3·8. All the chemicals were analytical grade. For the experiments on the effect of trace elements, a modified Pfeffer's solution was used containing, KH_2PO_4, 5 gm.; $MgSO_4.7H_2O$, 2·5 gm.; $(NH_4)_2SO_4$, 10 gm.; sucrose, 50 gm.; triple glass-distilled water, 1 litre. Most of the cultures were carried out in 125-ml. Erlenmeyer flasks containing 25 ml. of culture medium; however, for the experiments with trace elements it was found that 125-ml. polyethylene bottles could replace the 'Pyrex' glass flasks favourably, giving 2–5 times more efficiency in the growth response. As inoculum 2·5–3·0 millions of washed conidia obtained from submerged culture were added to each flask or bottle.

No significant stimulation was observed when the following vitamins at two concentrations (0·2 μgm. per ml. and 4·0 μgm. per ml.) were added separately to the basal medium: riboflavin, thiamine, pyridoxine, inositol, nicotinic acid, calcium pantothenate, *p*-aminobenzoic acid and folic acid. Biotin at the same concentrations gave slight stimulation. The mixtures of all vitamins did not significantly stimulate growth. These results indicated that *C. coffeanum* is self-sufficient so far as vitamins is concerned.

The utilization of different nitrogen sources was studied by adding the nitrogen compounds at a concentration of 0·5 gm. of nitrogen per litre of culture medium. The results (Fig. 1*a*) indicated that the fungus was able to assimilate nitrogen from both organic and inorganic sources. Among the inorganic sources, ammonium sulphate produced maximum growth; among the organic sources of nitrogen, DL-alanine was the best individual source, and a mixture of all the amino-acids tested supported maximum growth. Casein hydrolysates and some kind of peptones were satisfactory sources, whereas neopeptone (Difco) was a poor source of nitrogen.

Several carbon sources including carbohydrates, sugar alcohols and organic acids were added to the basal medium at a concentration corresponding to 8 gm. carbon per litre of medium. The results (Fig. 1*b*) indicated that D-fructose induced maximum growth; sucrose, maltose, D-galactose and D-glucose were fairly good carbon sources and, as a rule, sugar alcohols and organic acids did not support growth. When ammonium sulphate was replaced by DL-alanine as the nitrogen source, D-glucose appeared to be the best carbon source. The effect of trace elements was studied on a modified Pfeffer's solution purified by the Steinberg's technique[4] and dispensed in polyethylene bottles. The addition of iron and/or zinc ions at a final concentration of 0·2 μgm. per ml. favoured the growth of *C. coffeanum* strikingly (Fig. 1*c*). Combinations of iron, zinc and manganese ions gave the maximum growth response. Under the conditions of the experiments the addition of copper ions antagonized the favourable effect of iron ions.



(*a*) (*b*) (*c*)

Fig. 1. (*a*) Growth of *C. coffeanum* on a basal medium containing different nitrogen sources; (*b*) growth of *C. coffeanum* on a basal medium containing different carbon sources; (*c*) effect of trace elements on the growth of *C. coffeanum*

Detailed accounts of the experiments will be reported elsewhere.

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Nutritional Requirements of the Common Housefly, *Musca domestica vicina* Macq

The housefly *Musca domestica vicina* Macq., which has been reared in our laboratory for four years with a modified NAIDM medium[1], was used in these experiments. Eggs were collected from oviposition dishes, washed and sterilized. The most satisfactory sterilizing solution and technique were as follows. Modified Vanderzant's solution[2] was prepared, with the omission of sodium glycocholate and less mercuric chloride (0·15 gm. instead of 0·25 gm.). Instead of a single treatment, the eggs were submerged in the solution twice, each for 10 min., with an interval of 1 hr. between the two treatments. After each treatment, the eggs were rinsed with bacteriologically sterile water. Plating on common bacteriological medium revealed that the percentage of contamination was less than 10 per cent and the percentage of eggs hatched was more than 50 per cent[3].

The sterilized eggs were transferred to cotton-stoppered vials with sterile media, one egg to each vial. Observations on the growth and development of the larvæ were made at frequent intervals and growth-rates recorded. Vials contaminated with micro-organisms were discarded.

The composition of the medium was based on the medium for *Hylemyia antiqua*[4] and *Calliphora erythrocephala*[5], since it is reasonable to assume that the nutritional requirements of these flies might be similar. The ingredients of the medium per ml. were as follows:

Agar	20·0 mgm.
Ribonucleic acid	1·0 ,,
Cholesterol	0·1 ,,
Dextrose	15·0 ,,
Mineral mixture (U.S.P. XIII, No. 2)	2·0 ,,
Casein	11·0 ,,
Vitamin mixture (per 100 ml.)	
Vitamin A	5,000 U.S.P. units
Rachitosterol D	1,000 ,, ,,
Thiamine	2·0 mgm.
Riboflavin	2·5 ,,
Ascorbic acid	30·0 ,,
Niacin amide	20·0 ,,
Pyridoxine hydrochloride	0·2 ,,
Calcium pantothenate	1·0 ,,

Solutions of casein and ribonucleic acid were prepared separately by dissolving in distilled water, the former with 2 *N* sodium hydroxide. The mineral mixture was dissolved in hot distilled water. These solutions were mixed and agar added. When agar was dissolved by heating, the whole mixture was autoclaved at 15 lb. for two minutes. Cholesterol was first dissolved in 95 per cent ethyl alcohol, and emulsified with 5 per cent gum arabic solution. This emulsion, together with dextrose solution and vitamin mixture, were then added. The final mixture was adjusted to *p*H 6·4 with 2 *N* sodium hydroxide. 2 ml. of this mixture was put in each food vial, a cotton stopper was used, and the vials were again sterilized at 15 lb. for 15 min.

Larvæ developed normally in the basic medium except that the larval period was somewhat prolonged and the pupal weight decreased (Table 1). This was probably due to the deficiency of glycine and cystine in casein. Further retardation of growth-rates resulted when ribonucleic acid or vitamins A, C and D were omitted. Non-sterile eggs on the same basic medium showed no advantages, suggesting that bacteria or other micro-organisms were not necessary symbionts for the housefly larvæ, at least when all other nutritional requirements were fulfilled.

Table 1. Growth-Rates and Pupal Weight of Houseflies reared on Basic Medium and Modified Medium

Medium	Larval period			Pupal period (days)	Pupal weight (mgm.)
	First instar (days)	Second instar (days)	Third instar (days)		
Basic medium	1	1	3–6*	3–5	12–15
Basic medium less ribonucleic acid	3	3	3–4	4	11–15
Basic medium less vitamins A, C and D	1–3	1–2	3–5	3–8	12–15
Basic medium non-sterile eggs	1–2	1	5–11	3–4	11–13
Casein hydrochloride hydrolysate	1–3	3–5	—	—	
Casein pancreatin hydrolysate	1–2	2–4	2–4	6	11–12
Ten amino-acids	3–6	3	7	4	11
Modified NAIDM	1	1	3–4	3	15–18

* One larva had an extremely long third instar of 10 days.

Preliminary experiments on the amino-acid requirements of the housefly larvæ had been studied by using different hydrolysates of casein. The casein hydrochloride hydrolysate failed to support growth due to the lack of tryptophan, while pancreatin hydrolysate of casein (tryptophan not destroyed during hydrolysis) will support normal growth. Preliminary studies by varying the contents of amino-acid mixture to substitute for casein had also revealed that the essential amino-acids were probably the same for other dipterous insects such as *Drosophila melanogaster*[6] and *Pseudosarcophaga affinis*[7]. They are arginine, lysine, leucine, *iso*leucine, tryptophan, histidine, phenylalanine, methionine, valine and threonine; but the rate of growth with only these ten acids was very much retarded. Further studies are now in progress.

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Occurrence and Filterability of Protoplast-like Elements in Aged Bacterial Cultures

Cellular or subcellular units of certain bacteria that have been deprived of a rigid cell wall have been regarded in the recent literature as protoplasts. The conversion of rods into spherical protoplasts was observed mostly in media containing penicillin and magnesium ions plus sucrose as stabilizers[1], although Jeynes[2] has reported their natural occurrence.

The present communication describes the spontaneous occurrence of units in aged *Escherichia coli* cultures[3] which conform to the description of artificially induced bacterial protoplasts.

The *E. coli* strain used was isolated from human urine in 1952 and originally showed a certain degree of spontaneous polymorphism. Cultures were aged in horse-meat broth kept at 37° C. or at room temperature for several months in paraffin-sealed flasks. In electron-microscope preparations of samples from aged cultures the complete disintegration of some bacterial cells into naked plasmatic material containing electron-dense spots was readily observed. The disintegration was preceded by swelling of the cell and rupture of the rigid cell wall. Collodion membrane filtrates of the supernatant fluid (obtained after centrifugation at 2,000 r.p.m., 15 min.) of aged cultures contained units capable of regeneration when placed in fresh medium. The size of the smallest units so far found to regenerate has been estimated as approximately 350 mμ in diameter. Certain details of the regeneration were studied by light- and electron-microscopy. An initial fusion or coalescence followed by cell wall formation was noted. The individual protoplastic units were never observed to undergo division prior to fusion. The addition of washed *Sarcina lutea* cells to the filtrate appeared to stimulate the regeneration of the subcellular units. Microscopic observations and centrifugation experiments (Table 1) showed that this enhancement involved the adsorption of the protoplastic particles to the surface of the *Sarcina* cells.

Table 1. RATIO OF THE NUMBER OF CULTURES SHOWING GROWTH OF *E. coli* CELLS TO THE NUMBER OF TUBES INOCULATED WITH VARIOUSLY TREATED FILTRATES FROM AGED CULTURES

Samples	Experiment No. 1	2
Filtrate (*a*)	7/33	5/35
Sediment (*b*)	2/30	0/35
Sediment (*c*)	16/35	19/38

(*a*) Aged broth culture was filtered through a membrane with an average pore diameter of 600 mμ; the filtrate was adjusted to *p*H 5·8.

(*b*) The filtrate (*p*H 5·8) was centrifuged at 1,000 r.p.m. for 20 min., the sediment was resuspended in the original volume of fresh broth.

(*c*) Filtrate (*a*) (*p*H 5·8) was centrifuged at 2,000 r.p.m. for 20 min., following the addition of approximately 10^6 *Sarcina lutea* cells per ml.; the sediment was resuspended in the original volume of fresh broth.

0·2 ml. amounts of all the samples were distributed in broth tubes and incubated.

These results support the assumption that aged *E. coli* cultures can survive in the form of sub-units having no cell walls which, under adequate conditions, can regenerate into the vegetative form. Recent observations on ribonucleic and deoxyribonucleic acids as well as protein synthesis in protoplasts or in their subcellular fractions[4,5] give credence to the conception that they may retain the potential for reversion into the bacillary form. However, in relation to the number of protoplastic structures seen in the electron microscopic fields, the efficiency of regeneration obtainable so far must be considered as poor, even in samples filtered through membranes with large pore diameters.

The morphological resemblance of the *L* forms of *Proteus* to the protoplasts was recently pointed out by Pease[6]. The stimulatory effect of *Sarcina* or other bacterial cells on the growth of both protoplasts and pleuropneumonia organisms[7] suggests the existence of similar metabolic pathways.

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Sexual Behaviour and the Vaginal Cycle in the Cat

DIFFICULTIES have been encountered in studying the neural and endocrine mechanisms which underly the control of sexual behaviour in the mammal for two main reasons. First, conspicuous and easily observable patterns of stereotyped behaviour, which are uninfluenced both by learning processes and the conditioning effects of the experimental situation itself, are rather few among laboratory mammals. Innate reflex patterns of behaviour similar to those successfully utilized by ethologists in lower animals, that are stable and difficult to disturb, occur quite infrequently in higher forms. The sexual behaviour of the female cat is a conspicuous exception to this. Though Marshall has emphasized the virtual impossibility of determining the state of the sexual cycle in many species by external signs alone, the present study shows this is not the case in the cat. The second source of difficulty arises from the observation that some of the components of the total pattern of sexual behaviour may not be dependent upon the secretory activity of the gonads; this is most evident in the male, but is also quite apparent in the female of several mammalian forms. The female chimpanzee may accept the male at any time in her cycle (Yerkes and Elder[1]); similar behaviour has been observed in the female rat (Boling *et al.*[2]); and acceptance by both diœstrous and ovariectomized rabbits is well established[3,4]. Sexual receptivity and the associated postural responses cannot be regarded as depending solely upon ovarian hormones in these species. This makes for difficulties in the interpretation of behavioural changes which appear to follow hormone administration. However, earlier studies by Bard[5] have indicated that the full pattern of sexual behaviour of the female cat may be strictly dependent on hormones.

Patterns of sexual behaviour shown by thirty reproductively active female cats were studied for two years. Specially trained males were used for conducting timed mating tests under standard environmental conditions. These tests are best carried out in an observation pen of suitable design where the male is allowed to establish territory rights. After an initial training period, a suitable male will mount and attempt copulation with any female that is presented. The normal sexual displays of mature, cycling females running with the male under free colony conditions were compared with the patterns of response obtained during these formally conducted mating tests, enabling an assessment to be made of the effect of the test situation upon behaviour throughout the cycle. The responses to artificial sexual stimulation and vaginal probing were also investigated.

Table 1

		Behaviour				
		An-œstrus	Pro-œstrus	Œstrus	Met-œstrus	
Smear	An-œstrus	72·13 131 68·87	−12·41 8 20·41	−37·10 2 39·10	−12·60 1 13·60	142
	Pro-œstrus	−14·92 20 34·92	24·65 35 10·35	−2·83 17 19·83	−6·90 0 6·90	72
	Œstrus	−37·26 3 40·26	−6·93 5 11·93	49·14 72 22·86	−4·95 3 7·95	83
	Met-œstrus	−9·95 8 17·95	−5·32 0 5·32	−9·19 1 10·19	24·46 28 3·54	37
		162	48	92	32	334

Table 2

$O - E$ O E

$$\frac{(O-E)^2}{E} = \begin{array}{r}75\cdot544\\6\cdot375\\34\cdot484\\5\cdot515\\7\cdot546\\58\cdot707\\4\cdot026\\5\cdot320\end{array} \qquad \frac{(O-E)^2}{E} = \begin{array}{r}35\cdot202\\0\cdot404\\105\cdot632\\8\cdot288\\11\cdot674\\6\cdot900\\3\cdot082\\169\cdot009\end{array}$$

$$\chi^2 = 537\cdot707$$

$$n = (4-1)(4-1) = 9$$

From Fisher and Yates $\chi^2 = 27\cdot877$ for $P = 0\cdot001$.

It has been found that the behaviour patterns of individual animals are remarkably constant and that a well-defined behaviour cycle exists in this species. The behavioural characteristics specific to each of the four stages of the cycle, the anœstrous, the pro-œstrous, œstrous and metœstrous responses, will be enumerated in detail elsewhere. They were determined by combining the data on the responses of females to both artificial stimulation and the coital activity of the male during nine hundred mating tests. With the behavioural criteria established, an investigation was made of the relationship between behaviour and the cytology of the vaginal smear. 340 mating tests were conducted with 15 mature females and a corresponding number of vaginal smears collected. The description of the vaginal cycle given by Scott and Lloyd Jacob[6] was used, and the smears were examined without prior knowledge of the behavioural state of the animals from which they were obtained.

Correlating these data by means of a contingency table (Tables 1 and 2) reveals a highly significant association ($P < 0\cdot001$) between the behavioural patterns and the appearances of the vaginal smear at every stage of the cycle. The characteristic pattern of œstrous behaviour and the associated state of sexual receptivity, though commonly first appearing when the smear is pro-œstrous, continues throughout the period of full vaginal œstrous. The appearance of the metœstrous leucocytic infiltration in the smear closely coincides with the development of the metœstrous refusal pattern. Of the 142 observations on behaviour where the smear was anœstrous only once did mating occur, and in this particular animal the smear had cornified 24 hr. later. It can be concluded that mating behaviour with an anœstrous vaginal smear is a very unusual occurrence in this form, and further, that mating behaviour is almost invariably associated with either a pro-œstrous or œstrous smear. It was repeatedly observed that unless the specific œstrous posture is adopted, mating cannot take place no matter how energetic the copulatory efforts of the male. Only behaviourally œstrous animals can be mated; falsely positive mating tests due to 'rape' by the male do not occur in this species. Approximately 300 mating tests were conducted with 8 spayed females for periods of up to six months after operation during which time no vestige of œstrous behaviour was seen. Mating never occurred in this group even in those animals spayed at the height of œstrus and tested upon recovery from the anæsthetic 24 hr. later.

The highly conspicuous stereotyped mating response of the cat provides a sharp behavioural end-point for quantitative study and places it, in this respect, in a special position among laboratory mammals. The complete dependence of œstrous behaviour upon the presence of the ovaries has been confirmed beyond doubt. The relationship established between behavioural patterns and the state of the vaginal smear, together with the technique for conducting reliable mating tests, considerably facilitates the further study of sexual behaviour in this form.

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Diseases of the Intervertebral Disk of the Cat

ALTHOUGH the domestic cat is known to suffer occasionally from spondylitic lesions of the vertebræ[1,2] it is not supposed to be susceptible to diseases of the intervertebral disks themselves[3]. If any species of mammal can be shown to be free, or relatively free, from diseases of the disk it should be profitable to compare the functional anatomy of its vertebral column with that of mammals known to be susceptible. This might uncover anatomical factors influencing diseases of the disk in general, or protrusion of the disk (herniation of the nucleus pulposus) in particular. This line of reasoning has in fact already been attempted on the basis that the dog and man are much more susceptible than the cat[3,4].

In 100 adult cats we have found dorsal (posterior) protrusions in 26, a total of 91 disks being affected. Two types could be distinguished: in one the protruded mass perforated the annulus fibrosus, and in the other it caused a bulge without passing right through the annulus. The distribution of protrusions along the vertebral column is summarized in the histogram in Fig. 1.

In 50 of the cats, we investigated the incidence of macroscopic degenerations other than dorsal protrusions. Ventral (anterior) protrusions were found in eight cats, and a lateral protrusion was found in one. Calcification was seen in three cats and 'brown degeneration' in 15. General disorganization of the disk, sometimes attaining almost complete destruction, was much the commonest form of degeneration, for it was found in 27 cats and involved 178 disks; the distribution along the vertebral column of this general degeneration is summarized by the graph in Fig. 1.

These findings show that the cat is by no means indifferent to diseases of the intervertebral disk. If our survey of the incidence of dorsal protrusions in the cat is compared with the two main corresponding surveys in the dog[3,5] it appears that the cat is in fact nearly as susceptible as the dog. Unfortunately this nullifies the attempt, referred to above, to detect anatomical factors behind protrusion of the disk. However, it is a consolation that it helps previous efforts[3], hitherto based only on the dog, to dispose of the idea[6] that man's susceptibility to disk protrusion is simply due to his upright posture.

Analysis of the distribution along the vertebral column of dorsal protrusions and of other degenerations has been employed as another way of detecting anatomical factors. Taken as a whole, the first nine thoracic disks (*T*1–2 to *T*9–10 inclusive) are relatively immune to dorsal protrusion in the cat (and in the dog), even though general degeneration is particularly common. The conventional explanation for this in the dog is that the conjugal ligaments (which cross over each of these nine disks, in order to join the heads of nine pairs of ribs) support the disks dorsally and so prevent protrusion[3,5]. However, this is unlikely to be the whole answer. In the cat the first conjugal ligament is usually of negligible thickness, and therefore could scarcely be the sole reason for the rarity of protrusions from the disk which it covers (*T*1–2). A similar objection applies for the dog[7].

In the dog the highest incidence of both dorsal protrusions and general degeneration occurs in the last thoracic disks, between *T*10–11 and *T*13–*L*1 [3]. This region includes the point of maximum normal kyphosis and the supposed site of maximum mobility of the trunk; consequently curvature and mobility seem to have been suspected as possible factors controlling disk disease in this quadruped[3]. The point of maximum normal kyphosis and the supposed site of maximum mobility[8] in the trunk are much the same in the cat as in the dog. Yet in the cat the incidence of dorsal protrusion and general degeneration is low in this region. This seems to show that curvature and mobility may not be so important after all. However, there are reasons why this argument may be altogether too facile. First, although kyphosis may look similar in the dog and cat, the anatomical reasons for it may be different. At least two independent features can produce it, wedge-shaped disks and wedge-shaped vertebræ; these have not yet been assessed in mammals other than man. Secondly, mobility seems to have been inadequately studied[9]. When these and other fundamental data are available about the functional anatomy of the vertebral column of various mammals, analysis of the distribution of lesions of their disks may be a useful approach to the underlying causes of diseases of the intervertebral disk and especially of dorsal protrusion.

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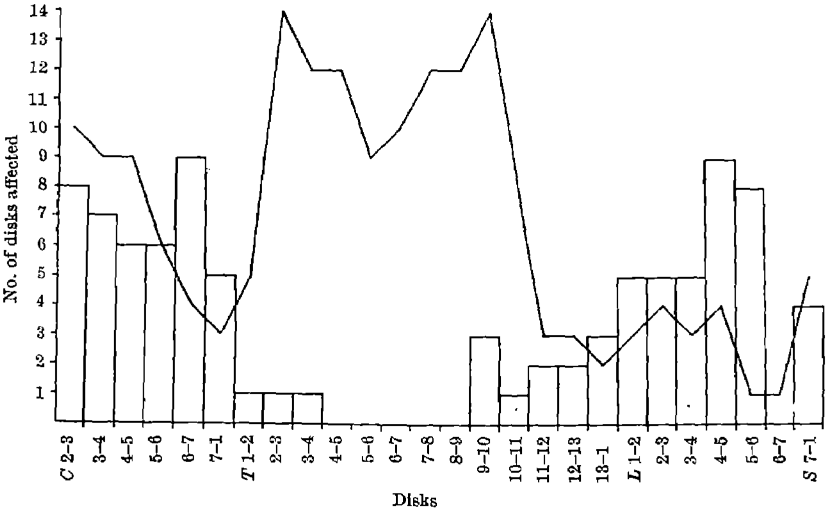

Fig. 1. Distribution of dorsal protrusions (histogram) and general degenerations (graph) of the intervertebral disks in the vertebral column

Sudanophil Inclusions in Ameloblasts, Odontoblasts and Cells of the Oral Epithelium

During studies of the lipid inclusions in cells of teeth and of the oral cavity of the rat, Baker's sudan black *B* method[1] was employed. The oral soft tissues were fixed in formalin–calcium solution, postchromed, embedded in gelatin, and cut on the freezing microtome. The enamel organ and pulp were dissected from the upper incisor tooth and similarly treated. Equally good results could be obtained from teeth if the entire tissue was decalcified with ethylenediamine tetraacetic acid (0·5 *M*) at *p*H 7·4, or with 10 per cent acetic acid, after fixation and before post-chroming. Beams and King[2] had investigated the Golgi bodies of dental tissues using Nassanow's method[3], and so this procedure was also used. Pyridine extraction of the tissues using Baker's method[4] was made in some cases. The results of the two methods agreed well on oral mucosa and that of the tongue.

Ameloblasts. Beams and King[2], using the Nassanow technique, described the changes in orientation of the osmic acid staining material in ameloblasts as these cells approached maturity and functional activity. These results were confirmed by me using Nassanow's technique. But with the sudan black stain, deep blue or black granules were seen in the undifferentiated ameloblasts, scattered throughout the cytoplasm in an almost haphazard way. In the tall functional ameloblasts, the granules tended to be more on the enamel side of the nuclei (Fig. 1), but were still scattered throughout the cell. The cytoplasm on the enamel side of the nucleus took up more sudan black than that elsewhere. These granules were completely removed by pyridine if extraction was made before postchroming, but were little affected if extracted after postchroming. In contrast, the lipid granules of the oral mucosa were completely removed by pyridine whether extraction preceded or followed postchroming. Pyridine extraction likewise removed all osmiophil granules from ameloblasts and oral epithelium cells.

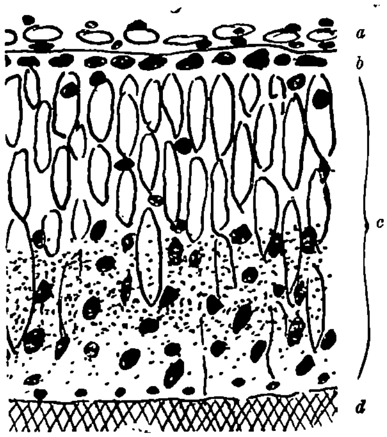

Fig. 1. Tall ameloblasts of the rat's upper incisor tooth stained by Baker's sudan black method. The sudanophil granules are black and the stippled area also stained with sudan black. × approx. 1,200.
a, Stratum intermedium; *b*, row of basal granules; *c*, tall ameloblasts; *d*, enamel

Basal granules. These are found only in the tall ameloblasts, at the stratum intermedium end of the cell. Beams and King[2] found them strongly osmiophilic, which I have confirmed. They also stained intensely with sudan black, with or without preliminary postchroming, and their staining was not affected by pyridine extraction. They thus seem to be chemically different from the lipid granules in the ameloblasts; but their nature is not known.

Odontoblasts. Unlike the osmiophil granules described by Beams and King[2], the sudanophil granules were distributed at random throughout the cytoplasm. These granules were removed by pyridine if extraction was done before postchroming, but were not soluble after postchroming.

Baker[5] has recently given a summary of the Golgi controversy, from which it would appear that inclusions in any cell, staining with osmic acid or silver, in a manner similar to that originally described by Golgi for nerve cells, have often unreservedly been called Golgi bodies or apparatus. It seems clear from the above results that sudan black stains more structures in the tooth cells than does osmic acid, and also that the properties of these inclusions differ in some respects from those of the oral epithelium. It is therefore unwise to append the name Golgi to them at all; in fact, Baker[5] has suggested that the name 'Golgi apparatus' should be abandoned.

Note added in proof. Since this communication was written, Symons[6] has reported findings with sudan black similar to those described above.

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Effects of *Simulium* Control on Insectivorous Fishes

EXTENSIVE evidence from North America shows that DDT, at concentrations lethal to *Simulium* larvæ, need have no direct, harmful effect on fishes[1]. However, it may severely affect other aquatic insects[2-4], notably Ephemeroptera and Trichoptera[2,4,5], which are known to be important as food for many insectivorous fishes. It follows that the feeding habits of some fishes are likely to be modified considerably by insecticidal treatment, yet apparently this aspect of control has only once[5] received attention in the past. In view of the *Simulium* control measures envisaged in Africa, it is considered desirable to record some effects of DDT on the feeding habits of fishes in Uganda.

During March 2–May 4, 1956, the Victoria Nile at the Owen Falls, Jinja, was treated with DDT in order to eliminate larvæ of *Simulium damnosum* (Theobald) between Jinja and Mbulamuti. This dosing has been described elsewhere[6]. On several occasions before and during the treatment the sluice gates in the Owen Falls Dam were closed temporarily, resulting in marginal exposure of the river bed. Advantage was taken of this opportunity to sample the fauna and thus to assess the effects of the treatment.

In the Victoria Nile the DDT affected the invertebrate fauna differentially: some groups seemed unaffected, whereas almost all species of Ephemeroptera and Trichoptera were eliminated. Certain species of insectivorous fishes were collected before and after March 2 from points 100–500 m. below the dosing point, and their stomachs examined for food. These fishes adapted themselves to the changed conditions with varying success.

Clariallabes petricola Greenwood (Clariidae) proved the most adaptable. Before March 2, 83 per cent of fishes contained lithophilic Ephemeroptera larvæ. When deprived of these, *C. petricola* exploited a wide range of plant and animal food: on various post-treatment occasions it fed extensively on chironomid and tipulid larvæ, on Copepoda and on fresh plant material. After recolonization of Ephemeroptera and Trichoptera had begun in mid-June, it returned to its original diet.

Gnathonemus longibarbis Hilgendorf and *Mormyrus kannume* Forskal (Mormyridae) had previously obtained their food from two sources: stones of the river bed and marginal grass swamp. When the lithophilic insect fauna became reduced, these fishes fed to a greater extent on the swamp insects, the position of which had protected them from the effects of DDT. *G. longibarbis* proved better able to adapt itself in this way than *M. kannume*.

The most specialized feeding habits were encountered in *Mastacembelus victoriae* Boulenger (Mastacembelidae), of which 92 per cent had been feeding on lithophilic Ephemeroptera larvæ before March 2. For at least five weeks after the dosing, specimens were very scarce, and only 50 per cent (as against 94 per cent previously) of the fishes collected had food in the gut. Then the commonest items of food were small fishes and Hirudinea, which had seldom featured in earlier gut samples. It appears that *M. victoriae* either moved away from the area, or else was obliged to suffer starvation. Like *C. petricola* it gradually resumed its original feeding habits when repopulation of the lithophilic insects took place.

These observations provide an indication of responses to DDT to be expected in certain insectivorous fishes. In the present instance, effects of treatment were greatly mitigated by the rapid recolonization of the main food items, which occurred from unaffected breeding populations upstream from the dosing point. This mode of relief, however, must be regarded as exceptional, since most *Simulium* control in Africa is planned for highland streams where repopulation is unlikely to take place rapidly enough to be effective. Since many fishes in such habitats rely mainly on lithophilic insects for food, *Simulium* control there may cause the extinction of many little-known or undiscovered animals. It is felt, therefore, that a strong case exists for making collections and hydrobiological surveys before extensive control measures are put into force.

The work described here is to be published in full elsewhere.

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Photosensitization of Bacteria by Furocoumarins and Related Compounds

IT has been known for many years that exposure to the simultaneous presence of various dyes and visible light results in the death of bacterial cells. This effect has been found to vary with different organisms, but in general, Gram-positive bacteria appear to be more sensitive[1,2]. Recently, Stainer and Cohen-Bazire[3], and Dworkin and Stanier[4] have reported that a mutant of *Rhodopseudomonas spheroides* devoid of carotenoid is killed on exposure to visible light, due to the photosensitizing action of endogenous chlorophyll. Photosensitization of human skin by topical application of another group of compounds, the furocoumarins, has been shown by Musajo *et al.*[5] to result in erythema, œdema, and vesicle formation on irradiation with long wave-length ultra-violet light. Fitzpatrick *et al.*[6] have demonstrated the same responses, as well as increased pigmentation, upon ingestion of the furocoumarin 8-methoxypsoralen. Photosensitization of bacteria by psoralen and related compounds is described in this communication.

The compounds were tested for activity by a paper-disk diffusion method on agar plates. The nutrient agar medium contained 0·3 per cent beef extract, 0·5 per cent peptone, 0·1 per cent yeast extract, 0·1 per cent dextrose, 0·05 per cent dipotassium hydrogen phosphate and 1·5 per cent agar. Whatman No. 2 filter paper disks, 6·1 mm. in diameter, were impregnated with 100 μgm. of the test compound. Six disks impregnated with different compounds were arranged uniformly on a freshly solidified 12-ml. agar layer in a 10-cm. Petri dish, with a dish impregnated with psoralen in the centre. A 6-ml. agar layer seeded with 0·02 ml. of an overnight broth culture of the test bacteria was carefully poured over the disks. After solidification of the second layer, the plates were incubated in the dark at 37° for 3 hr. before irradiation, to allow for diffusion of the test compound through the agar. Duplicate plates were left in the incubator to determine antibacterial activity. The test preparations, with the Petri dish covers removed, were irradiated 15 cm. from the pressed glass Wood's filter of a Model 70 Glo-Craft lamp (Switzer Bros., Inc., Cleveland, Ohio). The principal output of this lamp is the 3654-A. band of the mercury high pressure arc spectrum. After irradiation, the plates were reincubated in the dark at 37° overnight.

Single strains of *Bacillus subtilis*, *Escherichia coli*, *Proteus vulgaris*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Streptococcus faecalis* were tested against each compound at irradiation times of 20 and 40 min. Activity of the compounds was determined by measuring the diameter of bacteria-free zones surrounding the impregnated disks; the minimum measurable zone of inhibition was 6·1 mm., the diameter of the disk. The irradiation procedure itself had no effect on bacterial growth. Table 1 presents the results of 20-min. irradiation of those compounds found to be active. Irradiation for 40 min. resulted in only slightly larger zones. As noted in Table 1, partial, rather than complete, inhibition was observed with four compounds against some organ-

Table 1. INHIBITION PRODUCED BY ULTRA-VIOLET IRRADIATION IN THE PRESENCE OF FUROCOUMARINS AND RELATED COMPOUNDS

Compound	Inhibition zone (mm.)					
	Gram-positive			Gram-negative		
	B. subtilis	*S. aureus*	*S. faecalis*	*E. coli*	*P. vulgaris*	*P. aeruginosa*
Psoralen	19	21	20	17	25	9
5'Methyl-psoralen	19	21	19	10	17	0
5',8-Dimethyl-psoralen	20	21	22	0	14	0
4,5',8-Tri-methyl-psoralen	21	23	18	0	10	0
5-Methoxy-psoralen	16	18	18	0	10	0
8-Methoxy-psoralen	19	20	20	12*	15	0
5,8-Dimeth-oxypsoralen	12	11*	10*	0	0	0
Psoralen quinone	16	20	12	8*	0	0
4,5'Dimethyl-angelicin	15	14	11	0	0	0
5-Methoxy-angelicin	8	9	0	0	0	0
Thiocoumarin	12	12	9	9	10	0
Visnagin	16	17	12	0	0	0
Khellin	14	12*	11*	0	0	0

* Partial inhibition.

isms. In these cases the zone boundaries were not distinct. On non-irradiated plates there were a few instances where anti-bacterial activity of the compounds shown in Table 1 was observed. The zone diameters of inhibition on such plates were as follows: psoralen with *B. subtilis*, 7 mm.; 8-methoxypsoralen with *B. subtilis*, 9 mm.; psoralen quinone with *B. subtilis*, 12 mm.; with *S. aureus*, 11 mm., with *S. faecalis* and *E. coli*, 7 mm.; thiocoumarin with *S. aureus*, 8 mm. Photosensitization was demonstrated by the appearance of much larger zones of inhibition on the irradiated plates, and this effect compared with that of 16 hr. or more dark contact with the diffusing compound, leaves no doubt about the role of light in the phenomenon. Indeed, most of the furocoumarins and related compounds showed activity only on the irradiated plates. As with dyes and visible light, Gram-positive organisms are more susceptible to photosensitization by these compounds.

The following furocoumarin derivatives were found to be inactive: 8-hydroxypsoralen, 5-geranyloxypsoralen, 2-thio-8-methoxypsoralen, 5-amino-8-methoxypsoralen, 5-nitro-8-methoxypsoralen, and 3,4-dihydro-8-methoxypsoralen. Of the furochromones, khellin and visnagin were active, but chellolglycoside and visamminol were not. The pyranocoumarins samidin, dihydrosamidin, and visnadin were also inactive. 3-Hydroxyflavone and six naturally occurring flavanoids gave no photosensitization; conversely, anti-bacterial activity on the unirradiated controls of three of the compounds was lost on irradiation. Other related compounds showing no activity were *o*-hydroxycinnamic acid, caffeic acid, cinnamic acid, 2-acetobenzofuran, phloridzin, 4-(*p*-methoxyphenyl)-3-buten-2-one, and twenty-two variously substituted coumarins. Coumarin was inactive at the usual 100 μgm. per disk; but very slight photosensitization did appear at 200 μgm. per disk. Eosin and methylene blue were inactive when tested in this system.

Eight of the thirteen active compounds reported here are found in various plant species. All the active compounds are weakly fluorescent except for psoralen quinone and thiocoumarin. However, since many of the inactive compounds are also fluorescent, this characteristic cannot *per se* confer photosensitization activity. Estimation of the relative activity of the various compounds would be hazardous, since the comparative rates of diffusion are unknown. However, their similar molecular weights and solubilities should result in similar diffusion rates.

The simultaneous presence of bacteria and compound is required for the effect since pre-irradiation of disks impregnated with 8-methoxypsoralen either alone or on the base agar layer resulted in no activity against *S. aureus* or *P. vulgaris*, no matter whether the seed layer was added immediately following irradiation or after three hours incubation. Irradiation of mixtures of 8-methoxypsoralen and bacteria in saline, followed by conventional plating techniques for surviving organisms, clearly shows that this photosensitization is bactericidal. Investigations are in progress on the kinetics of the lethal action and the effect of environmental factors.

We are indebted for some of the compounds used in this study to Dr. B. E. Christensen, Oregon State College, Corvallis, Ore.; Paul B. Elder Co., Bryan, Ohio; Givaudin-Delawanna Inc., New York; S. B. Pennick Co., New York; Sandoz Ltd., Basel, Switzerland; Sunkist Growers, Corona, Calif.; Trubek Laboratories, E. Rutherford, N.J.; U.S.D.A. Fruit and Vegetable Research Laboratories, Pasadena, Calif.; and Van Ameringen Haebler Inc., New York.

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Cell Wall Composition in Bacterial and *L* Forms of *Proteus vulgaris*

α-ε-Diaminopimelic acid is known as an important constituent of the 'basic structure' of the bacterial cell wall[1-3]. As *L* forms seem to have a much less rigid cell wall than bacteria, the assumption that the *L* forms lack a normal wall became a main issue[4,5]. It was suggested that penicillin blocks some of the steps necessary for the condensation of the definitive wall. Recently, Weidel[6] has concluded from his experiments on phage enzyme that the main site of action of penicillin is the 'basic structure', consisting of α-ε-diaminopimelic acid, glutamic acid, alanine, glucosamine and muramic acid. Accordingly, this fraction should be missing in the *L* forms.

Comparative studies of the amino-acid composition of the bacterial form and the unstable and stable *L* form of *Proteus vulgaris* have shown[7] that the unstable form still contains α-ε-diaminopimelic acid, whereas it is absent in the stable form. In recent studies, Weibull found small amounts of α-ε-diaminopimelic acid also in a stable *L* form strain[8].

Attempts were made to isolate the 'basic structure' from the *L* form of *Proteus vulgaris*. The material and culture methods used were the same as those described earlier[9,10]. Most of the experiments were carried out on a stable (*A* strain) form cultivated on penicillin-free media for more than 200 passages without any sign of reversion to the bacterial form, and on an unstable (*B* strain) form, which had been transferred about 100 times on penicillin-containing media, without losing the ability to form normal rods when penicillin was omitted.

To isolate the wall material a recently described[11] simple method was applied. Bacterial or *L* forms were cultivated in a liquid medium and harvested by centrifuging for 20 min. at 15,000*g*. After washing the organisms twice in a 2 per cent sodium chloride solution they were suspended in 1 *N* sodium hydroxide and heated at 60° C. for 60 min. After diluting the sodium hydroxide to 0·5 *N* the undissolved material was centrifuged for 30 min. at 25,000*g* and the resulting gelatinous sediment was suspended again in 1 *N* sodium hydroxide. After heating at 60° C. for another hour the sediment was kept at 37° C. for 12 hr., then centrifuged again, washed with

Table 1. AMINO-ACID CONTENT OF HYDROLYSATES FROM THE BACTERIAL AND UNSTABLE *L* FORM OF *Proteus vulgaris*, EXPRESSED IN MOL. (α-ε-DIAMINOPIMELIC A ID (DAP) REFERRED TO AS 1) OR IN PER CENT OF ALL THE COMPOUNDS MENTIONED IN THE TABLE

	Mol.			Total (per cent)		
	Bacterial form		*L* form	Bacterial form		*L* form
	Whole cells	Wall fraction	Wall fraction	Whole cells	Wall fraction	Wall fraction
DAP	1·0	1·0	1·0	0·63	8·0	18·2
Glutamic acid	26·0	1·8	1·1	16·3	14·5	20·0
Alanine	23·0	3·3	2·0	14·5	25·5	36·0
Glucosamine	2·2	0·3	0·35	1·35	2·4	6·9
Muramic acid	?	0·2	0·2	?	1·6	3·4
Glycine	9·3	1·0	0·16	5·8	8·0	2·9
Serine	11·7	0·8	0·12	7·3	6·4	2·2
Lysine	20·0	1·2	0·16	12·6	9·7	2·9
Valine	17·2	0·70	0·05	10·2	5·6	0·9
Leucine	27·0	1·3	0·12	17·0	10·5	2·2
Aspartic acid	21·7	0·8	0·20	13·6	6·4	3·6

1 *N* sodium hydroxide and then three times with distilled water. Then the sediment was suspended in 6 *N* hydrochloric acid and boiled under reflux for 36 hr. The hydrolysate was tested for its amino-acid content by two-dimensional paper chromatography using two solvent systems—*iso*propanol (70), acetic acid (10), water (20); and picolin (78), ammonia (2), water (20) or picolin-solvent and water-saturated phenol. For the qualitative determination of α-ε-diaminopimelic acid the method of Ruhland *et al.*[12] was used.

The quantitative determination of the amino-acids was carried out according to Barrollier[13]. As shown in Table 1, α-ε-diaminopimelic acid predominates strongly in the wall fraction. Threonine, tyrosine, methionine, histidine, phenylalanine, proline and cystine (cysteine) are scarcely detectable in the wall fraction and are therefore not mentioned in Table 1. The composition of this cell wall fraction is probably very similar to the fraction, which Weidel[6] was able to split off *E. coli* using the phage enzyme. According to the density of the spots in his Fig. 2, there are also considerable amounts of lysine, glycine and valine (leucine is not shown) besides the main components (α-ε-diaminopimelic acid, glutamic acid and alanine).

When treating the stable *L* form (*A* strain) in the same way, the alkaline solution becomes entirely clear, and nothing can be centrifuged down. Sometimes very little of a white sediment could be obtained, but the hydrolysate showed a very complex composition without a trace of α-ε-diaminopimelic acid.

On the other hand, when unstable *L* forms (*B* strains) were used there was a slimy sediment as in the bacterial form. The hydrolysate showed a very pronounced pattern on the chromatogram, much more like the 'basic structure' of the cell wall of Gram-positive bacteria than that of the bacterial form. More than 80 per cent of the ninhydrin-positive substances are main components of the 'basic structure'.

Table 2. α-ε-DIAMINOPIMELIC ACID (DAP) CONTENT OF THE HYDROLYSATE FROM WHOLE CELLS OF THE BACTERIAL AND *L* FORM OF *Proteus vulgaris*; PERCENTAGE CALCULATED ON A MOLAR BASIS

	Bacterial form			*L* form		
	Total nitrogen (μmol.)	DAP (μmol.)	DAP (per (cent)	Total nitrogen (μmol.)	DAP (μmol.)	DAP (per (cent)
log, phase	357	0·31	0·085	470	0·82	0·17
Stat. phase	350	0·39	0·113	380	1·47	0·38

Further investigations will be made to find out if the high percentage of glycine, serine, valine and other 'impurities' in the wall fraction from the bacterial form is due to incomplete extraction or if it indicates that in the normal wall a protein component is present which is missing in the unstable *L* forms.

Although the results in Table 1 show that the 'basic structure' of the wall is also present in the unstable *L* forms, it might be possible that the total amount is much less than in the normal rods. To answer this question, rods and *L* forms were harvested from growing and resting cultures (bacterial form 4 and 25 hr., respectively; *L* form 18 hr. and 4 days), washed with 2 per cent sodium chloride and hydrolysed. Aliquots from the filtered hydrolysate were subjected to total nitrogen determination and to 1-dimensional chromatography in *iso*propanol–acetic acid, which allowed the measurement of α-ε-diaminopimelic acid. The results in Table 2 illustrate that in growing cultures as well as in resting ones the α-ε-diaminopimelic acid content of the *L* forms is higher than that of the rods.

Thus, penicillin does not prevent the synthesis of the 'basic structure' of the cell wall, nor does it prevent its condensation to an alkaline-insoluble macromolecular structure. The reason for the fragility of the unstable *L* forms must be sought in another wall component. The fact that our stable *L* forms lack the basic structure completely is in good agreement with our earlier findings[7,9] and indicates again that we are dealing with different types of *L* forms.

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Antigenicity of a Bacterial Deoxyribonucleic Acid

SINCE earlier evidence (refs. 1–3 and Medawar, P. B., personal communication) suggesting a serological reactivity for deoxyribonucleic acid (or the deoxyribonucleic acid moiety of a nucleoprotein) has been indirect or controversial, the problem has been

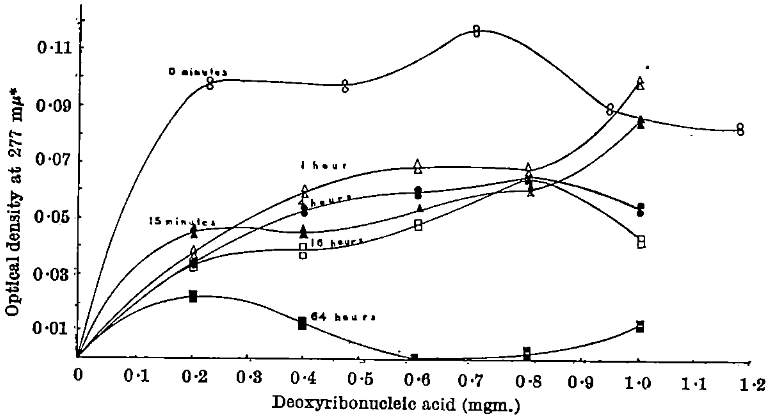

Fig. 1. Effect of deoxyribonuclease on quantitative precipitation. Antiserum, pooled rabbit anti-*Brucella abortus* - 19*M* deoxyribonucleic acid; antigen, homologous deoxyribonucleic acid after treatment with Worthington deoxyribonuclease for various periods of time†.

* 277 mμ is the wave-length of maximum absorption for the dissolved precipitate in 0·25 *M* acetic acid.

† Action of deoxyribonuclease was terminated by addition of ethylenediamine tetraacetic acid to the reaction mixture.

re-investigated with the aid of a preparation rich in deoxyribonucleic acid with transforming activity[4,5], isolated from *B. abortus* cells by extraction with 0·5 per cent phenol in citrate–saline. The extracted material was 'deproteinized' by chloroform and amyl alcohol treatments[6], but the final material still contained, in addition to typical deoxyribonucleic acid[5], approximately 20 per cent protein that could not be dissociated by conventional procedures. Such preparations of deoxyribonucleic acid were used for immunizing rabbits, and the resulting antisera were tested first for precipitating antibodies against homologous deoxyribonucleic acid by the gel diffusion method[7].

Five bands of precipitation, indicating more than one antigen–antibody system, were detected. One of these bands yielded a strong Feulgen-positive reaction, suggesting the presence of deoxyribonucleic acid in the precipitate. The described reactions remained identical when the test antigen was treated either with detergent, 6 *M* sodium chloride, trypsin, trypsin plus chymotrypsin, or when the antisera were first absorbed with whole cells. However, even though deoxyribonuclease alone did not react with the antiserum, treatment of deoxyribonucleic acid with deoxyribonuclease (Worthington 1 × crystallized) resulted in a noticeable decrease in intensity of one of the bands and a simultaneous increase in another.

A more decisive indication of the involvement of deoxyribonucleic acid in these precipitin reactions was obtained by quantitative procedures[8] in which various amounts of antigen were mixed in test tubes with a constant amount of antiserum. The resulting precipitates were washed free of contaminating serum proteins and excess antigen, were dissolved in 0·25 *M* acetic acid, and were analysed spectrophotometrically at 277 mμ. Normal serum controls were also included in all tests. The number of maxima in the resulting quantitative precipitin curve (Fig. 1) again indicated the complexity of the material under study. However, what appears to be of greater significance are the changes occurring following treatment of the antigen with deoxyribonuclease for different periods of time. A significant decrease in the amount of precipitate occurred throughout most of the tested range following treatment with deoxyribonuclease for as little as 15 min. An analysis of the precipitate in the region of lowest antigen concentration, in terms of the ratio of absorptions at 260 and 277 mμ, revealed the presence of deoxyribonucleic acid which decreased with increasing time of treatment with deoxyribonuclease. This deoxyribonucleic acid could have been precipitated either because it contributed to the immunological specificity of the antigen, because it was firmly bound to the antigen, or because it coprecipitated with an unrelated antigen–antibody precipitate. The virtual abolition of antigenicity following prolonged enzymatic treatment, the absence of coprecipitation with known unrelated antigen–antibody precipitates, and the absence of any detectable proteolytic activity in the deoxyribonuclease used, favour the conclusion that deoxyribonucleic acid itself contributed to the specificity and is not merely an inert part of the antigens. This is further supported by the apparent interdependence of the specific precipitates formed as a function of the time of treatment with deoxyribonuclease (note vacillations in the quantity of precipitin formed and apparent shift of maxima to regions of higher antigen concentrations in Fig. 1). This may be due to the formation, during partial depolymerization of deoxyribonucleic acid, of antigenically active molecules with quantitatively different antigenic characteristics.

Additional support for the involvement of deoxyribonucleic acid in these antigen–antibody reactions has come from preliminary tests of cross-reactions between the described antisera and deoxyribonucleic acid from different sources. Deoxyribonucleic acid from both smooth and non-smooth *Brucella* cells gave the same patterns of precipitation in gel diffusion. In contrast, equal amounts of deoxyribonucleic acid isolated either from calf thymus (duponol-extracted) or salmon sperm (phenol-extracted) yielded much weaker reactions. However, exposure of the heterologous antigens to deoxyribonuclease resulted in a striking increase in their cross-reactivity, as evidenced by an increase in precipitation and the appearance of additional zones. Such effects would be difficult to explain on the basis of similarities in the protein moiety. Finally, preliminary evidence suggests a capability of these antisera to antagonize the selective effects of deoxyribonucleic acid breakdown products upon changes in population from non-smooth to smooth in growing *Brucella* cultures[4].

The present information fails to reveal whether the formation of specific antibodies requires protein bound to deoxyribonucleic acid or involves only the acid molecule. However, from a genetic, biological, and analytical point of view it would appear that the answer to this question may be less critical than the indication that deoxyribonucleic acid can contribute to the specificity of an antigen.

We wish to express our appreciation to Prof. M. Heidelberger for his interest, suggestions and stimulating discussions. This work was supported in part by grants from the U.S. Public Health Service

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Relaxation of Snails before Fixation

Numerous narcotizing agents have been used for relaxing snails, and among the more important of these employed recently are menthol and nembutal[1,2,4]. Menthol has been reported as giving variable results[4]; some snails become well extended, but others contract when this agent is used. This variation in results is observed especially when larger freshwater snails (shell height 15–25 mm.) such as *Lymnaea palustris* and *Physa gyrina* are placed in water to which menthol crystals have been added. On the other hand, smaller lymnæids such as *L. humilis* (maximum shell height, 12 mm.) relax well with menthol[3]. Nembutal gives good results with *Pomatiopsis lapidaria* and *P. cincinnatiensis*[4], but, like menthol, is unsatisfactory for the much larger *L. palustris*. This snail will contract slowly over a period of 4–5 min. when placed in 10 per cent formaldehyde even after being in rather high concentrations of nembutal (5 ml. stock veterinary nembutal in 150 ml. water at 4° C. for more than 40 hr.). Using this concentration of nembutal at room temperature results in contraction of *L. palustris* before it is properly narcotized, so that it is unsuitable for fixation. The same result occurs with snails in higher concentrations of nembutal (10 ml. in 150 ml. water) at 4° C.

However, by combining nembutal and menthol in the following way good results with *L. palustris* and *P. gyrina* are obtained. As many as 80 animals are placed in 150 ml. of tap water containing 1 ml. stock solution of veterinary nembutal (60 mgm. per ml.). The snails are left in the nembutal-treated water at room temperature for 1¼–1½ hr., and at the end of this time the soft parts are well extended. Then powdered menthol crystals are added (sufficient to cover the surface of the water), and the snails are refrigerated (4° C.) for 16–18 hr. in a capped jar. After this period of refrigeration, the snails can be fixed with the soft parts remaining in a well-extended position. When first placed in the fixative, slight movements of the tentacles may occur. During the period of relaxation in nembutal alone, the snails must be kept separated from one another and prevented from clinging to the sides of the container, otherwise interference with the extension of the foot may result. After the snails have been placed in the nembutal-treated water (before menthol is added), the time necessary for extension of the foot with cessation of movement is related to the size of the snail. *L. palustris* with a shell height of 6 mm. takes about 35 min., a 17 mm. snail about 55 min., and a 26 mm. snail about 65 min.

An interesting seasonal difference has been observed with *L. palustris* using this nembutal–menthol method of relaxation. Better results have been obtained with snails collected in the spring than with those collected in late summer and early autumn.

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Occurrence of a 'Rare' Earthworm in Montgomeryshire

A preliminary survey of the Lumbricidae in Montgomeryshire has revealed large numbers of *Eisenia veneta* (Rosa) var. *zebra* (Michaelsen) in compost heaps, manure, under decaying wood and under stones at Caersws.

Michaelsen's specimens were from the Caucasus, and up to 1947[1] the only British records were two specimens from Limerick[2] and one specimen (?) from Colwyn Bay, North Wales[3]. In 1954, two specimens were sent to the British Museum (Natural History) from a compost heap in Staffordshire.

Var. *zebra* occurs, in Caersws, together with the common lumbricids of compost heaps, *Dendrobaena subrubicunda* (Eisen) and *Eisenia foetida* (Savigny); but has not been found in similar habitats in any of the neighbouring villages.

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Three Zoopagales from Brackish Water

The Zoopagales are a small group of predacious fungi, at times placed in either the Mucorales or the Entomophthorales, but now more generally given ordinal rank. Most species prey on rhizopods (usually amoebæ); a few on eelworms, by adhesion to their rather sparse mycelium. Consequently they are most frequently found where these animals are active. Duddington[1] and Dixon[2] have recorded several species from compost heaps, decaying wood and moss cushions, and Juniper[3] from decaying animal dung, while Peach[4] restricted her searches to the aquatic habitats of pond and stream, which produced a remarkably rich flora.

So far no known recordings have resulted from saline habitats, but I have recently obtained three species from a salt-marsh in the Blackwater Estuary.

Samples were collected on three occasions during 1957 near Maldon, Essex; and consisted of decaying debris and roots from tufts of the grass *Puccinellia maritima*, and swards of the alga *Enteromorpha*. Both regions were covered normally at high tides, with salinity readings of covering water of 24·6–32·4 (normal sea-water 35). Material was plated on rabbit dung agar. (2 per cent agar in water rendered a pale straw colour by addition of filtrate from stewed rabbit dung.)

Fungus *a* was readily identified as *Stylopage rhabdospora* Drechs.[5] by spore measurements, conidiophore structure and nature of the haustoria. This species is also common in terrestrial and fresh water habitats in Great Britain.

Fungus *b* may be provisionally described as a variety of *Stylopage rhynchospora* Drechs.[6] from which it differed mainly in smaller conidial size and the very slight and non-evacuated terminal beak to the conidium. It has not been recorded before from any other habitat.

Neither of these fungi produced zygospores or showed any evidence of sexuality, though from non-saline habitats these species do so very readily.

Fungus *c* has been recorded on two separate occasions from the same locality and cannot satisfactorily be placed with any of the described species of *Zoopage*. It may therefore be found necessary to create a new species to accommodate it, if warranted by further studies of this seemingly complex genus. This fungus is very persistent, and is characterized by the conidial chains of regularly only four conidia, each up to 60μ long and the stalked haustoria with short dichotomously branched lobes. Although under close observation for four months, no signs of sexuality have appeared.

The three fungi briefly described preyed on small amoebæ (unidentified) 10–18μ in diameter, and appeared 14–24 days after inoculation on several plates of each series. None showed sexuality, though most of the Zoopagales readily do so.

A full description of these fungi will be published later, when further work on similar habitats has been completed.

I wish to record my appreciation to Mr. C. Everard who collected the samples and determined the salinity readings, and Dr. C. L. Duddington for his interest and advice.

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Salmonellae in Uganda

THIS communication presents the preliminary results of an investigation into the carrier-rate of *Salmonellae* in zebu cattle arriving at the municipal abattoir of Kampala.

The cattle from which samples were collected had all been brought to Kampala from the Karamoja district, which occupies the north-eastern corner of the Protectorate and lies between latitude 1° 21′ and 4° 12′ N. and longitude 33° 20′ and 35° 0′ E. This district, which is administratively a closed area with relatively little contact with other territories, is the most primitive part of the Protectorate, and wild animals, including snakes and other reptiles, are present in considerable numbers.

Bacteriological examination was confined to fæces samples. The samples were collected by hand from the rectum a few hours after the animals had arrived at the abattoir. The samples were placed in a refrigerator within two hours of collection and cultured the following morning.

The method of isolation of *Salmonellae*, with a few minor modifications, was that used by Smith and Buxton[1] in the survey which they carried out in the United Kingdom. The types of *Salmonellae* isolated were identified by orthodox biochemical and serological methods, and the majority of the cultures were also sent to the Salmonella Reference Laboratory in England for confirmation.

Up to the present time, samples of fæces from 1,618 cattle have been examined and 33 samples, or 2·0 per cent, have been found to contain *Salmonellae*.

The species of *Salmonellae* encountered during the survey are as follows (the figures in brackets indicate the number of times each type was isolated) : *wien* (1), *heidelburg* (1), *shubra* (1), *stanleyville* (2), *ituri* (1), *makiso* (2), *oranienburg* (2), *newport* (1), *zega* (1), *orion* (1), *chandans* (2), *aberdeen* (1), *mishmar-haemek* (1), *brazil* (1), *cerro* (1), *chicago* (1), *kibusi* (1), *adelaide* (1), *nairobi* (2), *berkeley* (1), new type 1 (1), new type 2 (1), new type 3 (4), new type 4 (1), new type 5 (1).

The large variety of *Salmonella* types isolated and the complete absence of *S. dublin* is in striking contrast to the results of similar surveys undertaken in the United Kingdom, where in the course of five surveys[1–5] 250, or 96 per cent, of 260 *Salmonellae* isolated were *S. dublin* and the remainder consisted of four other types only.

The finding by other workers of various *Salmonella* types in lizards[6,7], snakes[8] and tortoises[9] might suggest that some of the types found during the present investigation had originated from reptiles or game. What their significance is in cattle this communication makes no attempt to decide. However, some of the types isolated have been implicated in the cause of disease elsewhere, and since, according to definition[10], all the known types are pathogenic for warm-blood animals, including man, the finding of a variety of these organisms in 2 per cent of the cattle entering an abattoir must be regarded as a potential danger to public health.

During the investigation five new types of *Salmonellae* were encountered. Their antigenic structures are as follows :

New type 1	1, 4, 12, 27 : z : z_6
,, ,, 2	16 : y : e,n,x
,, ,, 3	40 : z_{41} : 1,2
,, ,, 4	1, 42 : c : z_6
,, ,, 5	28 : 1, w : z_{10}

Types 1, 2 and 3 have been named *S. entebbe*, *S. kikoma* and *S. karamoja* respectively. Types 4 and 5 are still being examined at the Salmonella Reference Laboratory, and when their complete antigenic structures have been confirmed it is proposed to name the former *S. kampala* and the latter *S. moroto*.

It is intended to extend the survey to cover cattle other than those for slaughter and also to compare the carrier-rates in healthy and sick animals.

I wish to thank Dr. Joan Taylor, of the Salmonella Reference Laboratory, Colindale, for examining most of the *Salmonella* isolated. My thanks are also due to the Medical Officer of Health, Kampala, for allowing me to collect samples at the abattoir.

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An Inexpensive Easily Constructed Fish-marking Tag

A simple inexpensive fish tag, after the style of the hydrostatic tag devised by Einar Lee, has been constructed as follows (Fig. 1). Transparent vinyl plastic tubing (Crystal Vinyl tubing No. 6*A*, supplied by Portlant Plastics, Ltd.) ⅛ in. int. diam. is cut in lengths of 2 in. One end of the tube is softened by heating near the edge of a very low Bunsen flame and then the walls are pressed together with large forceps. Dipping the forceps in cold water between each operation keeps them cold and thus increases the desired effect of welding the inner walls of the tube while minimizing distortion of the outer walls which cool more rapidly by contact with the cold forceps. Cooling the forceps also eliminates a tendency of the warm vinyl plastic to stick to them. A slip of white paper with the mark number and instructions in indian ink for the finder is next inserted and then the other end is closed. In one of the flattened ends a hole is made to take a 12-in. length of 0·65 mm. diam. monofilament nylon (sold for anglers as 27½ pounds or 12·5 kilos breaking strain). After insertion the nylon is knotted to form a loop. The cost of materials works out at less than 4*d*. a tag.

The tag is attached to the back of the fish, just anterior to the dorsal fin, in the case of pike and in front of the posterior dorsal fin in the case of pollack. A darning needle (which has the eye cut open on one side to hold the nylon) is used for drawing the nylon loop through the skin and the muscles, and a double looped knot is made to hold the tag in place. Darning needles are now used instead of medical suture needles which were originally used. The former are easier to insert and are considerably cheaper.

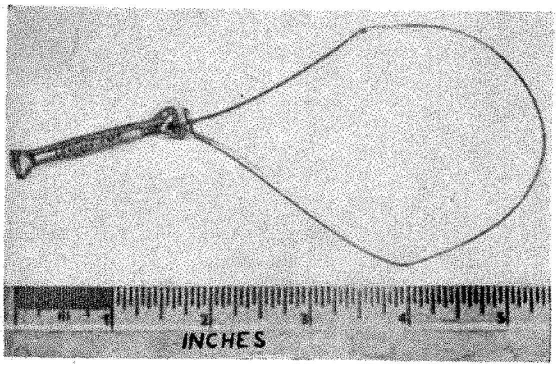

Fig. 1

We have used this tag in both freshwater (for pike) and sea water (for pollack). So far we have only had recoveries of pike; but these show that the tag is satisfactory. The wound made in the fish by tagging heals rapidly when this method is used and is completed in pike by the end of 48 hr. at water temperatures of about 10° C.

For freshwater work, at least, the tag has two advantages over the Einar Lee type; it is considerably less expensive and it is less conspicuous when submerged.

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Chromosome Number of *Marsilea*

The genus *Marsilea* has not previously been investigated by modern cytological methods, and we have only the early investigations of Strasburger[1] and de Litardiere[2] using techniques which experience has shown[3] to be unreliable when applied to ferns. It is therefore perhaps of importance to record a clear count of $n = 20$ (see Fig. 1) for a race of *Marsilea minuta* from northern India. We believe this to be a diploid and have found $2n = 40$ in squashes of root tips. Other cytotypes are, however, also present in this species, notably a sterile triploid with $2n = 60$, which reproduces vegetatively but which is otherwise very like the diploid and frequently intermixed with it. Further observations on this material will be published elsewhere.

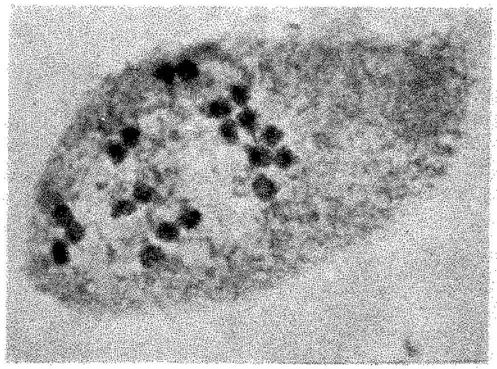

Fig. 1

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Growth Responses of *Fusarium oxysporum* to Metabolites of Some Rhizospheric Microflora of Egyptian Cotton Varieties

During studies on the rhizospheric microflora of different cotton varieties grown in Egypt, *Fusarium* wilt-resistant Ashmouni cotton variety rhizosphere proved to be inhabited by the highest percentage of strains of *Bacillus subtilis*, while susceptible Giza 26 cotton variety rhizosphere contained the highest percentage of a strain of *B. megatherium*[1].

Preliminary screening tests in which each of the bacterial strains was streaked against *Fusarium oxysporum* on either Dox's or soil-extract agar media have proved that *B. subtilis* strains were highly antagonistic to the wilt-inducing pathogen; the former spread rapidly and overgrew *Fusarium* mycelium and encircled it completely. Hyphæ of *Fusarium* were lysed and malformed. On the other hand, *B. megatherium* was stimulatory to *Fusarium* mycelial growth. The latter overgrew *B. megatherium* and produced comparatively very abundant conidia with abnormally large size and high septation.

Growth responses of *Fusarium oxysporum*, which proved to be a virulent pathogen causing wilt of either Karnak or Giza 26 cotton variety seedlings, to metabolites of either *B. subtilis* or *B. megatherium* on Dox's liquid medium have been tested by the following two methods: (1) germinative potentialities of *Fusarium* microconidia in hanging-drop cultures of either *B. subtilis* or *B. megatherium* metabolites; (2) growth of *Fusarium* mycelium on differently treated metabolites of either *B. subtilis* or *B. megatherium*. Filtrates of the test organisms were obtained from cultures of two ages, that is, 5- and 10-days old and were either cold-sterilized[2] or autoclaved. Control solutions using either Dox's liquid or water were also used.

The results (Tables 1 and 2) show that considerable suppressed germination of *Fusarium* microconidia and mycelial growth took place in response to either 5- or 10-days old culture filtrates of *B. subtilis* whether unheated or autoclaved. Ageing of culture or application of heat to its filtrate did not appreciably affect the latent period and final percentage of germination or the mycelial dry-weight of *Fusarium*. On the other hand, on using filtrates of *B. megatherium* from either 5- or 10-days old cultures, the final percentage germination of *Fusarium* microconidia rose to 100 per cent. At the same time, *Fusarium* mycelial growth was significantly higher as compared with that on control Dox's liquid media. A stimulatory factor for *Fusarium* microconidial germination and mycelial growth seems to be present in filtrates of *B. megatherium* the potency of which is not affected by heating. On the other hand, ageing of culture results in an increased stimulative effect over *Fusarium* mycelial growth.

Table 1. Growth Responses of *Fusarium* Microconidia to Metabolite-Filtrates of *Bacillus subtilis* and *B. megatherium* at 30° C.

Experimental medium	Age of culture	Filtrate treatment	Germinative capacities	
			Latent period	Germination (per cent)
B. subtilis filtrate	5 days	unheated	5 hr.	40
		autoclaved	5 hr.	40
	10 days	unheated	5 hr.	48
		autoclaved	5 hr.	50
B. megatherium filtrate	5 days	unheated	5 hr.	100
		autoclaved	5 hr.	100
	10 days	unheated	5 hr.	100
		autoclaved	4 hr.	100
Pure Dox's	—	—	2 hr.	90
Water	—	—	3 hr.	80

Table 2. *Fusarium* Mycelial Dry Weight (in mgm.) after 10 Days at 30° C. in Response to Differently Treated Metabolic-Filtrates of *B. subtilis* and *B. megatherium*. Pure Dox's Liquid is Diluted with Water and Metabolite Filtrates with Pure Dox's Liquid*

Experimental medium	Dilution (per cent)	Filtrate from			
		5-day old cultures		10-day old cultures	
		Un-heated	Auto-claved	Un-heated	Auto-claved
B. subtilis filtrate	100	33	35	29	30
	50	38	40	33	35
	25	45	48	38	41
B. megatherium filtrate	100	40	43	38	42
	50	73	77	80	85
	25	81	85	92	105

* Mycelial dry weight on 100 per cent pure Dox's liquid, 75 mgm.; on 75 per cent Dox's liquid, 61 mgm.; on 50 per cent Dox's liquid, 40 mgm.

Further work concerning the nature of the inhibitory anti-fungal metabolites of *B. subtilis* and the stimulatory factor of *B. megatherium* for *Fusarium* growth are still in progress. The former are probably of the nature of an antibiotic[3] while the latter seems to be a growth factor. Difference in the rhizosphere microflora of wilt-resistant and susceptible cotton varieties might explain why *Fusarium oxysporum* fails to invade Ashmouni cotton roots while its pathogenicity is established on susceptible Karnak and Giza 26 cotton varieties.

Thanks are due to Prof. A. H. Montasir for his unfailing help.

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Abbassia, Cairo.

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* Present address: Shambat Agricultural Institute, P.O. Box 71, Khartoum North.

[1] Naim, M. S., Mahoud, S. A. Z., and Hussein, A. M., *A'in Shams Sci. Bull.*, No. 1, 173 (1956).

Menon, K. P. V., *Ann. Bot.*, **48** (1934).

[3] Prescott, S. C., and Dunn, C., "Industrial Microbiology", 2nd Edn. (McGraw-Hill Co., 1949).

A Simple Technique for producing Fruit Bodies of Wood-destroying Basidiomycetes

In attempts to identify some of the many basidiomycete cultures isolated in our investigations of decay, we have tested a number of methods and have found that described here of the greatest value. It produces relatively large, identifiable fruit bodies from cultures representing a wide range of genera and families, and it has given consistent results in the hands of a number of workers, is not laborious, and requires no special equipment or materials.

The method involves establishing the culture to be identified on an enriched sawdust medium in a glass jar and then allowing it to grow through, and fruit on, a block of readily decayed wood incubated in diffuse daylight in a humid but not stagnant atmosphere.

The medium now used is a mixture of air-dry sawdusts (4–24 mesh) of seven timbers in the following proportions: *Pinus radiata* D. Don (sapwood), 25; *Eucalyptus obliqua* L'Herit. (sapwood), 25; *E. diversicolor* F. v. M., 10; *Acacia dealbata* Link., 10; *Nothofagus cunninghamii* Oerst., 10; *Rhizophora* sp. 10; *Ceratopetalum apetalum* D. Don, 10. (This

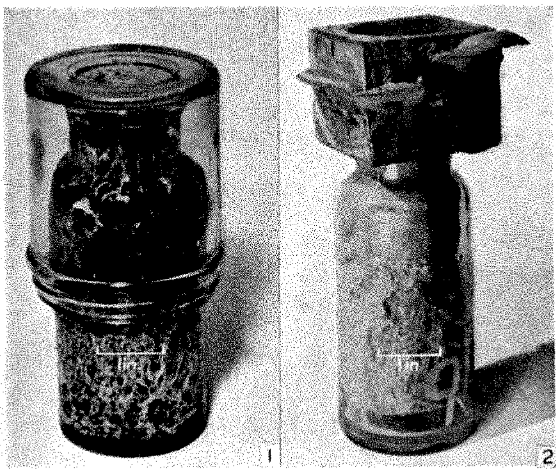

Fig. 1. Production of fruit bodies of wood-destroying basidiomycetes. 1, culture jar, with cover jar, after incubation at 25° C.; 2, culture jar showing fruit bodies of *Fomes gilvus* (Fr.) Lloyd on wood block

complex mixture, intended to ensure that fungi showing a strong host preference for fruiting in Nature will receive any accessory nutrients they require, is based on the general origins of our culture collection, and may be varied to reflect the origins of particular cultures.) The following nutrients are added to each 100 gm. of air-dry sawdust: 2·5 gm. maize meal; 1·5 gm. bone meal; 0·75 gm. potato starch; 0·2 gm. dried yeast; 0·5 gm. malt extract; 0·175 gm. casein hydrolysate; 0·0033 gm. thiamine hydrochloride. The first four are mixed in powder form with the dry sawdust; the last three are dissolved beforehand in the water used for moistening it. Sufficient water is added to saturate the sawdust particles without allowing free water to collect at the base of the culture jar, the amount required being determined for each batch of mixed sawdusts by draining saturated samples for 48 hr.

Enough moist nutrified sawdust is packed into a glass jar, 5¼ in. high and 2¼ in. wide, to come slightly above the mouth, which is then covered with an inverted wider jar (Fig. 1, 1) and the assembly autoclaved. An inoculum from a Petri-dish colony of the test fungus on malt agar is placed just below the surface of the sawdust and the jar incubated in darkness at 25° C. until a vigorous mycelium develops throughout the medium (Fig. 1, 1).

The inverted cover jar is then aseptically replaced by a sterile wooden block, 2¼ in. square by 1¾ in. high, with a ¾-in. deep well in the lower face to fit over the mouth of the jar, and a ¼ in. deep well in the upper face as a water reservoir (Fig. 1, 2). Blocks are usually either *Pinus radiata* sapwood or balsa, and are brought to a suitable moisture content for fungal growth (approximately 100 per cent for *P. radiata* and 300 per cent for balsa) before being autoclaved. It is essential that the block makes good contact with the top of the sawdust and fits tightly around the neck of the jar to prevent movement during subsequent handling. The block is covered with a sterile sheet of polyethylene film, gathered around the neck of the jar by a rubber band, to exclude contamination.

The culture jars are then incubated at laboratory temperatures (12–25° C.) in a shallow tank with a plate-glass lid, receiving abundant diffused light from the southern (polar) sky but no direct sunlight. Water in the bottom of the tank maintains a high humidity, and aeration is provided by bubbling compressed air through water in a flask and then into the tank. As soon as the fungus reaches the surface of the wood block, the polyethylene film is removed and the block is kept moist by adding water periodically to the well in its upper face. (Some contamination, usually *Penicillium* spp., may develop on the blocks, but has little adverse effect, though *Trichoderma viride* will often completely inhibit fruiting.) Jars are disturbed as little as possible, and if removed for inspection are replaced in the same position and orientation.

Fruit bodies are usually produced by 30–40 per cent of the culture jars included in each experiment, the time taken (after the jars are placed in the tanks) varying from 2 to 3 weeks, for *Schizophyllum commune* Fr., to 6 months or more, for *Fomes gilvus* (Fr.) Lloyd. They are usually of normal shape and coloration and of reasonably large size although some pileate species develop only a resupinate form. Fruit bodies may develop on any face of the blocks, but tend to be more frequent on the end grain and on the side facing the light; many develop from the lower face of the block. Satisfactory fruit bodies have now been obtained with species of *Polyporus*, *Coriolus*, *Trametes*, *Hexagona*, *Fomes*, *Ganoderma*, *Elfvingia*, *Poria*, *Dædalea*, *Merulius*, *Corticium*, *Peniophora*, *Coniophora*, *Stereum*, *Hydnum*, *Hymenochæte*, *Odontia*, *Lenzites*, *Lentinus*, *Paxillus*, *Schizophyllum* and *Hypholoma*; but it is not claimed that the technique described is suitable for all species of these genera, and research is continuing on further modifications and on other methods.

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Comparative Chlorophyll Content of the Two Generations of Bryophytes

THE occurrence of chlorophyll in the sporophyte of Bryophytes has been noted by a number of investigators. Bold[1,2] has reviewed the older literature, and, by cytological studies on living material, has demonstrated chloroplasts and starch grains in the foot, seta and capsule of a number of species of both liverworts and mosses. In the liverwort, ***Riella americana***, "as the sporange approaches maturity, its color is much more deeply green than is that of the gametophyte"[3]. Douin[4] has examined the pigments of gametophytes of forty species of mosses belonging to twenty-eight genera, finding that all of them contain chlorophylls *a* and *b*, as in higher plants. In a comparative study of the sporophyte and gametophyte of five species of mosses, no qualitative differences in chlorophylls *a* and *b* or carotenoids were found[5].

It is the purpose of this communication to present quantitative results concerning the chlorophyll content of sporophytes and gametophytes of *Anthoceros carolinianus* Michx., *Polytrichum commune* L., and *Dicranum scoparium* (L.) Hedw. After macroscopic separation of the fresh plant material into gametophytic and sporophytic portions, the samples were weighed. Extraction of the pigments and spectrophotometric determination of the quantities of

Table 1

Species and generation	Chlorophyll *a*	Chlorophyll *b*	Total	Sporophyte/ gametophyte ratio
Anthoceros carolinianus				
Gametophyte	0·31	0·18	0·49	
Sporophyte	0·72	0·43	1·15	2·35
Polytrichum commune				
Gametophyte	0·07	0·05	0·12	
Sporophyte	0·19	0·10	0·29	2·41
Dicranum scoparium				
Gametophyte	0·13	0·09	0·22	
Sporophyte	0·21	0·15	0·36	1·64

chlorophylls present were performed in accordance with Official Methods of Analysis of the Association of Official Agricultural Chemists[6]. In Table 1, the chlorophyll concentrations found are expressed as mgm./gm. fresh weight.

While the much smaller sporophytes contain less total chlorophylls than the gametophytes, when comparisons are made on the basis of equal fresh weights, the chlorophyll concentration in the sporophytes exceeds that in the gametophytes by a factor of 1·64–2·41. These findings have an obvious bearing on the question of the nutritional relationship between the two generations.

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[3] Studhalter, R. A., *Ann. Bryol.*, **11**, 153 (1938).

[4] Douin, R., *C.R. Acad. Sci., Paris*, **243**, 1051 (1956).

[5] Freeland, R. O., *Plant Physiol.*, **32**, 64 (1957).

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Propagation of Cacao in Plastic Bags

THE basic physiological requirements for the vegetative propagation of cacao (*Theobroma cacao*) have been broadly worked out by Evans (1951) and may be summarized in that semi-hardwood cuttings in an atmosphere near 100 per cent relative humidity, at a reduced light intensity (15–20 per cent of the incident sunlight), given adequate aeration at the base of the cutting, will produce roots in the order of 70–90 per cent rooting efficiency.

A comparison of the costs of commercial propagation in Trinidad has been made by Murray and Bridge[1], and McKelvie[2] has shown that cacao may be propagated at greatly reduced cost, on a commercial scale, using sawdust-cored baskets[3] containing cacao cuttings, covered by polyethylene sheets. This method adequately dispenses with the expensive installation of commercial propagating bins, and considerably reduces water consumption and labour costs. Another method, making use of the properties of polyethylene, which restricts water-vapour diffusion but permits some gaseous diffusion, is being developed here. Cuttings are rooted entirely in plastic bags, transported to the field in the same fashion and afterwards established in the field.

The base of a semi-hardwood cacao cutting bearing 4–6 trimmed leaves is dipped in hormone solution. The base of the cutting is first placed in wet, leached sawdust laid in coconut fibre. The fibre is then folded around the base of the cutting and held in place with an elastic band. The final size of the sawdust and fibre 'ball' is about the size of a half-clenched fist. The cutting is inserted into a plastic bag (150 gauge, 20 in. × 11 in.), water (150–200 ml.) added and the neck closed with string. The bag is suspended under a shade of domestic cloth, and no further attention is required until root formation has occurred. The roots emerge through the fibre and may be readily seen through the plastic. The light-intensity, calculated by means of an actinograph, is approximately 7 per cent of the incident sunlight, but is not critical over wide limits providing the light is diffused.

The cutting is transported to the field in the bag and planted under heavy shade with the roots still enclosed in the fibre. The surplus water from the plastic bag is tipped over the plant and the bag is inverted afterwards over the cutting with the mouth of the bag lying loosely upon the soil surface. Two banana leaves, which provide local shade, are arranged in the form of an inverted V over the cutting, with the petioles firmly pressed into the soil. Natural drying-out of the banana leaves permits progressively more light to fall on the cutting. After 4–5 days, the bag is removed and re-used for further propagation. The purpose of the inverted bag is to reduce transpiration and replaces the conventional hardening procedure. The probable reason why success is achieved by this method is that the roots of the cutting are intimately interwoven with the wet fibre and sawdust, which retains moisture for a considerable time during the critical period when the roots are becoming established in the soil.

The rooting percentage in the bag is of the order of 80–90, depending upon the clone, and establishment in the field about 60–70 per cent of the cuttings set in the bags. Plants of the more vigorous clones are ready for planting 22 days from setting.

The advantages of the method are many. The plastic bag costs 2½*d.* and may be used a number of times without deterioration. Labour charges and initial installation are negligible when compared with conventional methods. Plants are introduced into the field more quickly and are very easily transported by hanging the bags from wires in a vehicle. Furthermore, drying-out, which is frequently observed with plants in baskets transported over long distances, does not occur. The combined weight of a plant and basket is between 3½ and 4 lb. as compared with 1 lb. for a plant in a plastic bag. One man may carry up to 20 plants in bags without difficulty, whereas he is restricted to two basketed plants owing to the weight and shape. This means that inaccessible bush areas may be more readily planted with clonal cacao. Skilled labour is not required at any stage in the process, and normal care is all that is required at planting.

Further work is being conducted on the storage of plants in bags containing a nutrient solution, and a full account will be published elsewhere.

Thanks are due to Mr. G. W. Smith for the measurements of light-intensity using the actinograph.

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[1] Murray, D. B., and Bridge, C. J. R., "A Report on Cacao Research", 41 (Imp. Coll. Trop. Agric., Trinidad, 1957).

[2] McKelvie, A. D., *Trop. Agric.*, **34**, 260 (1957).

[3] Murray, D. B., "A Report on Cacao Research", 53 (Imp. Coll. Trop. Agric., Trinidad, 1953).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 24

British Society for the History of Science (in the Council Room of the Science Museum, Exhibition Road, South Kensington, London, S.W.7), at 5.30 p.m.—Dr. A. Armitage and Dr. N. H. de V. Heathcote: "The First International Polar Year, 1882–83—Forerunner of the International Geophysical Year".

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal evening on "Stereophonic Recording on Gramophone Discs". Talk by Mr. H. A. M. Clark.

University of London (in the Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. E. Heilbronner (Swiss Federal Institute of Technology, Zürich): "Some Studies on Non-Benzenoid Aromatic Compounds".*

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. Eric Shipton: "The Imperial College Karakoram Expedition".

Tuesday, February 25

University College, London (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.15 p.m.—Dr. C. A. G. Wiersma (California Institute of Technology): "Integration in Single Units of the Crayfish Central Nervous System".*

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. L. R. Creasy: "Prestressed-concrete Cylindrical Tanks".

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Prof. R. King: "Energy". (Further lectures on February 26 and March 4 and 5. Lectures for Sixth Form Boys and Girls from Schools in London and the Home Counties.)

Society of Chemical Industry, London Section, and Plastics and Polymer Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. G. Dring: "A Plastics Jubilee: 1907–1957" (Jubilee Memorial Lecture).

Wednesday, February 26

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. P. W. Brian: "Gibberellic Acid—a New Plant Hormone Controlling Growth and Flowering" (The Fernhurst Lecture).

Society for Analytical Chemistry (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Annual General Meeting. 5 p.m.—Sir Hugh Linstead, O.B.E., M.P.: "Science and Politics" (Bernard Dyer Memorial Lecture).

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Dr. J. A. Gray: "Boiler Water Treatment—a formula for the Control of Sludge and Scale in Internal (Carbonate) Treatment"; Mr. E. F. Thurston and Mr. L. Furnival: "Boiler Water Treatment—a Formula for the Control of Sludge and Scale in Internal Carbonate Treatment: Experiments in a Laboratory Boiler".*

Royal Aeronautical Society (at Church House, Westminster, London, S.W.1), at 6 p.m.—Sir George R. Edwards—Presidential Address.

British Institution of Radio Engineers (in the Lecture Theatre of the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. C. Powell and Mr. D. A. Hendley: "DECTRA—a Long-range Radio-navigational Aid".

Women's Engineering Society, London Branch (at the Central Electricity Authority Headquarters, Winsley Street, London, W.1), at 6.45 p.m.—Mr. Geoffrey Denton: "Three Case Studies in Automation".

Thursday, February 27

Institution of the Rubber Industry; and the Plastics Institute (at the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1), at 9.45 a.m.—Joint Conference on "Recent Advances in Polymer Technology".

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. S. Cotson, Mr. S. J. Holt, Mr. D. G. O'Sullivan, Mr. P. W. Sadler and Mr. R. F. J. Withers: "Studies in Enzyme Cytochemistry".

Institution of Electronics (in the Assembly Hall, University of London Institute of Education, Malet Street, London, W.C.1), at 7 p.m.—Mr. C. H. Gardner: "Germanium Transistors, Their Principles and Manufacture".

Chemical Society (in the Anatomy Lecture Theatre, King's College, Strand, London, W.C.2), at 7.30 p.m.—Prof. R. G. W. Norrish, F.R.S.: "Some Isothermal Reactions of Free Radicals Studied by Kinetic Spectroscopy" (Liversidge Lecture).

Friday, February 28

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. L. J. Cheshire, Mr. J. V. G. Evans, Mr. W. A. Goodsell and Mr. P. H. W. Wolff: "The Design and Construction of the Compressor for the 8′ × 8′ High-Speed Wind Tunnel at R.A.E., Bedford".

Institution of Chemical Engineers, Graduates' and Students' Section (at Caxton Hall, Westminster, London, S.W.1), at 6.30 p.m.—Mr. E. A. Stallworthy: "Project Cost Estimation".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Leon Radzinowicz: "Changing Attitudes Towards Crime and the Devices Used to Combat It".

Saturday, March 1

British Interplanetary Society (in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Prof. G. A. Witfield: "The Guidance and Control of Long-Range Vehicles".

British Glaciological Society (joint meeting with the Scott Polar Research Institute, at the Scott Polar Research Institute, Lensfield Road, Cambridge), at 8.30 p.m.—Mr. R. J. E. Brown: "Permafrost in Canada—Its Nature, Distribution and Influence on Northern Development".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturers (2) (honours graduates, preferably with some research experience in physical, inorganic or physical-organic chemistry) in Chemistry—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (February 28).

Professor (with high academic qualifications in engineering with teaching and research or industrial experience) of Applied Mechanics at the Royal Naval College, Greenwich—The Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting Ref. No. 4808/58 (March 4).

Assistant Lecturer in Geography; an Assistant Lecturer in Geology; and an Assistant Lecturer in Physics—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (March 8).

Assistant Lecturer or Lecturer in the Department of Pure Mathematics—The Registrar, The University, Liverpool (March 8).

Lecturer in Geology at the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 10).

University Lecturer (preferably with qualifications in applied thermodynamics) in Mechanical Engineering—The Secretary, The University, Aberdeen (March 11).

Assistant Lecturer (preferably with special qualifications in algebra and/or geometry) in Mathematics—The Secretary to the Council, Westfield College (University of London), Hampstead, London, N.W.3 (March 12).

Assistant Lecturer in Near Eastern Archæology—The Registrar, The University, Manchester 13 (March 15).

Assistant Lecturer or Lecturer (with special interests in sedimentation) in the Department of Geology—The Registrar, University College, Singleton Park, Swansea (March 15).

Experimental Officer (with a degree in chemistry or agricultural chemistry or equivalent qualifications), to carry out chemical analyses of soils and plants—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (March 15).

Professor or Reader in Agriculture—The Registrar, The University, Nottingham (March 15).

Research Assistant (graduate, with research experience) in the Department of Physics, to take part in research, under the direction of the Head of the Department, leading to the development of solid state image amplifiers; and an Assistant Lecturer in Geography—The Registrar, The University, Hull (March 15).

Lecturer or Assistant Lecturer in Mathematics at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, March 20).

Assistant Lecturer or Lecturer in the Department of Pure Mathematics—The Registrar, The University, Birmingham 15 (March 24).

Senior Research Fellow and Research Fellow in the Department of Theoretical Physics, Research School of Physical Sciences, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 28).

Imperial Chemical Industries Research Fellows in Chemistry, Biological Chemistry, Engineering, Pharmacology, Physics or related subjects—The Registrar, The University, Bristol (March 30).

Lecturer and an Assistant Lecturer in Physics—The Registrar, The University, Hull (March 31).

Lecturer or Assistant Lecturer in Agricultural Botany at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 31).

Plant Geneticist (preferably with some research experience) in the Plant Breeding Section of the Department of Agronomy, Waite Agricultural Research Institute, to investigate factors affecting the quality and yield in barley and their mode of inheritance and to apply them in a barley breeding programme—The Registrar, University of Adelaide, Adelaide, South Australia (March 31).

Research Fellow (zoologist, with interests in marine biology) in the Department of Zoology—The Registrar, University College, Singleton Park, Swansea (March 31).

Imperial Chemical Industries Research Fellow in Chemistry or Physics—The Registrar, The University, Leicester (April 9).

Assistant or Associate Professor in the Department of Entomology—Head of the Department of Entomology, University of Alberta, Edmonton, Alberta, Canada (April 15).

Chair of Physics in the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 15).

Senior Lecturer or Lecturer in Epizootiology in the Faculty of Veterinary Science, University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 15).

Senior Lecturers or Lecturers in Mathematics, Geology, Zoology, Agricultural Chemistry, Engineering Mathematics, Mechanical Engineering, and Architecture at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 15).

Senior Lecturer (preferably with special qualifications in numerical analysis) in Mathematics at Victoria University, Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, April 30).

Assistant Conservators of Forests (with a university degree in forestry) in the Western Region of Nigeria—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.61/410/01.

Assistant Professor (preferably with the Ph.D. degree or equivalent) in the Department of Mechanical Engineering—The Department of Mechanical Engineering, University of Vermont, Burlington, Vermont, U.S.A.

Head (with qualifications, teaching and research experience necessary for recognition as a teacher of the University of London) of the Department of Metallurgy—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

Lecturer (preferably with experience and interest in experimental techniques) in Aeronautical Structures—Professor of Aeronautical Structures, Department of Aeronautics, Imperial College of Science and Technology, London, S.W.7.

Scientific Officer (with an honours degree in biochemistry, chemistry or physiology, and preferably with postgraduate experience) with the East African Trypanosomiasis Research Organization, Tororo, Uganda, to undertake research on the physiological, biochemical and/or chemical aspects of trypanosomiasis related especially to the assessment of the efficacy and toxicity of new trypanocidal drugs in East African cattle—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/198/013.

Senior Lecturer (honours graduate, preferably with research and/or industrial experience) in Physics—The Registrar, Hatfield Technical College, Hatfield, Herts.

Systematic Botanist and Ecologist (with an honours degree in botany and at least two years research experience, preferably in ecology; or an honours degree or equivalent in agricultural science plus two years completed postgraduate training in botany, preferably with an ecological bias) in Sierra Leone, to carry out ecological studies appertaining to agricultural and forestry problems (including the maintenance and enlargement of a herbarium)—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/15/012.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Ministry of Health: Department of Health for Scotland. Report of the Committee to Consider the Future Numbers of Medical Practitioners and the Appropriate Intake of Medical Students. Pp. vi+38. (London: H.M. Stationery Office, 1957.) 2*s.* 6*d.* net. [212

Department of Scientific and Industrial Research. Forest Products Research. A Handbook of Softwoods. Pp. vii+73. (London: H.M. Stationery Office, 1957.) 8*s.* 6*d.* net. [212

Structural Concrete Hospitals. Pp. 24. (London: Cement and Concrete Association, 1957.) [212

Science Masters' Association. Science and Education: a Policy Statement by the Committee of the Science Masters' Association. Pp. 12. (London: John Murray (Publishers), Ltd., 1957. Published for the Science Masters' Association.) [212

Trade Effluent and Water Supplies in Western Germany: Report of a tour by an F.B.I. Delegation. Pp. iv+64. (London: Federation of British Industries, 1957.) 3*s.* 6*d.* [212

Laboratory Animals Bureau. Collected Papers, Vol. 6, 1957: Report of a Symposium on Humane Technique in the Laboratory, held by the Universities Federation for Animal Welfare at Birkbeck College, London, 8 May, 1957. Pp. 81. (London: Laboratory Animals Bureau, 1957.) 10*s.* 212

Boiler Availability Committee. Bulletin No. MC/286: Methods of Cleaning Modern Boiler Plant. Pp. 40. (London: Boiler Availability Committee, 1957.) [212

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 978, Vol. 250 (28 November, 1957): Precise Measurements of the Density of Mercury at 20° C. 1: Absolute Displacement Method. By A. H. Cook and N. W. B. Stone. Pp. 279–323. (London: Royal Society, 1957.) 17*s.* [212

Local Government Bill. Pp. 78. (Bill 15.) (London: H.M. Stationery Office, 1957.) 3*s.* 6*d.* [212

Fifth Special Report from the Select Committee on Estimates, Session, 1956–57. Pp. 25. (House of Commons Paper, No. 307.) (London: H.M. Stationery Office, 1957.) 1*s.* 3*d.* net. [212

Colonial Office. Fishery Publications, No. 9 (1957): A Preliminary Survey of the Hydrography of the British East African Coastal Waters. By B. S. Newell. Pp. ii+21. (London: H.M. Stationery Office, 1957.) 5*s.* 6*d.* net. [412

City of Leicester Museums and Art Gallery. 51st Report to the City Council, 1st April 1956–31st March, 1957. Pp. 43+4 plates. (Leicester: The Museums and Art Gallery, 1957.) [612

The Planning of International Meetings. (A Handbook issued by the Council for International Organizations of Medical Sciences established under the joint auspices of UNESCO and WHO.) Pp. v+113. (Oxford: Blackwell Scientific Publications, 1957.) 7*s.* 6*d.* [612

Southern Regional Council for Further Education. Tenth Annual Report. October 1957. Pp. 36. (Reading: Southern Regional Council for Further Education, 1957.) [612

The National Council for Technological Awards. Report for the period December 1955 to July 1957. Pp. 20. (London: National Council for Technological Awards, 1957.) [612

Air Ministry: Meteorological Office. Professional Notes, No. 123: Forecasting Cirrus Cloud Over the British Isles. By Dr. D. G. James. Pp. 10 (M.O. 623c.) 9*d.* net. Meteorological Reports, No. 18: Air Flow Over Mountains: Notes for Forecasters and Pilots. G. A. Corby. Pp. ii+53. 3*s.* net. (London: H.M. Stationery Office, 1957.) [612

Pharmaceutical Research in I.C.I., 1936–57. Pp. viii+78. (Wilmslow: Imperial Chemical Industries, Ltd., 1957.) [1612

Other Countries

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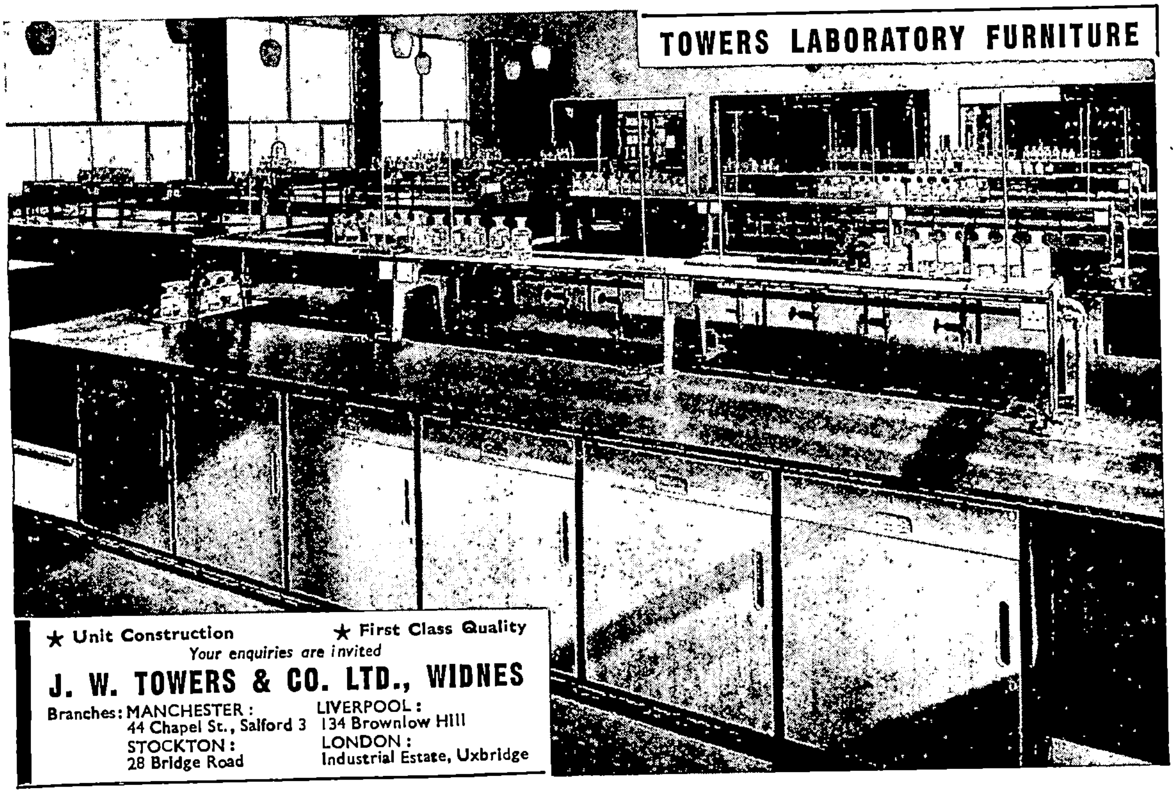

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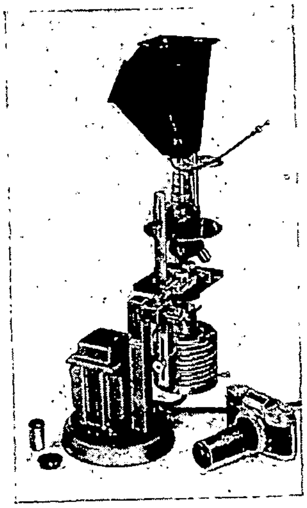

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Further particulars and details of the procedure for enrolment may be obtained from the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

UNIVERSITY OF LONDON: A COURSE of three lectures entitled "Physics as Geometry—the Present Status of Einstein's Programme" will be delivered by Professor John A. Wheeler (Princeton) at 5.30 p.m. on March 3, 5, and 10 at King's College, Strand, W.C.2. Admission free, without ticket.—James Henderson, Academic Registrar.

UNIVERSITY OF LONDON: A COURSE of three lectures on "Endogenous Diurnal Periodicity in Plants and Animals"; (i) "The Internal Clock System of Plants and Animals"; (ii) "The Phenomenon of Time Measurement in Photoperiodic Reactions"; (iii) "The Role of Yellow Pigments in Phototropic and Phototactic Movements" will be delivered by Professor E. Bünning (Tübingen) at 5.30 p.m. on March 4, 5, and 7 at King's College, Strand, W.C.2. Admission free, without ticket.—James Henderson, Academic Registrar.

UNIVERSITY OF LONDON: A COURSE of two lectures on (i) "Bacterial Endotoxins (Lipopolysaccharides)—Chemical and Immunological Aspects"; (ii) "Bacterial Endotoxins—Biological Activities and Investigations on their Mode of Action" will be delivered by Professor O. Westphal (Freiburg) at 5.30 p.m. on March 3 and 5 at the Westminster Medical School (Meyerstein Lecture Theatre), Horseferry Road, Westminster, S.W.1.—Admission free, without ticket.—James Henderson, Academic Registrar.

UNIVERSITY OF LONDON KING'S COLLEGE

CHEMICAL ENGINEERING

Applications for places next October in the postgraduate one-year course for the College Diploma should reach the Registrar, from whom particulars and forms may be obtained, by March 15.

The College offers Shell Studentships of the value of £375, with free tuition and examination fees. Applications for these should also be in by March 15.

This course is approved by the D.S.I.R. for Advanced Course Studentships. Applicants interested in these should inform the Registrar of the College by February 24.

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Further particulars can be obtained from the Head of the Department of Geology.

UNIVERSITY OF LONDON: A COURSE of four lectures entitled "Acoustic and Magnetic Effects in Compressible Shear Flow" will be delivered by Professor H. W. Liepmann (California Institute of Technology) at 5.30 p.m. on March 3, 5, 10 and 12, at Queen Mary College (Stern Hall), Mile End Road, E.1. Admission free, without ticket.—James Henderson, Academic Registrar.

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Inquiries and applications should be addressed to Professor H. E. Duckworth, Chairman, Department of Physics, McMaster University, Hamilton, Ontario, Canada.

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Further particulars may be obtained from the undersigned, with whom applications (four copies), giving the names of two referees, should be lodged not later than March 24, 1958. (A candidate from overseas may submit one copy of this application.)

CHARLES H. STEWART,
Secretary to the University.

UNIVERSITY OF BRITISH COLUMBIA

DEPARTMENT OF PHYSICS

Applications are invited for appointments as Lecturer, Assistant Professor, Postdoctorate Fellow and Research Assistant in the Department of Physics. The vacancies have been created by the rapid expansion of the university. They are mainly in the fields of nuclear physics, optical spectroscopy, solid state physics and geophysics. Applicants should have an honours degree in physics and, except in the case of Research Assistants, a Ph.D. degree. They should not be more than 30 years of age and should be available in September, 1958. There are also Teaching Assistantships available to help students who wish to pursue graduate work towards a Ph.D. degree.

Applicants wishing fuller information regardin any of these positions or awards should write t G. M. Shrum, Head, Department of Physics, Uni versity of British Columbia, Vancouver, B.C., Canada.

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF AGRICULTURE

The Council invites applications for appointment as Professor or Reader in Agriculture. The appointment carries with it the Headship of the Department of Agriculture which is one of the four Departments of the Faculty of Agriculture located at the School of Agriculture, Sutton Bonington. Salary: Professor £2,450; Reader within the scale £1,650 by £75 to £2,150, with supe nuation (F.S.S.U.) and family allowances.

Conditions of appointment and form of app cation, which should be returned by March 15 1958, from the Registrar.

UNIVERSITY OF LONDON: APPLICATIONS are invited for IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWSHIPS in Biochemistry, Chemistry, Chemotherapy, Engineering, Metallurgy, Pharmacology, Physics. The Fellowships will be within the range of £800 to £1,000 per annum and will normally be tenable from October 1, 1958, for three years. Family allowances and F.S.S.U.—Detailed regulations and application forms may be obtained from the Academic Registrar, University of London, Senate House, W.C.1. Applications must be received not later than April 30, 1958.

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POSTGRADUATE COURSES IN CRYSTALLOGRAPHY

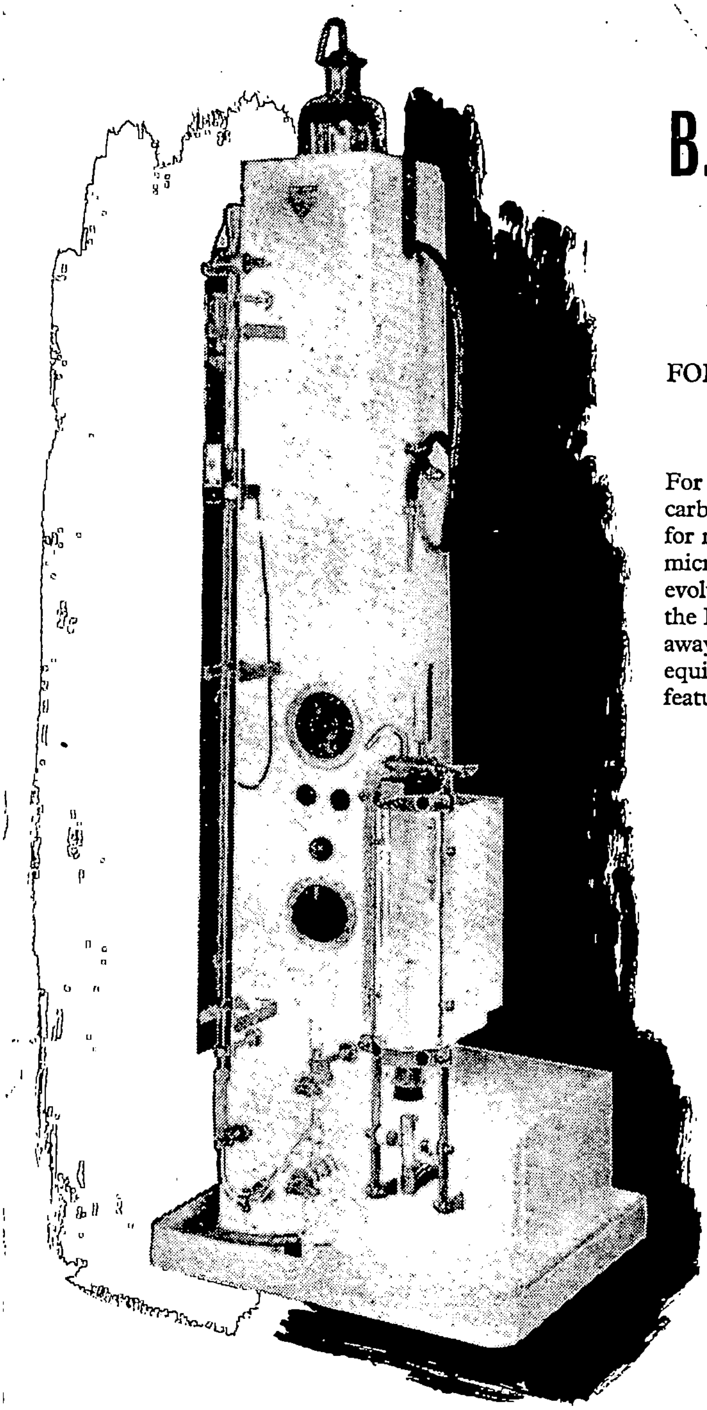
Postgraduate courses in Crystallography leading to the examinations for the degree of M.Sc. of the University of London or the postgraduate diploma of the Battersea College of Technology, D.C.T.(Batt.), will be held in the Metallurgy Department commencing in September, 1958.

The duration of the courses will be one session.

The entry qualifications to the courses will be those laid down by the University of London or the College of Technology, respectively.

Intending students are eligible to apply for D.S.I.R. Advanced Studentships, applications for which must be made before March 31, 1958.

Applications for entry to the course should be made to the Head of the Metallurgy Department.



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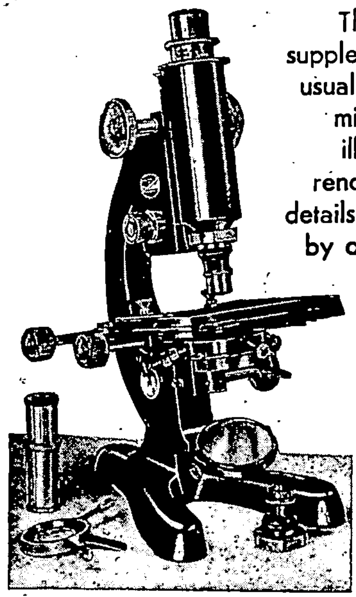

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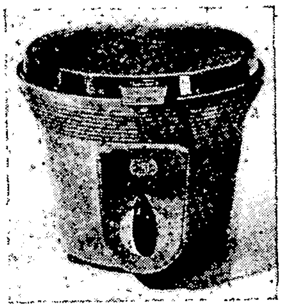

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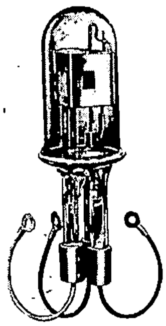

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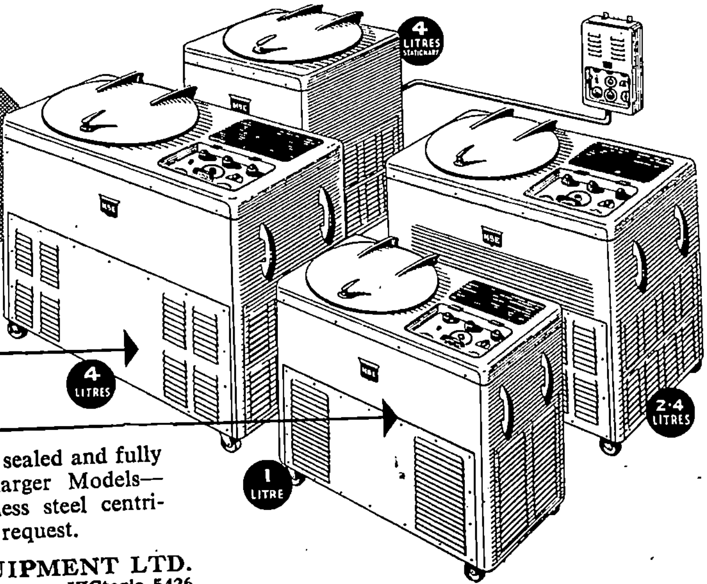

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LOCAL ADMINISTRATION IN A TECHNOLOGICAL AGE

ADDRESSING the Association of Municipal Corporations last September, Sir John Wolfenden asked what would be lost if the whole panoply and paraphernalia of local government were scrapped and the administration of Great Britain undertaken by local agents of the central authority. The question deserves a considered answer before, and not after, judgment is passed on the Local Government Bill now before Parliament; the Windscale incident alone is sufficient reminder that the issues are not so remote from the scientist and technologist as might appear at first sight. That the question should be asked at all is evidence that a well-known passage in de Tocqueville might not pass unchallenged to-day: "Local assemblies of citizens constitute the strength of free peoples. Town meetings are to liberty what primary schools are to science; they bring it within the people's reach, they teach men how to use and enjoy it. A nation may establish a system of free government but without the spirit of municipal institutions it cannot have the spirit of liberty".

In this passage de Tocqueville was concerned with the function of local government in civic self-education and, as was made clear in the three White Papers which preceded the Bill, and again by the Minister of Housing and Local Government, Mr. H. Brooke, in moving the second reading of the Bill on December 9, that is a main purpose of the Bill—to create conditions in which local government can gain new vitality. As was said in the first of the White Papers, on "Areas and Status of Local Government Authorities in England and Wales": "The test of any system of local government in this country should be whether it provides a stable structure, capable of discharging efficiently the functions entrusted to it, while at the same time maintaining the local democratic character". In introducing the Bill, Mr. Brooke rejected, however, the argument of this White Paper that comprehensive reform is unnecessary, and claimed that the Bill, while retaining the broad lines of the existing system of local government as the framework of re-organization, points the way towards achieving effective local government in present circumstances without going too far and causing rigidity. The financial provisions, in particular, he said, are designed to strengthen the local character of local government by enabling local authorities to exercise greater responsibility over the expenditure of money in their own areas, and in the provisions relating to the area and status of all concerned, the local authorities, the two Local Government Commissions and the Minister are enjoined to secure "effective and convenient local government".

During recent years, much public discussion besides the series of White Papers has prepared the way for the Bill. Mr. H. Maddick, for example, in an article in the *Westminster Bank Review* entitled "Local Government—Partner or Agent?", some three years ago discussed essentially this question put by Sir John Wolfenden. Mr. Maddick unhesitatingly answered "Much" to Sir John's question and argued that, in spite of the admitted dangers, in most areas the quality and nature of the local services should be left to the action of local inhabitants. It is a most cogent argument for a continuing, viable system of local government that it teaches citizens how democracy works in a context that is not too wide and too complex for them to understand; it provides them with expert advisers who are familiar with all the local problems and peculiarities; and it brings them up against the cost of providing services.

It is significant, in view of the trend of Opposition criticism in the House of Commons of the present Bill, that Mr. Maddick particularly specifies the value of the much wider realization of the cost of education to be secured in this way, and he would obviously support the Government's policy to place education, so far as possible, under local control; nevertheless, he recognizes the difficulties over finance and stresses the importance of providing local authorities with alternative sources of finance, at once adequate, resilient and independent of Government sanction. He also supports the principle of block grants rather than percentage grants, and suggests that more could be done to bring the experience of one locality to the notice of the council and electors of another. Further research into such questions is needed which, he suggests, could be the main function of a central department.

The most casual reading of the debate in Parliament on the second reading of the Bill indicates the value of such independent academic opinion. Concern about the possible effect of the Bill on education led to attacks which were pressed with complete disregard of the impossibility of effective reform of local government unless the local authorities were entrusted with greater responsibilities and, *ipso facto*, with the possibility of making mistakes. Yet Mr. Frank Bower, in an article in *Progress* last year, written after the publication of the first of the White Papers, argued convincingly that the present financial subservience to the central Government needs to be replaced by a real independence and correspondingly by a real responsibility to the ratepayers. A revision of the functions of central and local government in this sense would eliminate much waste of effort and money in the detailed control of local authorities from Whitehall, and by giving new vitality and independence to the local authorities would also encourage responsible citizens to undertake the work of councillors.

Once again, Mr. Bower recognizes the difficulty over education, which represents some seven-eighths of all expenditure on the dozen services covered by the Government's proposed block grant; but he points out that while the central Government should assist the local authority by a block grant to provide a minimum standard of service, the authority could be left to add to that standard at its discretion and its own cost. Mr. Geoffrey Lloyd has indeed affirmed most specifically his intention of seeing that standards are observed. It is no part of the Government's policy, he said in the debate on December 10, to reduce the central Government's grant aid to local authorities' expenditure on education or to freeze the contribution at its present level; on the contrary, the Government's policy is to increase that contribution in accordance with the conditions laid down in Clause 2 of the Bill. In this speech, Mr. Lloyd laid bare what appears to be the hard core of the opposition to the Bill—the fear that the local authorities will be unwilling or unable to provide the money required. It is clear, as Mr. Lloyd pointed out, that the changes proposed in the Bill will involve education (and other) committees much more closely in explaining and defining their proposals to their councils and finance committees and to local public opinion, and this is undoubtedly all to the good. If indeed local authorities are not to be trusted to administer so vital a service and fail to seek the essential understanding and support from local public opinion, they will frustrate the national policy approved and provided for by Parliament; in that event we may well turn to the further question asked by Sir John Wolfenden: Is local government in danger of ceasing to be government at all?

In the debates on December 9 and 10 the Opposition seemed to take the view that local government has already gone far towards becoming simply a system of local administration of national policies; but there is substance in Sir John's contention that local agents of a central authority are not necessarily less sympathetic than local authorities to local needs and can be just as good from the point of view of sheer efficiency. The retention of local government cannot be justified on such grounds, least of all when local councils are increasingly content to behave as agents of the State, rather than as independent bodies, serving in matters of national concern as its junior partners but carrying the primary responsibility for social welfare in local affairs. Throughout the debate, the chorus was not of dependence on Government grants but of the inadequacy of those grants: the manifest loyalty of local councillors was not so much to local government itself as to their own administrative unit. Yet until local government as such receives not merely lip service but also the devotion and firm support which can break the present vicious spiral and over-ride the prejudices and obsolete patterns which have caused its structure to lose all touch with rapid changes of twentieth-century life, there is no hope of effective reform. Independent and impartial observers and students have pointed the way, although social and technical changes have enormously extended both the scope and scale of the services which local authorities are required to administer. But the whole task would still be well within the competence of local government, organized on a two-tier basis, if its administrative units had been adapted to the radical changes in the pattern of town and country life and social habits, and if Parliament had conceded the financial resources of independence.

This, however, is not to assert that local authorities and local electorates are enlightened enough about national needs for a service so important as education, for example, to be entrusted more closely to their responsibility; but without such trust and responsibility the prospect of progress is slight. Indeed, local government reform fundamentally is a task of education—of awakening and holding the interest and loyalty of the average citizen, of bringing him to an awareness of the issues that will lead him to vote the necessary supplies and to resist the blandishments of those who wish to bring party political views to bear. For the sound administration of both local affairs and national affairs in this technological age, the average citizen must be sufficiently aware of such issues.

That is the real reason why local government is the concern of those who wish to see the fullest public benefit derived from the application of scientific knowledge. Effective delegation of local issues to the maximum extent is the only way of easing the pressure on the central administration and making the task of central government possible among the complexities of to-day without resort to autocracy or dictatorship. Local administration is essential, moreover, not simply to lighten the burden at the centre but also for the value of the contribution it can make to efficient government itself, and to the preservation of the personal touch and awareness of human issues; it can keep the central administration itself sensitive to public needs and views, as well as stimulate a closer interest on the part of the citizen himself, and a sense of being able to influence his own affairs.

One difficulty is that of reconciling a shift of responsibility with the needs of good administration, when most functions call for highly specialized staff and some may require substantial resources and can be administered efficiently and economically only on the basis of large areas or populations. Even here, however, as the experience of the Nature Conservancy and the National Parks Commission indicates, without local understanding and support it is difficult to achieve the ends of national policy or to eliminate real or imaginary clashes between local or sectional and national interests.

In principle, the Local Government Bill is sound. The block grant will make the local council a more impartial body and put more responsibility for getting value for money on those who make the decision to spend it. Provided the transitional period for redistribution of grants is not too protracted and some room is provided for experiment with incentive factors in weighting the block grant, any serious diversion of money from education is unlikely, and there is every prospect of much more effective elimination of waste.

At one extreme, local authorities are local government bodies performing local services to meet local needs. At the other, they are administrative agents for implementing locally a national policy which has been laid down by Parliament. Conflict arises when the local authority is required to raise for the latter purpose large sums of money for local resources, and it is the blindness of both major political parties to this ever since the National Parks Commission was established that is the real reason for legitimate doubts as to the efficacy of the present measures. There are adequate sanctions for the Minister to deal with those authorities which are reluctant to maintain standards, just as the proviso that the Minister may alter the boundaries of individual urban areas or groupings of areas when the responsible commission is unable to make appropriate recommendations may avoid the frustration that befell the earlier Local Government Boundary Commission.

Criticism there should and will be on points of detail, and it should also be recognized that in regard both to functions and areas the White Papers on which the Bill is based sought to bridge the considerable gap between what was needed and that on which the local authority associations themselves had been able to agree. Neither the Minister nor the Commissions should be unduly limited by that restricted measure of agreement, but should seek with imagination and courage to exploit to the full the opportunity of rebuilding democratic strength provided by this new widening of the areas of decision open to local government. Much hard and unprejudiced thinking is needed, to which the central Government itself and especially the Treasury has something to contribute, if the existing anomalies are to be removed and new strength and flexibility imparted to local finance. But at least we are shown the way forward to local institutions which could be kept abreast of changing conditions and values, and in which local needs are met by local decisions made increasingly in a context of real awareness of national problems in a technological age.

STEAM INTELLECT SOCIETIES

George Birkbeck

Pioneer of Adult Education. By Thomas Kelly. Pp. xii + 380 + 11 plates. (Liverpool: At the University Press, 1957.) 45*s*. net.

The Mechanics' Institutes of Lancashire and Yorkshire Before 1851

By Dr. Mabel Tylecote. Pp. x + 346 + 8 plates. (Manchester: Manchester University Press, 1957.) 37*s*. 6*d*. net.

CHARLES DUPIN, a French mathematician and naval engineer visiting Britain in 1816, was much struck by two brothers who worked in a bakehouse which they had equipped with portable gas-lights. In the intervals of baking bread, these two made a steam engine which they used in turn to make "des machines et des instruments de physique". Their uncle (who apparently owned the bakehouse) was neither amused nor interested; according to Dupin, "il préfère de beaucoup la boulangerie et la pâtisserie à la gazometrie et l'astronomie".

These baking brothers, who symbolized for Dupin the incubation of technological zeal in Britain, were neither an isolated nor a new phenomenon. As early as 1717 the weavers and artisans of Spitalfields were working out mathematical problems on their slates. In 1789, a group of young men in Birmingham began to earn for themselves the title of 'The Cast Iron Philosophers' from their habits of discussing mechanics and natural philosophy with foundry workers and others. In 1800, the geologist, Thomas Webster, was discussing, at the newly founded Royal Institution, "the application of science to the common purposes of life". In the autumn of the same year George Birkbeck, a twenty-four-year-old medical graduate of Edinburgh, enrolled seventy-five workmen for a course of lectures "abounding in experiments, and conducted with the greatest simplicity of expression and familiarity of illustration, solely for persons engaged in the practical exercise of the mechanic arts". The steam-intellect societies had begun. Technology-hungry artisans were, as Dupin rightly said, a portent. One of them, Timothy Claxton, was determined to form a "Society of Ingenious Working Mechanics . . . to study and improve the Arts of this Kingdom". It began in 1817 and lasted until 1820, when Claxton went to Russia. Four years later he appeared in Boston with an air pump and some apparatus.

The anastomizing threads of all this activity came together in 1823 when a mechanics' institute was founded in London. As Dr. Kelly, in his long-needed and well-documented biography, points out, Dr. Birkbeck was not the literal founder. That honour is reserved for a Fleet Street journalist and patent agent named J. C. Robertson. Yet the London Mechanics' Institution was based on Birkbeck's earlier work in Glasgow, the effects of which M. Dupin so much admired; and the London Mechanics' Institution was the real starting point of the mechanics' institute movement in Britain. Nine years after Birkbeck's death in 1841 there were 700 mechanics' institutes in Britain alone, catering for a membership of 120,000. More than 600 of these were in England.

Since more than a quarter of the total number of such institutes in England were in Yorkshire and another ninth in Lancashire, it is natural that a survey of these two areas should have been made. Dr. Mabel Tylecote's, begun more than thirty years ago, reinforces what has previously been suspected about the efficacy of these institutions. Nearly a hundred pages of her text are virtually proto-histories of the Manchester College of Science and Technology and of the Huddersfield Technical College. Of the latter in its days as a mechanics' institute she writes (p. 66), "There was not in Lancashire a success parallel to that of the Huddersfield Mechanics' Institute, or even, perhaps, to that of some of Huddersfield's neighbouring institutions".

Some of those who laboured in the cause were, incidentally, keen students of the history of technology: Henry Dircks of Liverpool and C. F Partington laboured in their spare time on such seventeenth-century figures as Hartlib and the Marquess of Worcester. Others, like James Hole, the secretary of the Yorkshire Union, looked out from existing institutions to an 'industrial university': "Inefficient as they may be as a means of industrial instruction", he wrote, "they afford the best instruments for introducing an improved system". That 'improved system' was to occupy the efforts of scientists and statesmen for the rest of the century and at each stage apathy, indifference, hostility and misunderstanding dogged their efforts.

Dupin's prediction to the mechanics of Paris that in the next twenty years "the conquests of science and industry in Great Britain [would] surpass those of all the generations which had given so much prosperity to her people" was, as we know, fulfilled. What we did not know, and do now, thanks to these meticulously careful and patient studies of Dr. Kelly and Dr. Tylecote, is the way in which the mechanics of those days took their instruction and their fun. For the Yorkshire Union was a regular Channel 9; Dickens and Emerson trod their lecture platforms as well as the local cognoscenti. They were the Royal Institutions of the plebs, as virile as those for whom they catered.

W. H. G. ARMYTAGE

AN ECOLOGICAL PERSPECTIVE

Biogeography

An Ecological Perspective. By Pierre Dansereau. Pp. xiii+394. (New York: The Ronald Press Company, 1957.) 7.50 dollars.

THE sub-title of this volume is more appropriate to its contents than the main title, for it is essentially a text-book of general ecology, containing but little of the traditional material of plant and animal geography. The principal sub-divisions indicate the scope of the work: history of biota; bioclimatology; synecology; autecology; and man's impact on the landscape. These form the five 'levels' of Prof. P. Dansereau's perspective, and within this framework he deals with all the more important aspects of the environmental relationships of living organisms. As he states, much of his ecological philosophy is derived from the Zurich–Montpellier school; it is not surprising that this should be so, for his mind is evidently given strongly to systematization.

In fact, Prof. Dansereau adopts a taxonomic approach to all aspects of ecology, descriptive and otherwise, for while he stresses that the crux of ecological thinking is in the holocoenotic point of view, his method of treating phenomena both static and dynamic is to dissect, define and classify. As a result his text is copiously subdivided, and studded with tabulations. This is undoubtedly a treatment admirably suited for the student seeking to gain some sort of grasp of this huge and inherently somewhat amorphous field; for him it has the all-important merits of clarity, apparent unambiguity and memorative value.

The demerits of this sort of treatment should not be overlooked, however; many issues are not to be resolved merely by classification and definition, and indeed such a process may create a mask for ignorance and obscurity. It is questionable, for example, whether even for an elementary student it is justifiable to present so cut-and-dried a view of the climax hypothesis as Prof. Dansereau does in his synecological section.

Be this as it may, bringing order to so wide a field in so compact a volume represents a fine achievement, even if the treatment involved in doing so is occasionally procrustean. Although as is to be expected the illustrative material is predominantly botanical, the width of example quoted is impressive, based as it is upon Prof. Dansereau's acquaintance with American ecology from tropics to arctic. The bibliography of more than 400 references supplies an excellent entry to ecological literature, notwithstanding its marked bias towards that of the New World.

A word must be said, also, about the illustrations. Like many recent North American text-books, this one makes frequent use of a cartoon-style of diagram which, at its best, is capable of lending an immediate force to a point and of registering it upon a reader more securely than many pages of text. The bulk of the diagrams are outstandingly successful, but one or two have reached a degree of over-elaboration which reduces them to a form of puzzle or intelligence test—sometimes, like those concerning the structural description of vegetation, merely to an exercise in memory.

A similar charge of over-elaboration may be levelled at some of the technical vocabulary. True, precise expression demands an adequate terminology, but it does little service to a subject to snow it under with polysyllables. In the introduction to his glossary, Prof. Dansereau notes the need to avoid calling a spade a geotome, but a sneaking sympathy with those who do so is surely shown when he himself refers to a long-day plant as a longidiurn and a short-day plant as a brevidiurn.

In summary, it may be said that this is a treatment of a wide and difficult subject which, by careful planning and avoidance of controversy, manages to be both comprehensive and concise. To the good teacher and the thoughtful student it should supply an excellent basis for a course in general ecology; but there is at least a risk that the very efficiency of the author's rationalizations of the subject-matter could tempt the mediocre to an under-estimation of its complexities.

J. HESLOP-HARRISON

SIXTH-FORM PHYSICS

New Intermediate Physics

By G. R. Noakes. Pp. viii+962. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1957.) 30*s.* net.

MR. G. R. NOAKES has a very high reputation as a writer of physics text-books for use in the sixth forms of public schools and grammar schools. The present work collects into one volume his previous books on separate branches of physics; but since two of these, on light and on electricity, were not easily adaptable, those sections have been completely re-written. The other sections have been somewhat modified so as to keep them within the comprehension of that increasing number of students who cannot be regarded as possible entrants for university scholarships, but who may nevertheless be valuable contributors, at a lower level, to the scientific man-power of the nation.

In his new section on light, the author uses both the real-is-positive and the new Cartesian conventions; this seems to augur the final—and very proper—victory of the latter. It would, indeed, be interesting to know whether any English university department of physics now uses the real-is-positive convention. The section has most of its discussions in terms of wave theory, which makes for greater interest than the rather bare bones of geometrical optics. The somewhat short treatment of the diffraction grating might have been expanded to answer explicitly the usual schoolboy question as to why more than two lines on the grating are necessary.

It is, however, in the section on electricity that Mr. Noakes is at his best. The arguments, which are remarkably ingenious, are based entirely on the M.K.S. system. Mr. Noakes takes trouble, by simple analogies, to make clear the relations and differences between lines of force and lines of induction, usually left very vague, in books of this standard, and in many others. It is pleasant, also, to find a short discussion of magnetic domains, which gives details of the structure of both antiferromagnetic and ferrimagnetic materials.

A few omissions have been noted; thus, the term 'enthalpy', coming into increasing use, does not appear in the index. A more striking omission is radioactivity, of which no mention in any form appears. A chapter on this subject is surely desirable, in view of its great importance, which has caused it to be introduced already into the syllabuses of some of the examining boards for the Advanced Level General Certificate of Education. A rather fuller account of Essen's experiments on the velocity of electromagnetic waves might have been given, since these are of much higher accuracy than the more usually described optical methods.

On the whole, the book may be commended as an excellent production, well worthy to rank with the author's previous works, and very good value for money. W. H. Dowland

THE PHASE RULE

Chemical Phase Theory

A Comprehensive Treatise on the Deduction, the Applications and the Limitations of the Phase Rule. By Prof. J. Zernike. Pp. xv+494. (Deventer: Kluwer's Publishing Co., Ltd.) n.p.

THE phase rule is physical chemistry *par excellence*; yet older physical chemists in industry cannot help feeling that the modern young recruit, bristling with university degrees and knowing his electronic theory and quantum mechanics inside out, is less well versed in the phase rule and its applications than his predecessors. This is doubly unfortunate, since not only does every chemical manufacturing process come up against the rule sooner or later, but the study of equilibria between phases and the construction of phase diagrams offer a wealth of intellectual delight that few other subjects, if any, in chemistry can surpass.

Good books on phase equilibria are few and far between, and the appearance of a new one can be regarded as something of an event. Once again the veteran is apt to hold the view, with some justification, that there is only one treatise on the subject worthy of consideration, namely that commenced by Bakhuis Roozeboom in 1901 and concluded by his successors Schreinemakers, Buchner and Aten. These books are now very rare, and any library or individual owning a copy of the complete work can be considered exceedingly fortunate. Any physical chemist desirous of winning the lasting gratitude of his peers could do no better than translate Roozeboom into English, and persuade an enterprising publisher to bring out a new edition.

It would not be fair to compare Prof. J. Zernike's 500 pages with Roozeboom. Nevertheless, "Chemical Phase Theory" is a very good book indeed. I prefer the rigorous thermodynamic proof using the partial molar Gibbs functions to the rather elementary proof adopted by Prof. Zernike in Chapter 1. The rigorous proof of the phase rule, however, cannot be appreciated without a good introduction to thermodynamics, and Prof. Zernike may have felt that this was outside the scope and aim of his book, which is to be, above all things, descriptive. The concept of the number of components of a phase system, which is often confusing to the beginner, is very well explained. The fact that the system made up from sodium chloride, sodium sulphate and water is one of four components, not three, should puzzle no one after reading this book.

One-component systems are dealt with in less than 40 pages, but with no lack of thoroughness. Polymers, glasses and infusible substances are all considered. It is impossible not to share Prof. Zernike's enthusiasm as he suggests new experiments for testing some moot point in the theory. It will come as a shock to many physical chemists to learn that as long ago as 1901 a case of superheating above the melting point of a crystalline solid was reported.

It is by the treatment of the binary systems, however, that the merit of a treatise on phase equilibria can best be judged. Since such systems can be described in terms of pressure, temperature and one composition variable, they are eminently suitable for pictorial representation on paper in all their aspects, either as pressure-temperature, temperature-composition or pressure-composition diagrams. Every chemist can draw the simple diagram showing the eutectic in a system composed of a salt in aqueous solution. The humps for the intermediate hydrates can probably be put in as well. Liquid-vapour equilibrium diagrams showing high and low boiling azeotropes are also part of the industrial chemist's repertoire. But how many of them can draw the diagrams showing equilibrium between solid, liquid *and* vapour phases together; especially if the components are only partially miscible in the liquid phase or completely miscible in the solid phase? What do temperature-composition and pressure-composition diagrams look like in the region of the critical points of the components? It is particularly pleasing to observe that the recent work on the nitrogen-ammonia system at high pressures, which has been reported as exhibiting two immiscible gas phases, is shown by Prof. Zernike to be entirely accounted for by classical theory, in that it is simply a system showing immiscible liquid phases at a temperature above the critical point of one of the components.

Prof. Zernike describes the systems which have been experimentally investigated, but points out that all the theoretically possible cases are by no means exhausted in his book. Having been shown the way, the astute reader is left to work out and draw new combinations for himself; certainly the quickest and best method of becoming an expert in the subject.

Ternary systems are not as difficult to deal with as might be at first imagined because no new parameter is involved; only a second composition variable. Prof. Zernike's treatment of ternary systems is just as thorough as that of the binary systems. His descriptions of the 'salting out' process and of systems of reciprocal salt pairs are masterly. In the case of multicomponent systems the chief interest lies in the graphical dodges which can be used to depict these systems, in part if not in entirety, on paper.

In his text Prof. Zernike has included 64 problems to tax the imagination and understanding of the reader. The answers are given at the back, and they should be tackled by every serious student. The book is very well produced, and the numerous diagrams are beautifully clear. Here and there a "bij" and a "probleem" have escaped the proof reader to remind us that this book is published in the Netherlands. Prof. Zernike's meaning is always clear although his English is occasionally unorthodox. These are not criticisms of the work; they add to the delight of reading it.

This book should be owned by every library and every serious student of the phase rule. It can be put alongside Roozeboom; no further praise is necessary.

F. Din

PROPERTIES OF SYNTHETIC PIEZOELECTRIC CRYSTALS

Piezoelectricity

(General Post Office: Selected Engineering Reports.) Pp. x+369. (London: H.M. Stationery Office, 1957.) 75*s*. net.

As stated in the foreword, this volume is the first of its kind which makes available to the general public the results of engineering reports of the English General Post Office. This report by the staff of the Materials Division of the Research Branch is in the field of synthetic piezoelectric crystals. Dr. R. Bechmann (now at the U.S. Army Signal Corps Engineering Laboratory, Fort Monmouth, New Jersey) was responsible for the theoretical investigations and indicated suitable fields for experimentation. A. C. Lynch, and later P. L. Parsons, were responsible for the physical measurements. Dr. R. Taylor supervised the crystal-growing experiments. The preparation of the reports for publication was undertaken by Dr. R. Taylor and Mrs. S. Ayers.

The book starts out with a general description of the fundamental properties of piezoelectric crystals. The notation for the fundamental quantities, and for rotated cuts, follows that standardized by the Piezoelectric Committee of the Institute of Radio Engineers (United States). A chapter on the use of tensor transformation in calculating the properties of rotated cuts was written by Bechmann. Since all the properties of the crystal are measured by means of the resonant and anti-resonant frequencies of fundamental modes, a complete discussion of modes of motion is given by Bechmann and Ayers. A feature of this discussion is the use of contour modes for measurements. However, little mention is made of the very extensive thickness mode solutions obtained recently by Prof. R. D. Mindlin and his associates at Columbia University.

These studies are preliminary to the determination of crystal constants by resonant frequency and capacitance measurements. A chapter by Lynch and Parsons discusses automatic methods for tracing out such resonances. The coupling factor is determined by the difference in capacitance above and below the resonant frequency.

Next follow chapters on methods for growing water-soluble crystals, for measuring their orientations by X-rays and for cutting them with wet string saws. The crystals studied seem to be nearly identical with those studied at Bell Laboratories as substitutes for quartz in filter plates and for underwater-sound transducers. The particular crystals studied are ammonium dihydrogen phosphate, sodium chlorate and sodium bromate, ethylenediamine tartrate, lithium sulphate monohydrate and di-potassium tartrate. A rather complete study has been made of the tartrates, but no new crystals are produced. Very complete determinations have been made for the elastic, piezoelectric and dielectric constants of these crystals, which will probably remain the most authoritative determinations of these properties.

The present reviewer misses a chapter giving a survey of probable uses for such crystals. In the United States, the only water-soluble crystal which survived competition with natural and synthetic quartz is ammonium dihydrogen phosphate, which is still used in underwater sound equipment. This may not be true in Britain. In any event, the series of reports can be recommended as giving a very broad background in piezoelectric crystal investigations and as containing the most recent set of elastic, piezoelectric and dielectric constants for piezoelectric crystals. The general idea of making available for wider circulation a series of engineering reports of one organization is also a commendable one and should be extended further.

Warren P. Mason

HÆMOLYTIC DISEASE OF THE NEW-BORN

Comparative Aspects of Hæmolytic Disease of the Newborn

By G. Fulton Roberts. Pp. 199. (London: William Heinemann (Medical Books), Ltd., 1957.) 17*s*. 6*d*. net.

This account of hæmolytic disease of the newborn in man and animals is divided into nine chapters. The first, which deals with the history of the human disease, will probably be of limited appeal, but it serves a very useful purpose in giving proper credit to earlier workers in what is often assumed to be a modern preserve. Chapters 2 and 3 deal with hæmolytic anæmia and the problem of kernicterus, respectively. The latter chapter clearly suffers from the lack of knowledge on neonatal jaundice and the metabolism of the bile pigments, but the author comes through this ordeal well and is on firmer ground when discussing serological considerations in Chapter 4, which is stimulating and very much to the point.

At this stage, Dr. Roberts leaves the human infant and discusses, in two chapters, the disease as it is seen in the horse and the pig, and then, in Chapter 7, work on the experimental production of the condition. His grasp of the veterinary aspects of hæmolytic disease is sure and there is no lack of balance between human and veterinary medicine throughout the book. Chapter 8 is devoted to comparative pathology, and here the author best exhibits his gift for bringing together and assessing widely scattered data. A final chapter on treatment is brief but adequate for a book of this type.

In an age of increasing specialization, it is a pleasure to find an author who can see a disease as a whole. But Dr. Roberts does more than this in venturing along the many scientific paths that radiate from the clinical case. The book is written clearly and with great economy of words, and although the author describes it as a short account of present-day views it is, in fact, a comprehensive review with more than five hundred references.

PRACTICAL MODERN MICROSCOPY

Traité de Microscopie

Instruments et Techniques. Par A. Policard, M. Bessis et M. Locquin. Pp. vi+608. (Paris: Masson et Cie., 1957.) Broché, 4,500 francs; Cartonnétoile, 5,200 francs.

THIS book is concerned with the use of modern microscopes in biology. It contains much information that would be valuable to all users of microscopes, but it is especially well suited to the needs of pathologists, histologists and cytologists. The attempt to cover the requirements of these three groups in a single volume is becoming increasingly difficult, for new instruments and techniques are being invented one after another in almost bewildering profusion. The authors make a bold attempt to deal with the whole subject, from direct microscopy with the light microscope through phase-contrast and interference to electron-microscopy. The book is logically arranged and can be used as a work of reference as well as a text for systematic study. It can be strongly recommended. There is probably no other single volume that contains so much useful, up-to-date information on the subject. It is adapted throughout to the needs of the practical man, anxious to get the best results from his instruments by the use of rational techniques but not interested in the niceties of physical and chemical explanations.

In writing such a book as this, it is difficult to know how much physical and chemical explanation to include. Some of the theoretical sections are not satisfactory. A considerable amount of space is devoted to the theory of phase-contrast. It would not seem that the authors have had much experience in explaining the optical principles involved to intelligent persons ignorant of the subject. The treatment is neither well adapted to the needs of the beginner nor helpful to the initiated. It is possible to explain phase-contrast in a much more straightforward way, without any sacrifice of accuracy. The remarks on the theory of fixation and dyeing also leave a good deal to be desired. Indeed, it seems questionable whether the short sections on these subjects were worth including in the book. One might get the impression from the general remarks on pp. 289–290 that almost nothing is known about the chemistry of dyeing. In fact, of course, there is an immense wealth of knowledge, gained by the researches of Ehrlich, Fischer, Mann, von Möllendorff, Seki, Lison, Singer, and many others.

The balance of the book is on the whole good, though there may be a few subjects to which an unnecessary amount of space is devoted (secondary fluorescence, for example, and the shadowing of objects for light microscopy). Insufficient information is given on certain other subjects. It would not be possible to use collodion successfully as an embedding medium without more detailed instructions than are given here. Not nearly enough space is devoted to vital coloration. This important branch of microtechnique has unfortunately been pushed into the background by the invention of phase-contrast. Two objects that look identical by phase-contrast may react very differently to vital dyes, and a pointer may thus be given to differences of chemical composition. The techniques of vital colouring are not very easy to learn, and the account given in this book is inadequate.

The book contains a few mistakes in matters of fact. For example, neutral red is said to be a neutral dye, and the cochineal insect is described as a beetle; there is no mention of the use of tannin in the instructions for carrying out del Río-Hortega's tannin–silver method. There are some queer words in the list of English equivalents of French technical terms (falx image, gelatinous glycerin (for glycerine-jelly), kristall, microscop, prisma, etc.).

A defect of the book is the casual way in which the illustrations are introduced. Many of them are not referred to in the text, and one might suppose that they were chosen after the book had been written. The legends do not suffice in all cases to make the meaning clear.

The merits of this book greatly outweigh the minor defects that have been mentioned. It is clear, logical, modern, comprehensive, and eminently useful.

JOHN R. BAKER

H. K. MOOKERJEE MEMORIAL VOLUME

H. K. Mookerjee Memorial Volume of the Proceedings of the Zoological Society, Calcutta

Edited by J. L. Bhaduri, B. Biswas and S. P. Ray-Chaudhuri. Pp. ix+396+21 plates. (Calcutta: The Zoological Society, 1957.) Rs. 30; 50*s*.

PROF. MOOKERJEE had a distinguished career, both in Great Britain and in India, where he was the first occupant of the Sir Nil Ratan Sircar professorship of zoology at Calcutta. His influence on the development of Indian zoology is outstanding. When he was a student, teaching in zoology was intended for medical students and there was no special course of study in zoology followed in Bengal. The fact that thirteen contributions of the present issue have been written by Indian zoologists is ample evidence of his achievement in fostering the study of zoology in India.

In this memorial volume, thirty-two contributions are collected dealing with almost all aspects of zoology. They range from an article on "Sex Determination in Metazoa" by J. B. S. Haldane to an essay on "The Growth of Knowledge of Animals in Palestine from Paleolithic Times" by F. S. Bodenheimer. There are notes on mammals collected during a Himalayan Expedition by Biswamoy Biswas and H. Khajuria, and a study of the chromosome numbers in human cervical cancer by G. K. Manna.

Of the thirty-two papers, four deal with sex determination and genetics; four with cytogenetics; four with experimental biology; four with descriptive embryology; ten with evolution and systematics; and the remaining ones with entomology and protozoology, except for a contribution on palæozoology. It is obviously impossible to review in a brief space any of the contents of this book adequately, but it is perhaps worth while pointing out that of the non-Indian contributions, eight come from the United States, seven from the United Kingdom, one from the U.S.S.R., two from Australia and one from Israel, thus again bearing testimony to Prof. Mookerjee's influence on the development of zoology, not only in his own country but also abroad.

Indeed, the collection of papers on so many unrelated subjects, which at first sight appears somewhat haphazard, may be taken as a tribute to the width of Prof. Mookerjee's interests. A. GLUCKSMANN

Bulletin of the Institute of Nuclear Sciences 'Boris Kidrich'

Vol. 7. Pp. 166. (Belgrade: Institute of Nuclear Sciences 'Boris Kidrich', 1957.)

THIS volume contains papers in English, French and German, describing work by members of the Institute. The work is mainly in chemistry, including radio-chemistry, but there are also papers in nuclear physics and electronics.

My chief qualification for this brief review is that I spent a week in the summer of 1956 at the Institute, which is about ten miles east of Belgrade, at a place called Vinća. It is a 'little Harwell', equipped with canteens, houses, etc., as well as laboratories. The main equipment is to be an experimental reactor (with a power of 1 megawatt or more) which was being engineered in the U.S.S.R. The building work was half complete in 1956, but I have not heard that the reactor is working yet.

The Institute is therefore planned to centre on the physics and chemistry of nuclear reactors. But there are groups, as at Harwell and Saclay, working on nuclear physics research, instrumentation, etc. The atmosphere is very enthusiastic, and there are a number of able scientists there, many of whom have studied abroad, mostly in the Western countries but some in the U.S.S.R. The Institute is, of course, entirely Government supported and there are no formal ties with the University of Belgrade, though some of the staff also lecture there. The Government has evidently realized that it must start by building up research work, and my impression was that they have made a very good beginning. The British Council is interested in the Institute and in particular in arranging the exchange of publications with research departments in Britain.

H. W. B. SKINNER

The Flora of Wiltshire

By Donald Grose. Pp. iv + 824. (Devizes: Wiltshire Archæological and Natural History Society, 1957. Copies obtainable from The Museum, 41 Long Street.) 42*s*.

THIS flora is presented to a large extent in the format which has become traditional for such works in Britain. These publications are the product of much industry, stimulated largely by local pride and enthusiasm, but to botanists accustomed to dealing with the systematic problems on a world scale, county floras such as this seem proportionately to have scant scientific value. It is true that in the "Flora of Wiltshire" some ecology is included in the section dealing with the vegetation of the county, in the form of lists of species forming associations typical of selected habitats. In a county which is mainly agricultural and pastoral, with little elevation above 600 ft., and dominated by the chalk formations of Salisbury Plain and the Marlborough Downs, there is a surprising number of species represented. In all, some 1,406 flowering plants, ferns and charophytes are listed, of which just over 900 are deemed to be native to the county. No descriptions are given, and, as is usual in this typically British production, a very extensive knowledge is assumed of the British flora.

The book is really in the nature of a detailed catalogue and it is a pity that, in the fashion of the Druce era, there is such a proliferation of names of subspecific rank to which botanists will have difficulty in referring plants.

Check-List of North American Birds

Prepared by a Committee of the American Ornithologists Union. Fifth edition. Pp. xiii+691. (Ithaca, N.Y.: American Ornithologists Union, 1957.) n.p.

THIS big volume is a result of many years work (1939–57) of a committee of eleven eminent American ornithologists with Dr. Alexander Wetmore as chairman. The fourth edition of 1931 covered 1,420 species and subspecies, and in the present volume this number has grown to 1686. A hypothetical list including 41 species is also added. The area covered is North America north of Mexico, Greenland, Bermuda and Baja California. The distribution of each species or subspecies is treated with great care and detail, and especially in regard to some rarer species the amount of evidence and the manner of presentation deserve the highest commendation. The title of the book does not sufficiently indicate its contents, since it is much more than a simple check-list normally is. This long-awaited, excellent work is invaluable for everyone interested in the distribution of birds in general and especially of those of North America. Serious ornithologists will find it an indispensable source of information. It is very desirable that a similar check-list of European birds should be prepared as a counterpart of this American work, and the forthcoming twelfth International Ornithological Congress to be held at Helsinki in June offers a good opportunity to discuss the problem. The international compilation of such a monumental work seems not impossible and would certainly be a very valuable undertaking because no modern check-list of the birds of Europe as a whole exists at present.

W. RYDZEWSKI

Determinism and Indeterminism in Modern Physics

Historical and Systematic Studies of the Problem of Causality. By Ernst Cassirer. Translated by O. Theodor Benfey. Pp. xxiv+227. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1956.) 40*s*. net.

IN the halcyon days of the 1920's, most of the essentials of modern physics had been achieved. It is not surprising, therefore, that this distinguished book, written originally in German, but published in Sweden, should contain a large part of the epistemology necessary for the basic understanding of almost any system of natural philosophy. But it was intended to supply (in 1936) a final chapter on the causality problem, a project destined to failure, on account of the author's death. Luckily, Prof. Margenau, a close associate of the late Prof. Cassirer, has been able to contribute a very impressive preface on the most important developments in this field. It does two things: it brings out the contrast between 'causality' and 'determinism'—as Cassirer conceived them—and current interpretations, and it discusses recent advances.

Where the author himself is strongest is in his insistence upon the intimate connexion (almost amounting to fusion at times) between physics and the theory of knowledge. He takes account of the whole cycle, from the most mechanistic beginnings to the present-day sub-quantum determinism of David Bohm. In this way, the build-up of thought is seen to be continuous through the periods of matrix-calculus and wave-mechanics, and much of the dual character of Nature is made more comprehensible. The translation into English is excellent.

F. I. G. RAWLINS

NON-FLOWERING STRAINS OF HERBAGE GRASSES

By Prof. M. L. PETERSON*, Dr. J. P. COOPER and P. B. VOSE

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of Wales, Aberystwyth

THE results of more than thirty years of grass breeding, together with the insight that has been gained into the physiology of flowering, now make it feasible to examine the possibility of producing 'non-flowering' strains of herbage grasses. These strains would remain permanently vegetative within the regions of their agronomic adaptation.

It has been realised since the early work of Fagan and Jones[1] and Woodman *et al.*[2] that the leaves of herbage grasses are lower in fibre, higher in protein content, and more digestible than the stems, and hence of greater nutritive value. For these reasons, plant breeders have deliberately selected leafy strains with a high proportion of vegetative to fertile tillers at flowering time. In spite of the lower proportion of heads, seed production of these leafy strains has proved quite practicable. The development of strains of grasses which remain permanently vegetative seems possible by continued selection in this direction[3].

Most herbage strains show marked seasonal productivity, characterized by a steady rise in production during the spring and early summer, and reaching a peak with the emergence of the inflorescences. Flowering and seed formation are followed by a depression in yield, which is succeeded by a secondary period of aftermath growth reaching a peak in the early autumn. This midsummer depression of yield has often been attributed to water shortage, but Hunt[4] has recently emphasized the seasonal growth-cycle and the seriousness of the summer gap under Ayrshire conditions, with a relatively high summer rainfall. Non-flowering strains should not exhibit such periodicity of growth, since their seasonal production would be determined by environmental factors, such as rainfall and temperature, rather than by the sequence of the reproductive cycle. They should also maintain a higher protein and lower fibre content than flowering strains.

The efficient utilization of incoming radiation for photosynthesis depends on the maintenance of a high leaf area index in the crop[5]. Langer[6] has found that *S*.48 timothy attains its maximum leaf area at about the time of ear emergence, this being followed by a period of rapid decrease during flowering, and then by a smaller rise in early autumn. In a non-flowering strain, the leaf area should remain at a high level during midsummer when both the incoming radiation and the net assimilation rate are at a maximum.

The absence of elongated flowering shoots may also make it easier to maintain a balanced grass-clover sward with a relatively constant proportion of grass to clover. It is during the stem-elongation stage of the grass that competition for light is most liable to depress the clover content of the sward[7].

The management of non-flowering strains could prove easier than that of normal herbage. Many farmers refuse to grow cocksfoot, *Dactylis glomerata*, because of the difficulty of retaining it in a palatable condition, and avoiding the 'tussocky' growth that easily arises under lenient cutting or grazing. Pastures of ryegrass, *Lolium perenne*, frequently become very stemmy after midsummer, and good management requires that they should then be topped over with the mower. The importance of keeping herbage short and leafy is emphasized in the gang-mowing technique of Merricks[8], and a non-flowering strain could supply such short, leafy herbage. A non-flowering strain of ryegrass would also be an obvious choice for playing fields.

There are, however, certain difficulties attached to the use of non-flowering strains of grasses, the most obvious being their economic propagation. Although vegetative propagation is practicable for special purposes, such as lawns and sports grounds, adequate seed supplies are essential for use on a farm scale. A study of the physiology of inflorescence development in the herbage grasses suggests several ways of overcoming difficulties in propagation. A strain which fails to flower in one environment may produce heads freely in another, so it should be possible to choose seed-growing areas of appropriate climate and latitude.

Absence of heading may be associated with low vigour or with late spring growth, but the main advantage of such strains would lie in their steady mid-season production. Sylvén[9] observed that a strain of meadow fescue, *Festuca pratensis*, from north Sweden which failed to flower in the south because of inadequate photoperiod also showed poor vegetative vigour. On the other hand, spaced plants of perennial ryegrass and cocksfoot, which remained vegetative when grown in California, were quite vigorous in relation to flowering plants. In the ryegrasses, late heading and late spring growth are not invariably correlated. The late-flowering pasture strains, *S*.23 and *S*.101, are known to be later in spring growth than the early-flowering strains. However, Italian ryegrass is later in heading date, but is earlier in spring growth than the early-flowering perennial ryegrasses.

Most grasses of temperate regions require long photoperiods for floral initiation and stem elongation, although the time from ear initiation to ear emergence is modified by spring temperature[10,11]. Species of economic value the flowering behaviour of which has been studied include *Bromus inermis*[12–14], *Cynosurus cristatus*[15], *Dactylis glomerata*[12,13,15,16], *Lolium perenne*[11,15,17], *Phleum pratense*[12,13], and *Poa pratensis*[12,13,18]. Both species and strains vary in their exact photoperiodic responses, earliness or lateness of heading depending on the critical photoperiod. In *Lolium perenne*, for example, the early-flowering strains, Irish, Ayrshire and *S*.24, will initiate heads in a photoperiod of 11–12 hr., while the later-flowering *S*.23 and *S*.101 require 13–14 hr. or more for spikelet initiation[11,17]. Similarly, in *Phleum pratense* the early-flowering American strain Marietta, from Ohio,

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Table 2. Response to Selection for Early and Late Flowering in Kent Perennial Ryegrass

Original population Mean	(Extreme)	First generation Mean	Second generation Mean	Third generation Mean	(Extreme)	Direction of selection
22.8 May	(3 May)	5.9 May	27.2 April	28.2 April	(16 April)	Early–early
	(5 June)	30.4 May	3.6 June	8.7 June	(21 June)	Late–late

All figures refer to date of ear emergence in 1957. Each mean based on fifty seedlings; S.E. of mean = 1·06

will begin to produce heads in a 12-hr. photoperiod, while the later-flowering Canadian strain Huron requires 13½ hr. or more[12]. The photoperiodic requirements of a strain are closely related to its latitude of origin, and the transfer of material to different latitudes often results in altered flowering behaviour. Allard and Evans[12], for example, find that strains of *Phleum nodosum* from north Europe (50–60° N.) fail to head or head very sparsely in natural photoperiods at Washington, D.C. (39° N.), but will flower freely under supplementary illumination. In Sweden, Sylvén[9] gives examples of plants of *Festuca pratensis* from north Sweden (66° N.) which fail to head when brought down to the south (56° N.).

The flowering behaviour of *S*.23 perennial ryegrass has recently been compared at Aberystwyth (52° N.) and Davis, California (38° N.). Seed of this strain when grown at Davis gave rise in 1955 to a number of non-heading plants. These were induced to flower the following year and interpollinated in a group, the seeds from each mother plant being harvested separately. The nineteen progeny lines and the original *S*.23 were grown outdoors at Aberystwyth and at Davis, and the percentage of plants heading and the median heading date were recorded for all lots in summer 1957 (Table 1). The results indicate that while at Aberystwyth all plants headed except for two in line 7, in California most lines showed a proportion of non-heading plants, this being as high as 40 per cent in line 7. The two plants which failed to head under natural photoperiods at Aberystwyth produced heads when transferred to continuous light in the glasshouse. At both Davis and Aberystwyth nearly all the progeny lines were later than the original *S*.23, and there is a significant correlation (+0·828) between the median heading dates for the two stations. Furthermore, those lines which were later heading at Aberystwyth showed a higher proportion of non-heading plants at Davis, suggesting that in both cases a high photoperiod requirement is involved.

These studies suggest that it is possible to select plants which fail to flower in a particular latitude because photoperiodic requirements are not satisfied. It is not yet known whether such plants will fail to flower in succeeding years. There is the possibility that such plants may be carried only part way towards floral induction in the first season, and failing to head will proceed from that point on in the next season or seasons until heading ultimately occurs. The answer to this problem awaits further research.

Table 1. Heading Behaviour of *S*.23 Perennial Ryegrass and Derived Progeny Lines at Davis, California (38° N.), and at Aberystwyth, Wales (52° N.)

Material	Aberystwyth Heading (per cent)	Aberystwyth Median heading date (1957)	Davis Heading (per cent)	Davis Median heading date (1957)
Original *S*.23	100·0	June 6	97·9	June 6
Line No. 8	,,	,, 8	100·0	,, 2
10	,,	,, 12	100·0	,, 8
12	,,	,, 6	97·1	,, 3
5	,,	,, 12	97·1	,, 11
6	,,	,, 15	97·1	,, 11
11	,,	,, 18	97·1	,, 11
16	,,	,, 16	97·0	,, 15
2	,,	,, 19	94·3	,, 19
9	,,	,, 21	91·2	,, 16
13	,,	,, 19	91·2	,, 27
17	,,	,, 20	90·9	,, 29
19	,,	,, 20	85·3	,, 26
14	,,	,, 19	82·9	,, 27
18	,,	,, 18	80·0	July 1
15	,,	,, 19	80·0	,, 1
3	,,	,, 19	78·8	,, 1
4	,,	,, 21	74·3	June 29
1	,,	,, 20	71·4	July 4
7	90·0	,, 22	60·0	,, 12

California material, sown October 15, 1956, planted outdoors November 26, 1956. Aberystwyth material, sown November 25, 1956, given 80 days cold treatment at 0–5° C., planted outdoors February 23, 1957

There have been few detailed investigations of the inheritance of flowering behaviour in the herbage grasses, but in *Lolium*, Cooper[19] finds the difference between the early-flowering group (Wimmera and Irish) and the late-flowering *S*.23 perennial ryegrass to be polygenically controlled, with no evidence of one or a few main gene differences. In these outbreeding strains, most plants are highly heterozygous for genes controlling flowering date, and the genetic variance of progenies from selfing or crossing individual plants is of the same order as that of the whole population. As a result, much potential genetic variation is stored in the population, making possible considerable response to selection. In Kent perennial ryegrass, three generations of selection were made for early and late flowering, beginning with four early and four late-heading plants. As shown in Table 2, selection for earliness advanced the mean heading date 16·9, 25·6 and 24·6 days, respectively, in each of three generations of selection. Selection for lateness retarded mean heading dates 7·6, 11·8 and 16·9 days, respectively, for three generations. A divergence in mean heading dates of 41·5 days and a divergence between extreme plants of 66 days was obtained in the third generation[20]. This difference of sixty-six days corresponds to a difference in photoperiod of about 3½ hr. at Aberystwyth (52° N.).

In addition to their long-day requirement for floral initiation and subsequent development, many temperate perennial grasses possess a 'winter' requirement for short day and/or low temperature before floral induction is possible, little or no heading occurring after a late spring sowing. Such a 'winter' requirement has been reported for *Bromus inermis*[14], *Cynosurus cristatus*[15], *Dactylis glomerata*[16], *Lolium perenne*[15,21], and *Poa pratensis*[18], but does not occur in *Phleum pratense*[22,23]. In *Lolium*, both low temperature and short days have an inductive effect, either alone or when combined. Cold induction can be given to the imbibed seed, to the young seedling, or to the mature plant, but for short-day induction, some leaf tissue must be expanded. In *Poa pratensis*, Peterson and Loomis[18] find that both low temperature and short days are necessary for floral induction, while in *Dactylis glomerata*, Gardner and Loomis[16] report that short days must accompany or precede the cold treatment.

Strain or ecotype differences in 'winter' requirement also occur. In *Lolium*, there is a close correlation between the degree of 'winter' requirement and the annual, biennial or perennial habit[20,21]. The summer-annual Westernwolths ryegrass possesses no requirement for either low temperature or short-day, while the winter-annuals, such as Wimmera ryegrass, show a quantitative response, heading being accelerated by either cold or short-day. In the biennial Italian ryegrass, some plants fail to head without exposure to winter conditions, the proportion of non-heading plants varying with the climatic origin of the material. In perennial ryegrass nearly all plants have an obligatory requirement for cold or short day or both, this being greatest in the persistent pasture strains and least in the shorter-lived 'commercial' types. Plants of Irish, *S*.24, *S*.23 and *S*.101 perennial ryegrass have been kept vegetative for more than two years under continuous light in a warm glasshouse.

As with the requirements for long photoperiods, the response to low-temperature induction in *Lolium* is polygenically controlled[19], no main gene differences having been detected in crosses between the annuals, Wimmera and Westernwolths ryegrass, and perennial ryegrass. Furthermore, considerable genetic variation is carried in the heterozygous state within individual plants, and gradually becomes available for selection.

In the temperate herbage grasses, therefore, at least two developmental mechanisms exist whereby the timing of inflorescence development can be controlled; a 'winter' requirement for short-day and/or low temperature before floral induction is possible, and also a requirement for long photoperiods for floral initiation and subsequent development. Considerable genetic variation in all these responses has been shown to exist within species, its distribution being related to the climatic or agronomic origin of the material. It should therefore be possible to select, in a particular region, plants which remain vegetative indefinitely, because their requirements for either 'winter' exposure or long summer photoperiods are not satisfied under local conditions. They may then be grown for seed production in districts or under artificial conditions favourable for reproductive development.

A fundamental problem in the production of a non-flowering strain is to decide whether to concentrate on the photoperiodic response or the 'winter' requirement, as the factor limiting inflorescence development. In this connexion, the seasonal regularity of the limiting factor is important. Winter temperatures in one locality vary considerably from year to year, and the response to winter conditions in one season may not be strictly reproducible in subsequent years. The effective temperature-range for cold induction is not known for most herbage grasses, nor do the usual meteorological records give an exact measure of the temperature experienced by the growing point of the grass plant. It is clear that the regional mapping of effective winter temperatures may be rather difficult. On the other hand, the seasonal distribution of photoperiod is regular from year to year, and being based only on latitude, can be calculated accurately for any locality. Apart from the modifying effects of temperature during inflorescence elongation, flowering performance in any one season may therefore serve as a guide to future behaviour. Response to photoperiod thus forms a more reliable basis for the production of non-flowering strains.

The next step is to obtain plants the critical photoperiod of which is above that of the longest summer day in the region where the strain is to be used. One obvious source is the collection of late-flowering material from higher latitudes. In the case of Davis, California (38° N.), this presents few difficulties. The longest summer photoperiod (as measured by civil twilight) is only about 16 hr. and the British pasture strain of perennial ryegrass, *S*.23, has already provided some non-flowering plants when grown in California. For Aberystwyth (52° N.), with a maximum summer photoperiod of about 18 hr., the problem is rather more difficult, since plants with a critical photoperiod above this figure are only likely to occur naturally in arctic or sub-arctic latitudes, thus restricting the initial choice of material. Plants with such high critical photoperiods do exist in arctic regions. Material of *Oxyria digyna* brought back from Jan Mayen Island (71° N.) by Wilson[24] remained vegetative under natural photoperiods at Reading (51° N.), but flowered freely when given continuous illumination.

Another source of non-flowering material lies in selection from within existing late-flowering strains. As already mentioned, outbreeding strains of *Lolium perenne* contain considerable potential genetic variation which is released in each generation by segregation and recombination, and thus becomes available for selection. For example, samples of Kent perennial ryegrass showed a mean date of ear emergence of May 23, 1957, at Aberystwyth, with extreme plants on May 3 and June 5, but three generations of selection for lateness of heading from this strain have produced plants in which heading is delayed until June 21, 1957 (Table 2). The later-flowering strain, *S*.23, might provide even more useful material for selection (see Table 1). One advantage of using existing strains is that they are already fairly well adapted for vigour and herbage production under local conditions.

There remains the possibility of using non-flowering mutants. These have been recorded from inbred progenies of Italian ryegrass at Aberystwyth[25]. Natural mutants occur infrequently, but induced mutants might be obtained by irradiation.

Whether the non-flowering plants are derived from collections from high latitudes, or by selection from within existing strains, they will provide only raw material for further breeding and selection. They may, for example, lack the ability to grow at low temperatures in the spring, a character which could then be introduced from Italian ryegrass.

Even when non-flowering plants of satisfactory performance have been obtained, the problem arises of seed supply on an economic basis. Obtaining seed from small lots of non-flowering plants, either for breeding purposes or for the production of foundation seed, offers no problem. Flowering may readily be induced by extension of the day-length using incandescent lamps of low wattage, the plants being kept outdoors or in an unheated greenhouse. In long-day plants, it is the length of the dark period which is important in preventing flowering, and reproductive development can be induced by a short break in the middle of the dark period. Artificial light, therefore, need only be used for a short time at midnight, and has in fact been employed for this purpose in the production of sugar beet seed in breeding nurseries in the United States.

For larger quantities of seed, artificial lighting is not practicable, and seed production would have to be carried out at higher latitudes, where the day-length is adequate for floral induction. In Britain, this would mean growing seed crops in the north of Scotland, preferably above latitude 58° N. A strain could probably be selected which would flower at that latitude, and yet remain vegetative in the south of England. The flowering and vegetative limits of such a strain would be an integral part of its description.

The farther north the strain is to be used for pasture, the more difficult it will be to produce a non-flowering strain, since there will be fewer areas suitable for seed production. To obtain a strain which would remain vegetative everywhere in Britain, for example, seed would have to be grown on a commercial scale at latitudes above 60° N., probably in Scandinavia.

Although the biochemical basis of the photoperiodic response is not yet fully understood, it seems probable that in the future it will be possible to induce flowering in unfavourable photoperiods by suitable chemical treatment, thereby removing the main difficulty of seed production in non-flowering strains.

In conclusion, it seems clear that the production of non-flowering strains is now technically possible, but their economic use in farming practice will depend largely on the cost of seed production. It is suggested that the development and testing of such non-flowering strains deserve serious consideration.

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RADIOMETRIC AND GEOCHEMICAL SURVEY TECHNIQUES

At the Geophysical Discussion of the Royal Astronomical Society held on January 31, Sir William Pugh introduced four invited speakers. He referred to the importance of atomic energy to our national economy and added that, although we had recently heard of the possibilities of the controlled release of thermonuclear energy, the present reactor programme was based upon uranium as the main fuel element. In view of this, and of the increased demands for rarer metals of value to our expanding industries, he stated that it was particularly appropriate to discuss radiometric and geochemical methods of prospecting at this time.

Mr. S. H. U. Bowie, in opening the session, recalled that prior to the Second World War only two mines, namely, Shinkolobwe in the Belgian Congo and Eldorado in Arctic Canada, produced significant tonnages of uranium ore ; but, as a result of the intensive search during the past decade, more than 300 mines were now in production. Most of the discoveries had been made by the sound application of geological knowledge aided by instruments capable of detecting and measuring the gamma radiations from near-surface mineral occurrences. Both Geiger–Müller and scintillation counters are used in prospecting, and a variety of different instruments had been designed for specific purposes. The choice of a suitable instrument depends largely on the degree of reproducibility sought. If no allowances are made for terrain factors such as local topography, absorption of gamma photons by soil cover, or disequilibrium between uranium and its daughter elements due to weathering, a high statistical accuracy in the measurement of count-rate is unnecessary. Thus, a light-weight ratemeter, which averages the pulse-rate over a short period of time and has a count-rate of one or two pulses per second over flat-lying bedrock of a grade equivalent to 0·001 per cent equivalent U_3O_8, is adequate for preliminary prospecting purposes. More sensitive instruments are necessary for use by geologists in the detailed gridding of an area of anomalous radioactivity. In car-borne and airborne surveys, where the average radioactivity over intervals of traverse is recorded, scintillation counters of high sensitivity are necessary. For example, to obtain a count-rate of an accuracy of 10 per cent over 50-ft. intervals of traverse at a speed of 30 m.p.h., the count-rate of the instrument would have to be about 85 pulses per second over the same low-grade bedrock.

Airborne ratemeters designed by the Atomic Energy Research Establishment have single or triple thallium-activated sodium iodide crystals each $4\frac{5}{8}$ in. in diameter and 1 in. thick coupled optically to a photomultiplier tube. Flight altitude and lane widths are dependent on the geology of the terrain to be surveyed, but two general techniques have been evolved. In one, flying is undertaken at an altitude of 500 ft. and at lane-widths of a quarter of a mile ; in the other, the altitude is usually between 200 and 300 ft. and the lane-widths reduced accordingly.

Mr. Bowie concluded by saying that because of the ease with which uranium and thorium can be detected by geophysical means, geochemical techniques were not so important in the search for uranium as in the search for base metals. However, because of the high degree of mobility of the uranyl ion $(UO_2)^{2+}$ in solution, the detection of uranium in run-off water, particularly in river basins draining mountainous or forested country, was a valuable aid in the delineation of favourable areas.

Dr. J. S. Webb, who followed, said that geochemical methods of mineral exploration are based on the premise that diagnostic disturbances in the normal distribution pattern of chemical elements may exist in accessible material in the vicinity of concealed ore deposits. Such geochemical anomalies result from the natural dispersion of elements from the site of the parent deposit and are commonly sought by the systematic sampling and analysis of rock, soil, vegetation, stream water and stream alluvium.

Geochemical dispersion patterns are subdivided into two genetic categories, namely, *primary dispersions* formed in depth at the time of mineralization, and *secondary dispersions*, which are usually formed in the zone of weathering. Primary dispersion patterns may occur as regional variations in the trace element content of rocks and minerals associated with metallogenic provinces, aureoles of impregnation in the wall-rocks surrounding individual deposits, or 'leakage' dispersions of trace metals in the channel-ways followed by mineralizing solutions. In all cases, the primary dispersion is genetically related to the ore-forming processes. The interpretation of the geochemical anomalies in terms of the location of possible associated deposits is often difficult and is dependent on the understanding of the local geology. Secondary dispersions, on the other hand, are usually associated with the weathering cycle, and although the dispersion processes are complex, considerable progress has been made in the development and application of techniques having a proved practical value in prospecting. This is particularly true of geochemical soil surveys in areas of residual overburden, where the methods have been successfully used for detecting the presence of sub-outcropping deposits of copper, nickel, arsenic, gold, antimony, chromium, tin, tungsten, molybdenum and other metals.

At times, positive results have been obtained where copper, lead and zinc mineralizations have been concealed by transported glacial cover up to some tens of feet thick. Here, the metals have had the opportunity of migrating upwards into the overlying material by diffusion and other processes, including the growth of vegetation which has extracted the ore metals as part of its nutrient uptake. Although the systematic analysis of the plants themselves has been employed on occasions, it is normally found more practicable to sample the underlying soil wherein metal has accumulated over generations in the biogeochemical cycle. Geochemical soil and vegetation anomalies are usually restricted to the immediate vicinity of the parent mineral deposit, but abnormal concentrations of metal may sometimes be detected in the surface drainage system up to several miles downstream from mineralization. Where such geochemical dispersion does exist, the systematic sampling of stream water or alluvium may constitute a useful aid in the rapid mineral reconnaissance of comparatively large areas. Sampling and analysis of stream alluvium for metals extractable at normal temperatures have given particularly encouraging results in reconnaissance for copper and base metal deposits.

The practical application of geochemical methods has been made possible only by the development of extremely rapid, simple tests and there are now trace analytical techniques for a wide range of metals capable of being performed with adequate accuracy by semi-skilled personnel. For the most part, these tests are simplified versions of classical colorimetric and chromatographic methods, although spectrographic, fluorimetric and other procedures may be utilized for particular problems.

Current research is active and aimed at broadening the scope of existing methods, extending knowledge of dispersion processes, investigating the regional approach to comprehensive geochemical reconnaissance and developing appropriate analytical techniques. Progress in the application of geochemical techniques indicates that, when used in conjunction with geological, geophysical and other sources of information, they will play an increasingly greater part in modern mineral exploration.

Mr. J. E. T. Horne next spoke on the determination of the age of radioactive mineralization and the importance of this in the search for further deposits. Knowledge of the age relationships between a mineralization, its enclosing sediments, and any igneous activity in the area could give, in many instances, a clearer indication of where to look for further occurrences. Such information was also valuable in understanding the genesis of ores, particularly in deciding between epigenetic and syngenetic origins. An example of a detailed age study that had led to practical results was the work of the United States Geological Survey on the uranium mineralization of the Colorado Plateau. There, field evidence had suggested a mineralization penecontemporaneous with the Triassic and Jurassic sediments, but analysis of more than fifty samples pointed to a late Cretaceous or early Tertiary age. This conclusion assisted in guiding a most successful prospecting and drilling programme.

Mr. Horne outlined the principles of dating uranium and thorium minerals from the four ratios lead-206/uranium, lead-207/uranium, lead-208/thorium and lead-207/lead-206, and discussed some of the factors responsible for the frequent lack of agreement in the derived ages. Formerly, the fact that lead/lead ages are commonly higher than the lead/uranium ages was attributed to the loss by diffusion of radon generated in the uranium-238 series, but laboratory measurements had failed to substantiate such loss in most cases. Lead derived from uranium and thorium before the deposition of a radioactive mineral and incorporated in it at the time of formation would seriously affect the apparent ages, and there was good evidence that such original radiogenic lead is present in some ore deposits. In this case, not only did all the apparent ages differ from one another, but also they were all too high. A third major cause of discrepancy was the loss of lead, either recently by leaching or earlier by solid diffusion. It was interesting that leaching experiments on some materials had effected a differential loss of lead-208 with respect to the other lead isotopes, indicating a difference in the distribution of uranium and thorium in the mineral. Finally, age discrepancies might arise from the loss of uranium or thorium and it was imperative to minimize this effect by obtaining the freshest possible material.

Age determination was not simple, but neither should it be dismissed as thoroughly untrustworthy. Some deposits were much more difficult to date than others ; these latter required the analysis of a comprehensive set of carefully selected samples, supported by meticulous observations in the field and mineralogical laboratory. Processes postulated to account for discrepancies must be established beyond reasonable doubt by independent evidence.

The last of the four principal speakers, Dr. W. Bullerwell, approached radiometric methods in borehole logging by discussing geophysical logs in general. He indicated, with examples from a deep boring for coal, how such records assist where core-recovery is poor and how geophysical marker horizons can help correlation between adjacent uncored boreholes. He stressed the importance of obtaining physical data on the properties of rocks from measurements made *in situ*, as the information so obtained could be applied in interpreting surface geophysical surveys. The continuous nature of the records also facilitates sampling and the averaging or integration of physical properties over a column of strata.

Just as classical studies first concentrated on natural radioactivity and later turned to activation methods, so borehole measurements of natural gamma radiation were followed by neutron techniques. For natural radiation measurements, ionization chambers, Geiger counters and scintillation counters have been used. The latter have a shorter 'active length' and this gives improved discrimination of thin beds. A relatively recent development is the scintillation spectrometer, which is capable of differentiating between the various energy-levels of incoming gamma rays. Since different elements are associated with gamma rays of differing energies, it becomes possible, in some instances, to obtain an indication of the nature of the nuclides responsible for the radioactivity by studying the pulse height distribution.

In neutron methods a neutron source is lowered into the borehole, followed by a detector. Neutrons will be captured by nuclei of the atoms that make up the surrounding rock, and the gamma rays emitted during these reactions can be recorded on a gamma detector. Similarly, if a neutron detector is used the distribution of neutrons in the borehole can be studied. Neutron sources commonly used, for example, radium–beryllium, also emit gamma rays, and it is necessary to shield the detector from the source in both neutron–neutron and neutron–gamma methods. Compton scattering and natural activity of the formation add complications. In gamma–gamma logging, which combines a gamma source and gamma radiation detector, scattered radiation, however, provides information related to formation density. Neutrons lose most of their energy in collisions with hydrogen, and as this element is abundant in both water and oil, neutron logs are important for porosity studies in oil exploration. In mentioning the combination of a neutron source with a scintillation spectrometer as detector, Dr. Bullerwell said that this would seem to offer the possibility of obtaining geochemical data by a geophysical method. A miniature Van de Graaff particle accelerator, 3 in. in diameter, 47 in. long and generating 200,000 V., has been used to produce an intense beam of neutrons during borehole experiments in the United States.

Radiometric logging methods have been applied in widely differing fields. Applications to detailed studies of radioactive ore-deposits are usually quite direct and closely controlled by assayed samples. Quantitative comparisons between sedimentary formations in oil-wells or deep structural boreholes, however, are complicated by varying conditions of observations. Calibration of instruments provides little difficulty, but ancillary data must be recorded to permit adequate correction for variations in borehole-diameter, mud-density, cement collars and thickness of casing. In concluding, Dr. Bullerwell stressed that these methods provide basic geophysical information, and he expressed the hope that should the proposal to drill a deep borehole to explore the Mohorovičić discontinuity come to fruition, then the opportunity to obtain a comprehensive series of geophysical logs should not be overlooked.

The chairman closed the meeting after a short informal discussion in which several speakers took part.

S. H. U. Bowie

CLIMATE, VEGETATION AND LAND UTILIZATION IN THE HUMID TROPICS

At the Ninth Pacific Science Congress, which was held at Bangkok, Thailand, during November 18–December 9, two days were devoted to a symposium on climate, vegetation and land utilization in the humid tropics, in which some eleven speakers dealt with different aspects of these closely related subjects. In addition to papers read by their authors, a few papers were read on behalf of contributors who were not present, and some invited guests, including one of the present writers (P. W. R.), who did not prepare papers, were asked to contribute to the discussions. The convener was Dr. F. R. Fosberg (Pacific Vegetation Project, Washington, D.C.), and the symposium was organized, and its proceedings will be published, with the financial support of Unesco. As so often happens, the time allotted for general discussion proved insufficient; nevertheless, a valuable opportunity was provided for an exchange of ideas between workers in different disciplines which do not come often enough into contact.

At the outset there was the question of definition: What do we mean by the tropics in general and by the humid tropics in particular? Broadly, as Dr. Fosberg said in his opening remarks, the two belts of trade-winds blowing towards the equator and the shifting belt of calms or doldrums are of greatest importance in defining these regions. Dr. David I. Blumenstock (Hawaii), who contributed a paper on the characteristics and distribution of tropical climates, expanded this by reminding the Congress of the special significance of weather or circulation regions, such as the monsoon region and, perhaps surprisingly, the hurricane areas; he regarded the tropical climatic realm as best defined as the region within which the temperature of the coldest month in the lowlands averages at least 64·4° F. (18° C.), with the included upland and mountain areas. In this sense the lowland humid tropics are the frost-free areas of the world, where the unique features are in the illumination and radiation regimes rather than in that of insolation. Dr. Blumenstock considered that radiation is a more important factor than previously believed. In regard to temperature he emphasized the importance of extremes; in regard to moisture, the significance of dew and the variability of rain through the year.

Dr. C. G. G. J. van Steenis (Leyden) and Dr. Carl Troll (Bonn) dealt, respectively, with the lowland and the mountain vegetation of the tropics. In the course of a very comprehensive review of tropical-vegetation types, van Steenis took the discussion away from mathematically defined climatic types to vegetation types related to different phytoclimates. After briefly discussing plant life-forms and the use of individual plant species as climatic indicators, he proposed a system of ten 'fundamental' climatic types of tropical lowland vegetation. This was later criticized by Prof. P. W. Richards as consisting of a mixture of climatic, edaphic and seral types of very unequal importance in the tropics as a whole. Dr. Troll made out the case for six altitudinal zones of tropical mountain climates, again based chiefly on vegetation. He demonstrated the use of thermo-isopleth diagrams and stressed the importance of frost in determining the altitudinal zones in the tropics.

A trend away from the definition of tropical climatic types in terms solely of a mathematical interpretation of figures, and towards one based on their influence on vegetation and crops appeared in the contributions of Dr. F. Egler (Aton Forest, Connecticut) and Prof. P. Dansereau (Montreal); the former, in fact, stated the case for the geographer's approach (though he did not refer to it as such, but called it 'holism') in suggesting that climate, soil and vegetation must not be regarded, as they sometimes have been in the past, as mutually exclusive fields of study.

The sad death of Dr. R. L. Pendleton and the illness of Dr. D. L. Bramao left the preparation of a statement on tropical soils to Dr. R. Dudal (Food and Agriculture Organization). Although he described his paper as a hurriedly prepared draft and it was not available to the Congress until the symposium was over, his succinct oral presentation conveyed conviction that at last a logical classification of tropical soils was being worked out. Where tests had been made, in Java and Borneo, the ten types in the scheme proposed arrange themselves in a logical sequence related primarily to relief—slope and drainage. The principle that the soil types are related to a certain range of land-forms as well as to vegetation was in line with points made by Dr. Egler and later by Dr. Christian.

The whole symposium stressed the need for the survey or observational approach to many of the problems. The huge areas in tropical Australia, Papua and New Guinea surveyed from the air and mapped under his direction led Dr. C. S. Christian (Commonwealth Scientific and Industrial Research Organization) to ask how best the results may be utilized. He saw that the land must be considered as embracing all factors of importance to man's well-being. Specific areas identifiable by their 'major observable inherent features' (of topography, soil, vegetation and climate) are termed by Christian 'land units' grouped into 'land systems'. These are more or less equivalent, respectively, to the 'stows' and 'tracts' of J. F. Unstead, and because of the other uses of the word 'system' as applied to land, 'tracts' is perhaps a safer word to use.

The cartographic approach to the problems discussed in the symposium was dealt with particularly by Prof. Henri Gaussen (Toulouse), who exhibited a number of the vegetation maps of France and other countries produced by his laboratory. He suggested the publication of a series of maps of vegetation in the tropics on the scale of 1 : 1,000,000, the only scale on which base maps are generally available. Gaussen's scheme agrees essentially with that advocated by the Commission on World Land Use Survey of the International Geographical Union in mapping the vegetation actually present (that is, without making any theoretical assumptions about 'climaxes', etc.), but whereas Gaussen uses only eight types of vegetation—four types of forest, savanna, desert, shores and cultivation—the World Survey considered it possible to go further in separating categories of land-cover; it also thought that the interpretation of the pattern found should be made in explanatory memoirs, while Gaussen believes it possible to indicate ecological conditions by colours on the map itself. The case for these two alternative approaches has been argued before on many occasions. The World Land Use Survey wished to make the maps as objective as possible; the facts can be interpreted in more than one way and if, as Gaussen proposes, the ecological factors believed to be responsible are shown on the map itself, a subjective judgment is necessarily introduced. Given the validity of the underlying assumptions, however, the magnificent quality and value of the Gaussen maps will be generally acknowledged.

If the first day of the symposium may be said to have dealt with the fundamental features of man's environment, the contributors on the second day dealt mainly with the effects, direct and indirect, on these features of man himself. The opening speaker, Dr. E. Aubert de la Rüe (Paris), gave a broad review of the rapid disappearance of the natural plant cover in all parts of the tropics, which in the future may be seen only if national parks and nature reserves are established. Dr. Dioscoro S. Rabor (Silliman University, Philippines) in a communicated paper dealing with wild life in the Philippines made the further point that wild life (that is, mammals and birds) depends on the natural vegetation, and as long as that is conserved it, too, is protected.

Dr. Carl Sauer (University of California) in a communicated paper on "Man in the Ecology of Tropical America" accepted as proved (perhaps rather surprisingly) the view that there was formerly a much larger population in the American tropics and argued for the presence of numerous agricultural tribes even in the forests of Amazonia. Both he and Dr. Ooi Jin-Bee (University of Malaya), who followed with a paper on the distribution of present-day man in the tropics in a historical and ecological perspective, noted the comparatively simple relationship between human distribution and favourable environmental conditions (such as the wet lowlands suitable for rice in south-east Asia) in the past and the changes consequent on the development of exploitable resources. Dr. Sauer held that in the American tropics European livestock were able to range over the former fields of a decimated sedentary population. Whether this was so or not, it is generally agreed that much savanna formerly regarded as climax vegetation does not correlate well with either climate or soil and can only be explained by the destruction of tree seedlings during man's annual burning of grass. Tropical grasses are only palatable to stock when young and tender, hence the need to burn off the old tough stems and encourage new growth. A paper from Dr. R. O. Whyte (Food and Agriculture Organization) here reminded the symposium that scientific management of tropical grasslands has scarcely begun, and that a first step in any area is to try to understand the relationship between grassland and the climatic climax vegetation when the biotic factors of grazing and burning are eliminated.

A major current problem in the tropics is undoubtedly the integration of agriculture and forestry.

A paper from Mr. Colin Marshall (Malaya) emphasized some fundamental truths which are certainly not appreciated by most policy makers in tropical countries at the present day. The increase of population with the spread of Western medical, sanitary and economic systems in tropical countries makes scientific land-use planning and its acceptance by governments and peoples absolutely essential. It is perhaps because scientific forestry—the intelligent management of forested land on a sustained yield basis—has been imposed on the peoples of tropical Asia from outside that in their new-found independence there is an undoubted tendency to regard forest reserves not as an attempt to conserve a valuable resource or to control soil erosion and make good use of land unsuitable for other economic use, but as a restriction on the liberty of the people. The creation of useless wastes in many parts of the world is due to the mistaken concept that forest is simply an impediment to be destroyed in order to free land for grazing and cultivation. Nothing is more important than that forests should be maintained to perform their many functions in a balanced land economy; only land which can be used more effectively in that way should be turned over to cultivation.

This leads on to the question of shifting cultivation, which was dealt with by Dr. Karl Pelzer (Yale University), who, however, wished to replace the term 'shifting cultivation' by 'swidden farming'. It is not wholly bad, he said, as is sometimes maintained. Where it is a deliberate agricultural technique (as with 'bush fallow' in parts of Africa) the cultivator knows the value of rotating his patches of cultivation to maintain soil fertility and can be regarded as conservation-minded. Yet the forester recognizes the extravagance of a system in terms of land, which prevents the regeneration of natural forest or economic timber while maintaining the land almost completely idle for perhaps a dozen years out of fourteen. In exceptional cases, useful quick-growing trees such as *Casuarina* are deliberately planted in the fallow period, but normally there can be little doubt that the substitution of some other system or systems is vital and urgent. But what other systems? Almost certainly not the permanent dry-field cultivation of annual plants practised in mid-latitudes. The right use of many upland tropical areas is in perennial, especially tree, crops; while in many lowlands wet rice fields are not only a productive form of cultivation but ensure a well-guarded soil. In other words, agricultural developments must be integrated with physical conditions.

Prof. Dudley Stamp, in a paper on "Land Use in the Humid Tropics: Living Space and Recreation", directed attention to uses of land other than for food production; man can indeed not live by bread alone. The need of land for housing, industry, defence and recreation competes with the need of land for agriculture. In crowded countries where there is difficulty in deciding between alternative uses of land in the national interest, three principles may be applied—that of optimum use, that of multiple use, and that of the elimination of waste land.

In the concluding paper of the symposium the chairman and convener, Dr. F. R. Fosberg (Washington), considered man from an ecologist's point of view. Hitherto, he pointed out, man has behaved as a pioneer species, increasing rapidly in numbers, drastically altering his habitat, and using up the resources on which he depends at a rapid and accelerating rate that definitely places a limit to their duration; in the case of some of them this limit is already being approached. It may be, however, that with the development of the faculty of intelligence man has within his power the choice of behaving either as a pioneer organism, destroying its habitat and consequently soon disappearing from it, or as a climax organism preserving its habitat and learning to live in equilibrium with it. If this is to happen, the sciences of geography and ecology must take the lead in determining how to establish a permanent equilibrium between man and his environment. Ecology must perform, on a scale not heretofore imagined, its function of integrating the data provided by other sciences, including the social sciences. Though the magnitude and difficulty of this task may make it seem impossible, our courage in attacking it may well determine the future of man on earth.

In summing up the symposium, Prof. Dudley Stamp said that every paper led to the same conclusion—with increasing pressure of population there must be conscious planning of land use and resources firmly based on scientific knowledge as well as on an appreciation of the varied needs and desires of human beings. This is particularly true of the humid tropics, where in many parts there are vast resources but few people, and so still hope of avoiding the worst blunders made in cooler lands. There must be mutual co-operation between planners and users as well as between different users. Our case is hopeless if we continue to regard the forester and agriculturist as enemies or the conservation of fauna and flora as inconsistent with the economic development of resources; the varied aims, all desirable in themselves, must be co-ordinated into one comprehensive plan.

The first thing that is required is an inventory and appraisal of resources, which should take the form of a factual land-use survey preceding any attempt at interpretation. A few examples of such surveys from the humid tropics are the magnificent reconnaissance maps of Ghana, the recently completed outline survey of the Sudan, the aerial survey of Pakistan, the recently commissioned air survey of Burma, the survey of Samoa carried out by the University of New Zealand, the fine detailed maps of Hong Kong prepared by the University, the detailed maps of Taiwan and, if one may stretch the tropics so far, the superlative detailed maps of Japan. All these follow broadly the recommendations of the Special Commission of the International Geographical Union approved at a meeting sponsored by Unesco in 1950.

The field covered by the symposium was an immensely wide one, but Prof. Dudley Stamp thought it covered only half the main problem. The other half is the human angle. The whole purpose of planning and rational land utilization is to secure an increased standard of living and a fuller measure of life for the people. What, in fact, do people want? Are our Western concepts of the standard of living the right ones? May not our search for efficiency be destroying values far more worth-while? He mentioned these points to emphasize his belief that the demographer, the sociologist and their many colleagues must carry out studies parallel to those with which the symposium had been concerned. It is difficult to plan unless one knows what one is planning for.

L. DUDLEY STAMP
P. W. RICHARDS

OBITUARY

Prof. H. A. Kluge

News has only recently been received of the death of Prof. Hermann A. Kluge on December 25, 1956. We are much indebted to Mrs. Helen Androsova, of the Zoological Institute, Leningrad, who has supplied the biographical details for this notice.

Kluge was born in Radom, Poland, in 1871, and graduated in 1896 at the University of Kazan, taking his master's degree and becoming *Privat-docent* there in 1899. He had already gained the gold medal of the University for his first research investigation (on the natural history of the freshwater Polyzoa), and had studied in 1897 at the Solovetski Biological Station on the White Sea. His major scientific interests for the rest of his life, the Arctic and the Polyzoa, were thus established. Between 1900 and 1907, in preparation for his doctor's degree, Kluge studied at the Zoological Station at Naples, and also at museums in Germany, Sweden, Denmark and England, where he paid particular attention to the collections of Polyzoa from the various oceans.

Returning to Russia, Kluge began to work on the previously unstudied collections of Polyzoa from Russian seas in the Zoological Museum (now Institute) of the Academy of Science at Leningrad. He continued this work throughout his life, and the resulting series of papers demonstrated the existence in Russian Arctic waters of some 350 species of Polyzoa, many of them new. Two important contributions, on which he had worked for many years, are to be issued posthumously. Kluge's investigations also extended to the Polyzoa of West Greenland and the Antarctic. The care and accuracy of his descriptions and fine drawings, which are typical of all his work, are well seen in his monograph (1915) of the Anascan Polyzoa of the Deutsche Südpolar Expedition of 1901–3, perhaps the best known of all his publications to European workers. He also wrote on such little-studied groups as the Kamptozoa, *Rhabdopleura* and the cirripede *Dendrogaster*.

But all this was only part of Kluge's scientific life. From 1908 until 1933 he was director of the Murman Biological Station in Kola Bay, where he remained as a scientific worker after his retirement. Though not a large institution, it has been described as a model of its kind, with an excellent aquarium, a good library and museum, and well equipped for marine biological investigations. In 1934 Kluge visited the north of Novaya Zemlya, where he spent the winter at the polar station at Cape Zhelaniya. He was also one of the founders of the Arctic Museum in Leningrad, of which he was director for some time.

Kluge devoted his life and energy to the study of the zoology of the austere far north. Our knowledge of the biology of the Arctic Ocean owes much to him.

Anna B. Hastings
H. Dighton Thomas

NEWS and VIEWS

Sir James Swinburne, Bart., F.R.S.

Sir James Swinburne celebrated his hundredth birthday on February 28. Sir James, who until 1953 was chairman of Bakelite, Ltd., and who is now honorary president of the Company, is a distinguished engineer and one of the world's pioneers in the field of synthetic resins. His original work on phenolic resins at the beginning of the century made a major contribution to the development of the modern plastics industry. During his long life Sir James Swinburne has had many interests. In addition to being a Fellow of the Royal Society, he is past president of the Institution of Electrical Engineers, a past president of the Faraday Society, and a member of the Institution of Civil Engineers. He has always been interested in sociology and among his publications is the work "Population and the Social Problem". He has also been keenly devoted to music, and one of his early interests was the electric organ. Another of his hobbies is horology, and he has published books and papers on this subject. Sir James has now retired from active occupations to Bournemouth.

Social and Preventive Medicine at Belfast: Prof. A. C. Stevenson

Prof. A. C. Stevenson, head of the Department of Social and Preventive Medicine in The Queen's University, Belfast, will vacate his chair on April 1 to take up a new appointment as director of a Medical Research Council Population Genetics Unit. Prof. Stevenson joined the Department in 1948, after holding the post of senior lecturer in public health at the London School of Hygiene and Tropical Medicine. Prof. Stevenson has taken an active interest in the affairs of the Institute of Clinical Science, in which his Department is housed, which has given him ample opportunities for research in the field of genetics. Fortunate in having a defined population of convenient size for study in Northern Ireland, he has made a detailed study of the distribution of several harmful genes, including those involved in the transmission of myoclonic epilepsy, muscular dystrophies, congenital malformations, achondroplasia, epiloia, rheumatic fever, deaf mutism, retinoblastoma and tylosis palmaris et plantaris. Prof. Stevenson is the author of "Recent Advances in Social Medicine", published in 1950 by Churchill (London). In 1953 he was one of a team of medical scientists which visited Indonesia to study the public health problems and needs of that country for the World Health Organization.

The increasing hazards from ionizing radiation have directed attention to the fact that we have very few data on the genetic effects of radiation on human beings. Further information is required on the genetic structure of human populations and there is an urgent need for the collection of more information on fertility, consanguinity and mortality. The formation of a Medical Research Council Unit for the study of population genetics is a step in the right direction, and Prof. Stevenson's experience in Northern Ireland should stand him in good stead as head of the new Department.

Dr. J. Pemberton

Dr. John Pemberton, reader in social and industrial medicine in the University of Sheffield, has been appointed to succeed Prof. Stevenson. After working with Sir John (now Lord) Boyd Orr at the Rowett Research Institute, Aberdeen, in charge of a mobile nutritional research team, he went to Sheffield in 1940 as medical first assistant at the Royal Hospital, becoming medical tutor in 1941. During this time he maintained his interest in nutritional matters, working with Prof. H. A. Krebs on the extremely important experiments on deficiency of vitamin C in human volunteers. In 1946 he was appointed senior lecturer in medicine (social aspects) and student health officer in the University. In the next few years he carried out some extremely valuable studies on illness in general practice and socio-medical studies of hospital in-patients. In 1949 Dr. Pemberton joined the newly formed Department of Social and Industrial Medicine at Sheffield as senior lecturer, becoming reader in 1957. He has maintained contact with the hospital by accepting appointments as honorary consultant physician to the City General Hospital, where he has beds, and to the United Sheffield Hospitals, where he ran an out-patient clinic. He has played a most important part in developing the teaching and research programme of the Department, being particularly concerned with the running of the social medicine clerkship, and with the organization of case demonstrations and colloquia. With Prof. W. Hobson and Dr. H. Droller he helped to organize a medical survey of old people in their homes in Sheffield. In 1955 the results of this work were published in a book, "The Health of the Elderly at Home", of which he was joint author, and he was awarded jointly a prize of £100 for original work in geriatrics by the Ciba Foundation.

During 1953 Dr. Pemberton visited the United States to study teaching methods in American medical schools, and in 1954 spent a year at Harvard School of Public Health, working on the epidemiology of chronic bronchitis. His work in the United States resulted in his founding, with Dr. Harold Willard, the International Corresponding Club, of which he is the co-secretary. The Bulletin issued by the Club has been an outstanding success in making known to workers all over the world the developments in teaching and research which are going on in social medicine. In September 1957 he organized an International Study Group in Holland, financed by the Rockefeller Foundation. In 1957 a Medical Research Council group for epidemiological research on air pollution was formed in Sheffield, with Dr. Pemberton as director. His recent published work has been concerned with geriatrics, air pollution and respiratory disease.

National Physical Laboratory : Dr. E. Lee

Dr. Edward Lee, who is at present director of operational research in the Royal Naval Scientific Service, has recently been appointed to the new post of deputy director of the National Physical Laboratory. The deputy director will assume the main responsibility for work in the National Physical Laboratory which is closely geared to immediate demands from industry. Dr. Edward Lee was educated at Consett Grammar School and graduated at the University of Manchester with first-class honours in physics. After taking an M.Sc. degree at Manchester and a Ph.D. at Cambridge, he joined the Royal Naval Scientific Service in 1939 and was posted to the Admiralty Research Laboratory. In 1946, Dr. Lee joined the Defence Research Policy Staff at the Ministry of Defence and from then until 1951 his work was mainly concerned with relating Service research programmes to the scientific effort available and Service requirements. He has been director of operational research at the Admiralty for the past three years.

Reorganization of the National Physical Laboratory

During 1957, a comprehensive review of the organization and programmes of work of the National Physical Laboratory was carried out by a committee of the Research Council of the Department of Scientific and Industrial Research. As a result, certain changes in organization will be introduced about the end of March. One of the most important is a reorganization of the work at present carried out in the Divisions of Electricity, Metrology and Physics and in the Test House. These four units will be replaced by three new Divisions to be called Standards, Applied Physics and Basic Physics.

The Standards Division will be responsible for all fundamental work on standards of length, mass and time ; of electrical and magnetic quantities and also of temperature. Basically, it will consist of the present Metrology Division, expanded to include certain work on standards now carried out in the Electricity and Physics Divisions. The superintendent will be Dr. H. Barrell, at present in charge of the Metrology Division. The Applied Physics Division will be responsible in general for work in the field of classical physics of fairly immediate value to industry (excluding optics, which will continue in the Light Division). The principal areas covered will be electrotechnics, acoustics, heat and radiology. Test House, which has hitherto come under Administration, will become an integral part of this Division, but will preserve its identity under Mr. H. Bowley. The superintendent of the Applied Physics Division will be Dr. B. Wheeler Robinson, at present in charge of the Physics Division. The Basic Physics Division will be responsible for pioneering developments in certain branches of non-nuclear physics which have potential industrial applications in the less immediate future. The post of superintendent of this Division is at present vacant.

Expansion of Universities in Britain

A provisional building programme for university expansion, totalling £60 million during 1960–63, and including the foundation of a University College of Sussex, has been authorized by the Chancellor of the Exchequer. Announcing this in the House of Commons on February 20, Mr. Heathcoat Amory said that the programme would be subject to review if the economic situation changes substantially. The increase contemplated in the current rate of building is necessary if Britain is to secure the full benefits of future advances in science and technology, and it should be possible to achieve an increase from 106,000 to about 124,000 students by the mid-1960's, with a possible temporary rise of 10 per cent in the second half of the decade, an increase which may well prove to be permanent. Nearly two-thirds of the expansion will be devoted to faculties of science and technology of the existing universities and colleges of technology, which will enable the figure recommended by the Committee for Scientific Man-power to be reached and the number of scientists and engineers to be doubled. The education estimates, Mr. Amory added, would be £26·5 million higher next year.

In a written answer to a question in the House of Commons on the same day, Mr. Amory said that most universities are apparently dissatisfied in varying degrees with the grants allocated to them by the University Grants Committee, especially for the first two years of the quinquennium. The quinquennium settlement provides, however, for grants 8 per cent higher in the current academic year than in 1956–57, rising by a further 30 per cent over the next four years. To these will be added supplementary grants in respect of the cost of salary awards effective from last August, making the total grant 20 per cent higher in 1957–58 than in 1956–57.

It is proposed that the University College of Sussex should be built at Brighton, where the Corporation has offered a site of about 150 acres at Stanmer Park on the Lewes Road. Negotiations between the University Grants Committee and a committee representing the five local education authorities of Sussex and their education officers are at present in progress.

Nuclear Reactor Safety

The Parliamentary Secretary to the Minister of Power, Sir Ian Horobin, in a written reply in the House of Commons on February 10, said that the Government intended to introduce legislation to ensure, by a system of licensing and inspection, that nuclear reactors on land were effectively subject to control in the interests of public safety. Owners of such reactors would, like the Atomic Energy Authority, be required to prevent damage to property or personal injury from radioactive contamination and would be liable to pay compensation for such damage even from an unavoidable accident, except to the extent to which there was contributory negligence on the claimant's part. It was proposed to limit compensation in respect to any one incident to £5 million for each installation, and the insurance market was prepared to provide the necessary cover. The liability of the Atomic Energy Authority would not be affected, but problems of reactors in ships, submarines and aircraft required further study with regard particularly to the international aspects.

Technical Co-operation in Africa South of the Sahara

In a written answer in the House of Commons on February 5, Mr. Ian Harvey, replying for the Secretary of State for Foreign Affairs, said that the Government and other members of the Commission for Technical Co-operation in Africa South of the Sahara have agreed to set up a Foundation for Mutual Assistance in Africa South of the Sahara. The Foundation is designed to facilitate and encourage the provision of technical assistance for that region and would be inaugurated at Accra at the end of February. The House would be asked to approve provisions for a United Kingdom contribution of technical assistance through the Foundation, which would be under the general direction of the Commission with a combined secretariat.

Land for Service Requirements

The Land Powers (Defence) Bill, which is the first major Bill to implement the Government pledges in the debate on the Franks report, seeks to terminate Defence Regulations relating to land and to make permanent provision for the much more limited powers required for defence purposes in time of peace. Speaking in the House of Commons on February 10 on the second reading of the Bill, Mr. G. de Freitas said that in England, War Office holdings amounted to 1·47 per cent of the land; in Wales, 1·07 per cent; and in Scotland, 0·24 per cent. Asking for more information on the Government's policy on land for Service training, he stressed the need for knowledge of total Service requirements if supplementary requests were to be handled intelligently. The tendency should be for less and less land to be required by the Services but, after referring to the co-operation during the past year with the Nature Conservancy, of the War Office at Braunton Burrows and of the Royal Air Force at St. Kilda, as outstanding examples of the possibility of meeting the requirements of the Services side by side with those of scientific research, Mr. de Freitas pointed out that there were examples to the contrary. While accepting the general principle of the Bill, it was essential to see that the safeguards offered to the public were effective and that the objections of local authorities, the National Parks Commission and other bodies could be thoroughly examined. In his reply on the debate, the Attorney-General, Sir Reginald Manningham-Buller, said that the power to make representations to the Manoeuvres Commission, which was thereupon required to hold at least one public inquiry, was likely to be a much more effective way of protecting the amenity, ornithological and other interests in the land in an area covered by an Order in Council.

New Roads

Replying on a debate in the House of Lords on February 13 on the acquisition of land for roads, the Minister without Portfolio, Lord Mancroft, while agreeing that the announced programme of expenditure on roads of £240 million for the period 1958–62 was not big enough, claimed that it was commensurate with our resources of finance and man-power. Forty large projects on the Great North Road would be authorized by the end of the financial year and work on many was already in progress. Work on the Leicester by-pass, to cost nearly £4 million, was due to finish by the end of 1959. The Kingsferry Bridge in the Isle of Sheppey would cost more than £1 million, the northern approach to the Blackwall Tunnel nearly £2 million, the Birmingham Ring Road, the first stage of which should be finished this year, about £15 million, and work would start in March on a section of the London–Yorkshire motorway, which would be 53 miles long, take 19 months to complete and cost £15 million. The Ross Spur, to start on March 9, would take two and a half years. Much detailed work was involved in the preparation needed for the acquisition of land for road schemes, and the Government was trying to accelerate this work. He hoped in future it would be possible to provide local authorities with a programme approved in principle for three or four years ahead, which would enable them to work out details of the schemes and acquire property in time for the Minister to authorize the grant in the year in which he originally expected to make financial provision. After stressing the importance of flexibility, Lord Mancroft said that the Minister of Transport and Civil Aviation had set up a special planning section which was preparing a twenty- to thirty-year master plan for roads.

The Physics of Fluids

The Physics of Fluids (1, No. 1 (January–February, 1958). Pp. ii+72. Published bi-monthly. Annual subscription rate : 11 dollars. New York : American Institute of Physics, 1958) is a new bi-monthly publication of the American Institute of Physics. It will publish original research papers on the dynamics of flow, waves and shocks and also on the statistical thermodynamics of the fluid state. Particular attention will be given to the mutual interaction between the flow of fluids and electromagnetic phenomena or chemical or nuclear processes. The term 'fluids' is applied by the editors to liquids, including liquid helium, to compressed and rarefied gases and to plasma. The new periodical may owe its existence to the necessity of relieving *The Physical Review* and *The Journal of Chemical Physics*. Research workers in the field of fluid physics will welcome the increase in facilities for publishing their work.

There is a tendency to regard hydrodynamics and the molecular theories of liquids—to name only two significant examples—as somewhat outmoded and to appreciate them only in connexion with their engineering applications. Evidence to the contrary is apt to be overlooked when it is scattered over a number of different journals. In contrast, the first issue of *The Physics of Fluids* presents papers on topics such as the theory of bubble chambers, the effect of radiation on the propagation of shock waves, stability in magneto-hydrodynamics and the statistical quantum mechanics of the electron gas. It is clearly shown that fluid physics is closely connected with contemporary fundamental research. The American Institute of Physics intends to publish *The Physics of Fluids* at monthly intervals if need arises. In the interest of progress in a fascinating branch of science we hope this plan will materialize at an early date.

National Museum, Bloemfontein

The annual report of the National Museum, Bloemfontein, for the year ended March 31, 1957, reflects the activities of a progressive institution. New buildings include a board room, enlargement of the library, and a thatched shelter to protect the exhibits of rock engravings. In addition, the new displays include a diorama of wildebeest, a large diorama of Free State animals and Matjes River material. It is pleasing to note that the appointment of a book-keeper/clerk has enabled the director to give more time to research and the preparation of exhibitions in the Museum.

Clinical Use of Hormones

Information about hormones tends to be widely dispersed among specialized publications, and it is not easy for the ordinary clinician to obtain a balanced and up-to-date view of their status in medicine. *The Practitioner* (180, 5 ; January 1958) has therefore published a symposium of twelve short reviews, dealing with all the hormones now in general use with the exception of adrenaline. The articles are mainly of a practical nature, and discuss such questions as dosage, types of commercial preparations available, and indications and contra-indications for their use. In addition, in the small amount of space available, they provide a surprising amount of general scientific information on the nature and mode of action of the hormones, and they include short bibliographies of important papers and reviews.

The British Lichen Society

A society for the promotion of the study and conservation of lichens, under the title of the British Lichen Society, was formed at a meeting held at the British Museum (Natural History), South Kensington, on February 1, by kind permission of the Trustees. It is hoped eventually to publish a journal ; but in the meantime it is intended to issue lichenological notes and news in the form of a mimeographed bulletin. Particulars can be obtained from the Honorary Secretary, Mr. A. E. Wade, Department of Botany, National Museum of Wales, Cardiff.

University News : Bristol

The following appointments have been made : Dr. T. H. K. Barron, lecturer in physical and inorganic chemistry ; Mr. R. Bradshaw, lecturer in geology ; Dr. R. G. Chambers, senior lecturer in low-temperature physics ; Dr. J. Tinkler, lecturer in aeronautical engineering.

The following have resigned : Prof. G. C. Drew, from the chair of psychology on his appointment to the chair of psychology at University College, London ; Dr. E. J. Field, lecturer in anatomy, on his appointment as senior lecturer in neuropathology, King's College, Newcastle, and the Royal Victoria Infirmary ; Dr. K. Stewartson, reader in applied mathematics, on his appointment to the chair of applied mathematics at the University of Durham ; Dr. H. A. Thurston, lecturer in mathematics, on his appointment to the University of Vancouver.

The following gifts have been received : £7,773 from the British Empire Cancer Campaign for cancer research to be carried out in the Departments of Pathology, Physiology and Surgery, in 1958 ; £1,000 per annum for a period of two years from Messrs. Kodak, Ltd., to the Department of Physics as an extension of the grant in support of experimental work on the physical properties of silver halides ; £967 from the Agricultural Research Council to the Department of Physiology as renewal of the grant in aid of research on bovine acetonæmia for a third and final year from April 1.

Liverpool

Dr. C. A. Clarke has been appointed to a readership in the Department of Medicine.

London

Dr. M. L. Thomson, senior lecturer at the London School of Hygiene and Tropical Medicine, has been appointed to the University readership in applied physiology tenable at that School. The title of professor of pharmacology in the University of London has been conferred on Dr. George Brownlee, in respect of his post at King's College. The title of professor of biochemistry in the University of London has been conferred on Dr. William Robson in respect of his post at King's College. The title of professor of pharmacology in the University of London has been conferred on Dr. Miles Weatherall in respect of his post at the London Hospital Medical College. The title of reader in dental medicine in the University of London has been conferred on Mr. B. E. D. Cooke in respect of his post at Guy's Hospital Medical School. The title of reader in biochemical genetics in the University of London has been conferred on Dr. Harry Harris in respect of his post at the London Hospital Medical College. The title of reader in pharmacology in the University of London has been conferred on Mr. J. P. Quilliam in respect of his post at St. Bartholomew's Hospital Medical College.

Sydney

Prof. J. H. Gaddum, professor of pharmacology at the University of Edinburgh, has been appointed third visiting professor of pharmacology in the University of Sydney. Prof. Gaddum will leave for Australia about the middle of April and will spend approximately two months in Sydney. During his stay in Australia he will lecture in Sydney and other capital cities and will visit the Australian National University in Canberra. A fund has been established by the pharmaceutical manufacturers of Australia to enable the University of Sydney to invite a guest professor in this subject each year.

Vancouver

Dr. R. D. Russell, of the University of Toronto, has been appointed associate professor of geophysics in the University of British Columbia. A chair of geophysics, within the Department of Physics, was established last year by the appointment of Prof. J. A. Jacobs. Research at first will be mainly in the fields of isotope geology and geomagnetism.

The Night Sky in March

Full moon occurs on Mar. 5d. 18h. 28m. u.t., and new moon on Mar. 20d. 09h. 50m. The following conjunctions with the Moon take place: Mar. 8d. 21h., Jupiter 2° N.; Mar. 12d. 18h., Saturn 3° S.; Mar. 15d. 11h., Mars 6° S.; Mar. 16d. 11h., Venus 1° S. Mercury is favourably placed for observation at the end of the month, setting at 19h. 0m. on Mar. 15 and 20h. 20m. on Mar. 31. Its stellar magnitude is $-1\cdot3$ on Mar. 15 and $+0\cdot4$ on Mar. 31. Venus is a morning star, visible low in the south-east before sunrise. It rises at 4h. 50m., 4h. 30m. and 4h. 10m. on March 1, 15 and 31, respectively; its stellar magnitude is $-4\cdot2$. During the month its distance from the Earth increases from 37 to 58 million miles and the visible portion of the apparent disk from 0·227 to 0·450. Mars rises at 4h. 55m., 4h. 30m. and 4h. 00m. at the beginning, middle and end of the month, respectively; it will be difficult to observe. Jupiter rises at 22h. 20m., 21h. 20m. and 20h. 10m. on March 1, 15 and 31, respectively; it is east of Spica. The stellar magnitude of Jupiter is $-1\cdot9$, its distance from the Earth on March 15 being 430 million miles. Saturn rises at 3h. 05m., 2h. 15m. and 1h. 10m. at the beginning, middle and end of the month, respectively; it is east of θ Ophiuchi. It has a stellar magnitude of $+0\cdot7$ and a distance of 930 million miles from the Earth on March 15. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Mar. 1d. 22h. 16·7m., λ Gem. (*D*); Mar. 3d. 18h. 31·5m., ϰ Cnc. (*D*); Mar. 11d. 03h. 02·0m., ν Sco. *m.* (*D*); Mar. 11d. 03h. 31·9 m., ν Sco. *m.* (*R*); Mar. 26d. 22h. 01.4m., 104 Tau. *m.* (*D*); Mar. 30d. 20h. 58·0m., A^2 Cnc. (*D*). *D* and *R* refer to disappearance and reappearance, respectively. The vernal equinox occurs on Mar. 21d. 03h.

Announcements

About £50 is available from the Clough Memorial Research Fund of the Edinburgh Geological Society for geological research in Scotland and the north of England (Northumberland, Durham, Cumberland, Westmorland and Yorkshire) during the period April 1, 1958–March 31, 1959. Applications, stating the nature of the proposed research, should be sent before March 31 to the Secretary, Clough Memorial Research Fund Committee, Edinburgh Geological Society, Synod Hall, Castle Terrace, Edinburgh 1.

The Ministry of Agriculture, Fisheries and Food and the Department of Agriculture for Scotland propose to award, for the academic year beginning October 1, 1958, a number of postgraduate scholarships in the various branches of husbandry, farm management, agricultural economics, statistics, agricultural and dairy engineering, rural estate management and land economics. Awards will also be offered in agricultural science for students intending to pursue a course of postgraduate instruction. The closing date for receipt of completed application forms is March 31. Further particulars and forms of application can be obtained from the Ministry of Agriculture, Fisheries and Food, Room 284, Great Westminster House, Horseferry Road, London, S.W.1, or the Department of Agriculture for Scotland, St. Andrew's House, Edinburgh 1.

A symposium on "Science and Society" will be held in the William Beveridge Hall, Senate House, University of London, on March 19, under the auspices of the Royal Institute of Chemistry, the Institute of Biology and the Institute of Physics. Prof. P. M. S. Blackett will take the chair. The main speakers will be: Prof. L. T. Hogben ("Science and its Social Functions"); Prof. A. Haddow ("The Social Dangers of Science"); Dame Kathleen Lonsdale ("The Social Place of Science"); Mr. Anthony Smith, *Daily Telegraph* (in place of Mr. L. J. F. Brimble, *Nature*) ("The Deployment of Scientific Effort"). Further information can be obtained from the Secretaries of any of the above Institutes.

The British Social Biology Council is holding a one-day conference on "The Making of a Scientist" in the North Hall Suite, Victoria House, Southampton Row, London, W.C.1, on March 22. The conference will bring together men and women from the schools, universities, industries and public services who are concerned with the training of scientists and their employment. It will be open to anyone who is interested in education and science. Tickets for admission are obtainable from the Secretary, British Social Biology Council, 69 Eccleston Square, London, S.W.1. The programme for the morning, under the chairmanship of Mr. J. O. Blair-Cunynghame (National Coal Board), will consist of lectures on: "The Position of the Science Graduate in Industry" by Mr. E. A. Cooke (Imperial Chemical Industries, Ltd.); "Scientists in the Engineering Industry" by Mr. G. S. Bosworth (English Electric); "Fostering the Scientific Attitude" by Prof. J. Z. Young (University College, London). In the afternoon the chairman will be Mr. A. Rodger (Birkbeck College) and the lectures will be on: "Human Relations and Scientific Method" by Miss M. L. Johnson (University College, London); "Industry and the Artist" by Mr. B. Archer (Central School of Arts and Crafts); "Teaching Science: the Need for Research" by Mr. R. Weatherall (Eton College). There will be opportunities for questions and discussion.

Errata. In the communication entitled "Isotopic Tracer Method for measurement of Iron lost into and re-absorbed from Gastro-intestinal Bleeding Lesions" by M. Roche *et al.* (*Nature*, 180, 1278; 1957), par. 3, equation 2 gives the hæmoglobin in gm./100 c.c. and not mgm./100 c.c. as printed; par. 7, line 4, the footnote reference should be 4.

COLUMN PACKINGS FOR GAS CHROMATOGRAPHY

THE second in the series of informal symposia organized by the Gas Chromatography Discussion Group associated with the Institute of Petroleum was held in the Organic Chemistry Laboratory, Cambridge, on October 4. More than two hundred participants attended and four papers were presented. Local organization was carried out by Dr. J. H. Purnell.

After a short welcoming address by Prof. R. G. W. Norrish, Dr. A. T. James, chairman of the Discussion Group, outlined a new organization for the Group which it is hoped to put into effect shortly. This would allow a definite membership open to all workers in the field, and many of those present indicated their interest in the scheme. He also directed attention to the Second International Symposium on Gas Chromatography being arranged by the Group in Amsterdam during May.

Dr. J. J. van Deemter presented an introductory paper on column packings and peak sharpness. He considered the factors contributing to peak broadening in the light of current theories of gas chromatography and discussed the effects of gas velocity, sample size, support particle size and stationary phase proportion, on column efficiency. After considering the latest form of the van Deemter equation, relating the height equivalent to a theoretical plate (HETP) and diffusional effects, he pointed out that a variation in film thickness on the packing would also lead to peak broadening. This effect is probably particularly significant when low proportions of stationary phase are employed. An interesting observation was the fact that resistance to mass transfer in the liquid phase was not, in all cases, dependent on the viscosity of the stationary phase. With silicone oils, variation of viscosity over a hundred-fold range had little effect on column efficiency. Dr. A. J. P. Martin suggested that with linear polymers increasing chain length has little effect on the diffusivity of small molecules.

Mr. R. P. W. Scott then presented a paper describing an experimental investigation of many of the parameters determining column efficiency considered by the previous speaker. The hydrogen flame detector had been employed with a mixture of 75 per cent hydrogen plus 25 per cent nitrogen as carrier gas and a single stationary phase Apiezon Oil *A* supported on Johns-Manville *C*22 insulating brick. An examination of columns prepared from brick powders of different particle size with a constant proportion (20 per cent weight) of stationary phase at 78° C. had shown, as would be predicted by the van Deemter theory, that the smaller particles are more effective. In addition, the importance of a narrow particle size distribution was demonstrated. The best stationary phase/support ratio for short columns a few feet long was found to be 20 per cent w/w, but theoretical plates values above about 3,000 were best obtained by the use of long columns with low proportions of stationary phase, that is, 5 per cent w/w and below. Data were given for a 25-ft. column having an efficiency of 10,000–12,000 theoretical plates which would partially resolve *para*- and *meta*-xylenes on a volatility basis.

The afternoon session opened with a paper by Mr. C. S. G. Phillips on the use of metal salts as column liquids. Copper and zinc stearates and nickel oleate had been examined, the stearates at 156° C. and the nickel salt at 97° C. Although with hydrocarbons and other non-polar compounds separations were similar to that obtained with conventional stationary phase liquids, with amines, for example, strong co-ordination forces to the metal atoms produced new types of separations markedly dependent on steric factors. Several thousandfold differences in retention times could be obtained in favourable cases. Mr. Phillips cited the case of the separation of 2,6-lutidene and α-, β- and γ-picolines. About two hundred thousand plates were required to separate these compounds, using only their volatility differences, but with zinc stearate at 150° C. less than five plates are sufficient. The results with these metal-salt columns could be related to studies of complex-ion formation in aqueous solutions and provide information on complexing equilibria.

In the last paper Dr. J. H. Purnell put forward, on behalf of the Gas Chromatography Discussion Group, further recommendations[1] concerning the presentation of gas-liquid chromatographic retention data. It was proposed that retention data be presented in one of the two following ways, each being adequate provided any additional information required for interconversion is also given.

(1) In tables of relative retention times for at least two temperatures (so far as is practicable) with, where possible, the partition coefficient or specific retention volume of the standard solute. A suitable graphical method is the plot of logarithm of relative retention times versus the reciprocal of the absolute temperature.

(2) In terms of a linear equation relating the parameter chosen to temperature, for example, by an Antoine equation

$$\log V^0_g = A/(t + C) + B$$

where t = temperature in deg. C. and A, B and C are constants. This may be done graphically, but where results are numerous and the line represents the experimental results with accuracy, the constants of the equation (with the temperature limits between which it has been found to hold) will allow calculation or replotting on a large scale. It is hoped that the detailed recommendations will be published shortly in *Analytical Chemistry*.

Before the meeting closed, the chairman asked Mr. McWilliams, a visitor from Australia, to describe briefly a new detector he had mentioned earlier in the proceedings. This employed a small flame at the exit from the column, as in the detector developed by R. P. W. Scott, but instead of flame temperature, the ionization current between the jet and a positive platinum-gauze electrode inserted in the flame was measured. Large changes in current occur on introducing vapour into the nitrogen/hydrogen mixture feeding the flame, and a detection limit of 1 part in 4×10^8 v/v was claimed. The sensitivity in the units proposed at the last meeting[2] was given as 3×10^7 mV. ml./mgm. with a noise-level of 0·2 mV.

D. H. Desty

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[1] *Nature*, **179**, 241 (1957).

[2] *Nature*, **180**, 22 (1957).

THE BRITISH FLORA IN 1957

THE investigation of the British flora has passed through many phases. The past decade has been characterized mainly by concentration on detailed studies of individual species, or of small groups, making full use of the techniques of ecology, genetics and cytology as aids to taxonomy. In addition, there has been the detailed study of distribution organized by the Distribution Maps Scheme of the Botanical Society of the British Isles which has received the support of more than three thousand helpers. As a result of all this research, it has become more evident each year that the flora of the British Isles cannot be satisfactorily studied in isolation; it must be considered in relation to the European flora of which it forms a part. There has been an increasing tendency for British workers to make better use of Continental research, and to travel abroad to study the behaviour of British species overseas. It seems likely that this attitude will become the outstanding feature of the next phase of the study of the British flora, and that with the increased facilities of modern travel any remaining insularity will disappear.

It was in the belief that we are on the threshold of a change in emphasis, that exhibits on the relationship of the British to the European flora were a special feature of the Annual Exhibition Meeting of the Botanical Society of the British Isles on November 30. This was arranged in the lecture hall of the British Museum (Natural History), by kind permission of the Trustees, and was attended by 360 members and guests. There were fifty-nine exhibits.

The exhibit prepared by Prof. T. G. Tutin (Leicester) under the title of "Some Straightforward British Plants and their Continental Complexities" showed *Ranunculus bulbosus*, *Primula elatior* and *Helleborus viridis*. In Britain these provide no taxonomic difficulties, but the buttercup, characterized here by the swollen stem tuber, produces only a feebly developed bulb in the south of France, and no bulb at all in Spanish and Italian specimens; while the other two species exhibit subspecific variation in Europe with differences in habitat, distribution and morphology. Prof. D. A. Webb (Dublin) showed examples from the Irish flora of species which can only be understood by studying their behaviour in Spain. Thus, in Ireland, *Saxifraga hirsuta* hybridizes so freely with *S. spathularis* that it is very difficult to find the pure species; but in Spain the two are separated geographically, and much better differentiated ecologically. In Ireland, *Erica mackaiana* is sterile, producing only about one viable seed for every thousand flowers, but in Spain it sets seed freely but is self-sterile. It seems that both the Galway and Donegal populations may consist of a single clone.

Progress and problems of the projected "Flora Europæa"[1], which is expected to include descriptions of some 16,000–17,000 kinds of plants, were illustrated by Dr. V. H. Heywood (Liverpool). As examples of the difficulties of producing a condensed account of complex groups on modern lines, he showed series of *Anthyllis vulneraria*, and the clines in *Pinus nigra* aggr. Both have been the subject of voluminous literature; of the former, Jalas has published a recent treatment of part of the complex based largely on field and herbarium material; on the latter, ten papers on nomenclature have appeared during the past twenty-five years, but both require much work to produce suitable treatments over the whole area covered. The compilers of the "Flora Europæa" have many similar problems to face. Among the other exhibits which considered British plants in relation to their distribution or variation elsewhere were those provided by Dr. D. E. Coombe (Cambridge) on *Carex humilis*, N. K. B. Robson (Kew) on *Hypericum maculatum*, J. P. Savidge (Liverpool) on *Callitriche*, Dr. S. M. Walters (Cambridge) on *Carex* section *Distantes*, and Dr. E. F. Warburg (Oxford) on *Sorbus*. Fresh flowers and fruits from the Riviera were shown by Miss M. S. Campbell.

During 1957 there have been no important species added to the British list, but several very rare ones have been found in new localities. The most interesting of these is *Spiranthes romanzoffiana*, which was found in July on Dartmoor, and was exhibited by P. C. Hall and Mrs. B. Welch. This orchid was not previously known from England, and in some respects the Dartmoor plant is intermediate between the populations found in southern Ireland and those in northern Ireland and Scotland. R. A. Graham and R. M. Harley exhibited *Mentha* × *piperita* var. *sylvestris* from near Brixham, collected by K. Bull in 1954, as a mint not seen for 150 years. It was originally collected near Bath about 1790. *Poa bulbosa* was shown by J. Hodgson from near Frensham, Surrey. It is the first record of this usually maritime grass from the county since 1762, but although the new habitat is a suitable one, association with other species known to have been introduced suggests that the plant is not native here.

Considerable attention is now being devoted to the study of hybrids in the British flora. The old reproach, that if a plant proved difficult to name the easy way out was to call it a hybrid, is no longer true, and botanists are now investigating claims to hybridity with painstaking care. The British Museum (Natural History) exhibited type specimens of two hybrids new to science—*Potamogeton* × *cadburyae*, which is a cross between *P. crispus* and *P. lucens*, and *P.* × *pseudofriesii*, which is a cross between *P. acutifolius* and *P. friesii*. Both were described by J. E. Dandy and G. Taylor. An interesting example of a hybrid detected in the field was *Symphytum peregrinum* × *tuberosum* shown from Woodbridge, Suffolk, by E. Milne-Redhead (Kew). Synthetic hybrids in *Spergularia* were shown by J. A. Ratter (Liverpool). By artificial cross-pollination he produced *S. bocconi* × *salina* and *S. salina* × *rupicola*—in both there was complete failure to produce fruit, and flowering continued throughout the season. Dr. B. A. Hulme showed artificially produced hybrids in *Atriplex*. Using *A. patula*, $2n = 36$, *A. hastata*, $2n = 18$, and *A. littoralis*, $2n = 18$, as parents, she found that there was free crossing between *A. patula* and *A. littoralis*, but not between *A. patula* and *A. hastata*, and she was unable to produce *A. hastata* × *littoralis*.

P. M. Benoit had four exhibits of hybrids. *Festuca rubra* × *Vulpia myuros* was claimed as new to science. A single plant was found in Merioneth, morphologically intermediate, and completely sterile. *Cardamine flexuosa* × *hirsuta* he had synthesized, making successful crosses in both directions. *Myosotis caespitosa* × *scorpoides* he found in a marshy meadow at Dolgelley in 1956—this is new to the British Isles. He also had a very convincing exhibit of the common hybrid *Senecio aquaticus* × *jacobaea*, which is partially fertile and very variable and forms complex hybrid swarms. Dr. S. M. Walters and Miss A. Martin (Cambridge) showed an interesting study of *Calystegia sepium* and *C. sylvestris*. This was based on five populations in and near Cambridge for which they had scored measurements of parts of the flowers and arranged them on the principle of Anderson's "Hybrid Index". Both species are markedly incompatible, and small populations usually arise from a single clone and therefore set little or no seed, but seed is set in larger populations or those which are heterogeneous. Their analysis showed that morphologically intermediate populations of presumed hybrid origin occur frequently in the vicinity of Cambridge and presumably arose by cross-fertilization.

Two exhibits directed attention to new techniques. B. E. Juniper (Oxford) showed replicas of leaf surfaces obtained by the use of the electron microscope. These included, for example, *Oxalis corniculata* var. *atropurpurea* under a magnification of 34,000 linear. When the investigation of structures beyond the resolution of the light microscope is more advanced, new characters may be revealed to assist the work of taxonomists. D. E. Bradley exhibited a series of flowers of native orchids preserved by an embedding technique. After treatment in a colour-preserving solution, they were dried and embedded in transparent blocks of cold-setting 'Ceemar' resin.

Other aspects of British botany were represented by further exhibits, but it was clear that the Distribution Maps Scheme, the relationship to the European flora, and hybrids were the main interests of members of the Society in 1957. Progress made during the year as demonstrated by the exhibits represents a sound contribution to knowledge.

J. E. LOUSLEY

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[1] Burges, N. A., and Heywood, V. H., *Nature*, 179, 696 (1957).

THE GEOGRAPHICAL ASSOCIATION

THE annual conference of the Geographical Association was held at the London School of Economics during December 31–January 3. Prof. P. W. Bryan, in his presidential address, fascinated and impressed a very large audience by a series of beautiful coloured photographs and his insistence that geographers must deal primarily with the landscape as a whole, including the interrelated parts of the physical and the cultural. With the whole landscape as their basis, research workers could then go on to a detailed consideration of particular features.

One of these particular features, the landscape of glacial erosion, received detailed treatment by Mr. Vaughan Lewis, of Cambridge, in an analysis of the recent work done on "Erosion by Cirque and Valley Glaciers". He felt that the most helpful assumption now is that frost shatter is most severe in bergschrunds and related features, such as the enclosed head-wall gap reached by the upper tunnel dug through Vesl-Skautbreen, Jotunheimen, in 1951, when melt-water falls on to rock that is still a degree or so below the freezing point. This occurs in spring or early summer in the few weeks before the temperatures in the rock, and ice in the neighbourhood of the bergschrund, are raised to the freezing point.

He also considered that if rotation occurs as a result of the great downward thrust of an icefall, bed abrasion may be increased locally, partly by this great downward pressure and probably more effectively by the higher velocity induced in the deeper lower layers of ice in contact with the bed. Ice has not sufficient strength to hold very small stones firmly enough to do much grinding and gouging of the much stronger rock, but if the boulders or blocks of rock are large, the ice can drag them past the rock with great force and produce correspondingly great erosion. If the rock is well jointed, this abrasion, coupled with frost shatter wherever low temperatures can reach the rock, may account for the bulk of glacial erosion. But if the rocks are massive and like granites and certain metamorphic rocks consolidated under great pressure, then joints may form near the surface—the primary ones lying parallel to the surface—as a result of the release of pressure on the removal of the overlying rocks. The rocks may burst upwards, as it were, an action which has been noted in certain New England quarries. This action may help the recession of the walls bounding valley glaciers. It is hoped that Mr. Lewis's findings may be published in full at a later date.

One aspect of the cultural landscape, namely, urban geography, received detailed treatment in several lectures and constituted the main theme of the conference. Prof. A. E. Smailes, of Queen Mary College, London, read a paper on "Urban Studies" and paid tribute to the pioneer work that had been done on spheres of urban influence and in many detailed studies of urban morphology. The latter, largely based on maps, had greatly added to our knowledge of towns, but sometimes the use of a two-dimensional map failed to convey the true character of an urban area. It could easily ignore what Prof. Smailes called 'the texture' of a town by failing to emphasize the three-dimensional aspect of buildings. With a wealth of illustrative matter and descriptive detail, he gave examples of various types of towns viewed in three dimensions and went on to an analysis of the main forms of urban growth in the past century. He distinguished, for example, with the aid of air photographs, the terrace ribbing pattern of much Victorian housing, the villa studding of more recent housing, and finally the block clumping of flats in modern times.

Prof. E. W. Gilbert, of Oxford, in a lecture on "English Seaside Towns", stated that roughly 2½ million people now lived permanently in these places. After describing their diverse origins and present functions, he discussed the many lines of research on them now proceeding in several universities. He made a special plea for more work on the medical geography of resorts, emphasizing that little was known of the precise meaning of the 'bracing' and 'relaxing' qualities of places and of their exact influence on the human body. He felt strongly that more attention should be given to descriptive geography and especially to the aspect of towns. He urged geographers to analyse the beauty of urban and rural scenery and not to be afraid of expressing their own subjective feelings. Educated geographical opinion should unite to preserve the beauty of both coast and seaside Regency buildings.

Mrs. D. Monteith gave a fascinating account of the development of Saffron Walden, showing how the main-line railway had avoided the town and had greatly impeded its subsequent growth. Later in the week, Mrs. Monteith took a party of members to Saffron Walden to explain in more detail the methods and results of her survey. Dr. A. Garnett gave a detailed study of atmospheric pollution as a factor of urban geography, and Mr. G. F. A. Wilmot introduced a different facet by considering the scope of railway geography in urban areas and illustrating it by a coach tour to examine some aspects of railway development in North London. Prof. Beaver introduced yet another aspect by analysing the changing industrial landscape of Great Britain, emphasizing the great part that modern technology is playing in modifying the effects of industrialization.

The teaching side of geography also received suitable attention. A very lively discussion on the effect of Ordinary Level examinations on the teaching of geography opened the conference, and on the last day of the lectures Miss P. M. Jeffery gave a lesson showing the follow-up of a field expedition in an urban area, and Mrs. I. L. M. Long presented the results of the research project into "The Interpretation of Geographical Pictures by Secondary School Children".

The last day of the conference was devoted to a series of excursions which included, in addition to the two already mentioned, a tour of the sites of London's former airports, a tour of metropolitan Essex, a traverse by coach to Cambridge, and a walking expedition to examine the site and function of the City of London. R. C. Honeybone

THE NATIONAL PHYSICAL LABORATORY

REPORT FOR 1956

THE annual report* for 1956 of the National Physical Laboratory, Teddington, gives an excellent survey of the fundamental and applied research carried out during the year in the nine Divisions and Test House of the Laboratory. It contains also the report of the Executive Committee which was presented to the General Board at its meeting on May 23, 1957, the annual open day of the Laboratory (see *Nature*, **180**, 166; 1957).

The Executive met seven times during the year, but refrained from taking any major policy decisions while changes in the directorship of the Laboratory were taking place. Sir Edward Bullard, whose resignation as director became effective on December 31, 1955, was succeeded by Dr. R. L. Smith-Rose, who continued as acting-director until September 14, 1956, when Dr. G. B. B. M. Sutherland assumed his appointment as director. The arrangement whereby certain members of the Executive Committee form panels to visit and report on the scientific divisions of the Laboratory was continued, and reports were considered during the year from the panels which visited the Mathematics, Metallurgy and Physics Divisions. Both the chairman of the mathematics panel and the superintendent of the Mathematics Division made representations to the Committee that the supply of trained numerical analysts was inadequate to meet the increasing use of high-speed computers and that staff was not available in the universities to provide for the teaching of numerical analysis on an adequate scale. A panel, with Sir Charles Darwin as chairman, was therefore set up by the Committee, to consider this matter and to advise on whether special facilities for the training of numerical analysts should be provided at the Laboratory, in addition to using other means elsewhere.

Two new buildings, one for radiological work and the other for low-temperature research, were completed during 1956 and occupied by the Physics Division. The 24 in. × 20 in. high-speed wind tunnel in the Aerodynamics Division was put into operation and the construction begun of a new workshop on the West Aero site and of a new road and entrance to the Laboratory from Hampton Road. Good progress has been maintained on the new Ship Hydrodynamics Laboratory at Feltham and the completion date for the whole project is forecast in the report as early 1959. With regard to future building requirements of the Laboratory, it is still required that priority be given to the provision of a new library, lecture hall and canteen, and accommodation for an expanded Control Mechanisms and Electronics Division.

Four new booklets, Nos. 13, 14, 15 and 17, in the series "Notes on Applied Science" were published during the year, in addition to the proceedings of the symposia on "Boundary Layer Effects", "Cavitation in Hydrodynamics" and "Creep and Fracture of Metals at High Temperatures". In the series "Units and Standards of Measurement employed at the N.P.L." a new edition of Part 1 (on length, mass, time-interval, etc.) and a revised edition of Part 2 (on light) were issued. Three books, "Mass Spectrometer Researches", "Tables of Weber Parabolic Cylinder Functions" and "Wage Accounting by Electronic Computer" were published, of which the last mentioned has been so well received that it has already been reprinted three times. This work consists of the first report of the Interdepartmental Study Group on the Application of Computer Techniques to Clerical Work. Several earlier publications have also been reprinted including, in particular, the proceedings of the 1953 symposia on "Engineering Dimensional Metrology" and on "Automatic Digital Computation".

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* Department of Scientific and Industrial Research. Report of the National Physical Laboratory for 1956. Pp. viii+104+5 plates. (London: H.M. Stationery Office, 1957.) 5s. net.

The work of directing the attention of other organizations to the research and development proceeding at the Laboratory was extended. The two liaison officers paid 145 visits mainly to commercial organizations, and about a hundred return visits were made to the Laboratory for the interchange of information. 114 lectures were given by members of the staff of the Laboratory to various scientific and similar bodies and 156 scientific articles, details of which are given in the report, were published. Several items illustrating the work of the Laboratory were exhibited at the Physical Society's annual exhibition of scientific instruments and apparatus, and at the Factory Equipment Exhibition. In addition, demonstrations were given at the Royal Society soirée and at conversaziones arranged by the Institution of Civil Engineers and the Institution of Electrical Engineers. Visitors to the Laboratory included three parties of Russians, two of which were concerned with aerodynamics; a delegation of members of the West German Parliament; and parties of senior officials from the Ministry of Pensions and National Insurance and from the Treasury in connexion with the possibility of carrying out pay-roll work by digital computer. Thirty-four members of the senior staff made official visits overseas—ten to North America and twenty-four to countries in Europe. The British national copy of the international metre was taken to the International Bureau of Weights and Measures in Paris and, after re-graduation, was re-calibrated at the Bureau before its return to the Laboratory in December. Details of the visits, together with the names of the members of the general board, executive committee, Froude Ship Research Sub-committee, the Advisory Committee on Radioactive Standards, the Panel on Training of Numerical Analysts, and the senior members of the staff of the Laboratory are included in the annual report.

The individual reports of the various sections of the Laboratory make interesting reading. Most of the work of the Aerodynamics Division is concerned with fundamental problems in fluid motion related to the design and performance of aircraft and guided missiles, though a wide range of airflow problems not related to aircraft is also tackled. Special attention was paid during the year to problems of 'mixed' flows at high subsonic, transonic and supersonic speeds; to the extension of the speed-range covered by the Division's experimental equipment; to schemes which enable aircraft to take off and land vertically or from very short runways; and to the measurement of aerodynamic coefficients for oscillatory motion. For research on hypersonic flow several new wind tunnels that will give various Mach numbers up to 10 and operate over a wide range of stagnation pressures and at high temperatures, in addition to a shock tube, are designed or are being planned. The Division's compressed-air tunnel, stated to be the only equipment of its kind in Britain, has now completed 25 years service, but it is still considered a vital piece of equipment and its utility has been extended recently by improvements and the development of new techniques.

In the Control Mechanisms and Electronics Division, apart from the constructional work on the new automatic computing engine (ACE) and the maintenance of DEUCE, a small group has continued the study of the application of high-speed computers to clerical operations. The report on pay-roll work has been published. The Division has completed prototype equipment for automatically reading and calibrating telemetry records, and transistor circuits are being developed for use in pulse-counting systems. The cæsium resonator in the Electricity Division has been adopted by the Laboratory as its primary standard of frequency. The guaranteed accuracy of the standard frequency transmissions has been quadrupled, and the values of the radiated frequencies are now published with an accuracy of one part in 10^9. To permit a new determination of the absolute ampere, the current balance is being overhauled and fresh measurements of the dimensions of the coils are being made. Significant changes in the diameters have occurred since 1935. This work is closely linked with that on the new standard of inductance, for which measurements on the quartz cylinder are being made in the Metrology Division. A major item of new equipment in the Electrical Division is the million-volt transformer for the high-voltage laboratory.

Research into the properties of the average eye has again been the principal fundamental investigation of the Light Division. The primary standard of luminance was re-established, the final value being 59·7 candelas/cm.^{2}, 0·5 per cent below the value of 60 candelas/cm.^{2} prescribed in the definition of the candela. Further development took place in the making of diffraction gratings and improved methods of photometry were worked out to serve the needs of the electric-lamp industry. The Mathematics Division was able to devote more time to research and considerable effort was devoted to the solution of differential equations, particularly equations of the parabolic type. One result of collaboration with universities was the production of a series of programmes for DEUCE on the solution of crystallographic problems.

The most interesting result reported by the Metallurgy Division is the proof, using radioactive phosphorus, of the existence in certain irons of very thin grain-boundary films rich in phosphorus, which are associated with exceptional weakness and brittleness under suitable conditions. The possibilities of niobium, both as a basis of new alloys and as an alloying addition to other metals, are being studied and the most sensitive methods examined for the determination of very small quantities of impurities in metals. The Metrology Division has developed equipment, using the pneumatic gauging technique, to measure the thickness of thin sheet material to an accuracy of $\pm$ 0·5μ on sheet or foil 25–250μ thick. The value found for the density of mercury at 20° C. by weighing the mercury displacement of a 10-kgm. cube of tungsten carbide is 13·545892 gm./cm.^{3}. The error is estimated to be less than 1 part in 10^6. Preparations are being made for a new absolute determination of gravity in order to improve the accuracy of pressure measurements with the mercury barometer and the precision of determination of the ampere by the current balance, and to enable magnetic fields, for example those involved in the measurement of the gyromagnetic rotation of the proton, to be standardized absolutely. The method to be used for the gravity measurement involves the timing of the free fall of a ball in a vacuum.

The work of the Physics Division has been extremely varied, ranging over heat, acoustics and ultrasonics, high pressures and radiology. The demand for the supply of liquid helium to other laboratories has settled down to about 20 litres per week—rather smaller than originally estimated. In the Heat Section new equipment to apply the radial heat-flow method to the determination of thermal conductivities to temperatures of the order of 1700° C. is being installed and in the Temperature Measurement Section the investigation of the relative merits of the boiling point of sulphur (444·600° C.) and the freezing point of zinc (419·50° C.) as a primary fixed point is continuing. Measurements have been made of the elasticity of tiny single crystals such as sapphire and diamond, and of the elastic constants of single crystals of pure copper, copper–zinc and copper–gallium alloys. The Ship Division reports a delay of five to six months in the putting in hand of resistance and propulsion tests for shipbuilders. The delay is because of an increased demand for tests and because of the introduction of the five-day week in the Laboratory. The investigation of the effect of various structural roughnesses on the behaviour of ships' hulls has yielded some interesting information. For small ships the resistance of an all-riveted hull can be as much as 10 per cent greater than for an all-welded hull, and for larger and faster ships it may be as much as 25 per cent greater.

Finally, the annual report, which is presented in an attractive cover and is illustrated, concludes with a report of the Test House, indicating the significant increase in the variety of precision instruments submitted for test to the Laboratory.

S. Weintroub

UNIVERSITIES OF LATIN AMERICA

Although the nations of Latin America are of recent growth they inherit an ancient university tradition. Almost as soon as the Spaniards had completed the first of their settlements in La Española (Hispaniola), a Bull issued by Pope Paul III in 1538 transformed the island's Dominican college into the University of St. Thomas Aquinas. Not long after Hermán Cortés's conquest of Mexico and Pizarro's extinction of the Inca Empire in Peru, the Emperor Charles V established universities in his two new American kingdoms: Mexico City held its first classes in 1553 and San Marcos was functioning actively by 1578. The oldest Latin American universities are coeval with the oldest Scottish universities and antedate many famous European centres of higher learning. An account of them has been given by J. C. J. Metford of the University of Bristol (*The Universities Review*, 30, No. 1, October 1957).

As Spanish settlements expanded all over America, the Dominicans, Jesuits and Franciscans founded schools attached to their monasteries. Before the sixteenth century had ended, their *colegios* were to be found in places so far apart as Antigua, on the isthmus of Central America, Chuquisaca, in the lofty silver mining region of Bolivia, and Córdoba, in the foothills of the Andes. There, and in many other centres, courses in the arts, grammar, philosophy and theology were being delivered almost as soon as the townships were marked out in their characteristic grid-iron pattern. The *colegios* grew with the towns, and, in the eighteenth century, many *colegios* were granted the status of Royal and Pontifical universities. By the end of the colonial period, there was scarcely a region of importance in the Spanish American Empire without its university, or college, where advanced studies could be pursued.

As in Europe, the universities and colleges of Spanish America had their periods of brilliance and their times of decline, but, on the whole, they did not compare unfavourably with universities in the Old World. Although dependent upon endowments, or grants from royal, vice-regal or ecclesiastical treasuries, they enjoyed a reasonable measure of independence in the management of their internal affairs and in the granting of degrees. Their chief function was to train aspirants to the priesthood or candidates for higher theological degrees. Science was not wholly neglected: mathematics and astronomy were studied, and much work was accomplished on the curative plants and herbs known to the Indians. From an early date in Mexico City and Lima, there were chairs for the study of Indian languages, but the intention was to use this knowledge in the evangelization of the aborigines. University teachers were drawn chiefly from the ranks of the Dominicans and the Jesuits, but, in the eighteenth century, lay professors were not unknown.

Independence from Spain and Portugal caused little change in the social structure of the former American colonies, except that the wealthy *criollo* minority succeeded to positions which were previously the perquisites of peninsular Spaniards and Portuguese. Much lip-service was paid to the catchwords of freedom, equality and the pursuit of happiness, but little was done towards the realization of these ideals, except, to some extent, in the field of education. Nurtured in French, North American and British radical traditions, the fathers of the revolution believed sincerely in the power of education to spread enlightenment. The University of Buenos Aires was founded in 1821 by men associated with Rivadavia, who had corresponded with Jeremy Bentham. Bolívar founded the Universities of Cartagena, in Columbia and Trufillo, in Peru. His lieutenant, General Santander, established the University of Cauca. Political upheavals, anarchy, the rise of dictators and empty treasuries eventually terminated these ambitious schemes. Despite men like Andrés Bello, in Columbia and Chile, Sarmiento and Alberdi, in Argentina, and the Emperor Don Pedro II, in Brazil, little was accomplished, so far as universities were concerned, until the second half of the nineteenth century.

By that time, some of the major nations—Argentina, Brazil and Chile—had stabilized their domestic affairs and had grown in wealth and importance. The need, the means and the will to improve educational facilities followed. Institutions of higher learning and universities were created in the principal States. In Bolivia and Brazil, the tendency was to establish degree-granting faculties instead of universities.

The most significant event in the history of the modern universities was the reform movement which began in Cordoba, Argentina, in 1918. Essentially, it was the work of young men, who looked upon themselves as the harbingers of the new Latin America which would be fundamentally American, freed from dependence on Europe and purged of inherent abuses. They were all greatly influenced by the iconoclasm of the Spanish writer and thinker, Miguel de Unamuno. Much of their educational outlook derived from the works of Ortega y Gasset. Practical measures were embodied in Argentine law between 1919 and 1922. From Argentina, the reform movement spread to many other Latin American countries and influenced legislation on university government especially in Bolivia, Colombia and Cuba.

The Second World War brought far-reaching changes in the life of Latin America which were not without their impact on the growth of universities. High prices from the belligerents for raw materials meant an astronomical increase in national wealth. At the same time, attempts were made to create locally industries for the production of commodities which had hitherto been imported. To fulfil these national and industrial ambitions, a supply of university-trained men would be needed. With this in mind, some of the more perspicacious governments arranged that part of the newly acquired wealth should be diverted either to the improvement of existing institutions or to the creation of new universities. The best examples of this new policy are the superlative modern buildings constructed for the University of São Paulo in the midst of Brazil's rapidly growing industrial area.

To-day, there is no country in Latin America without at least one university. There are eighty-eight throughout the region, although some have only two or three faculties and some are little more than a loose confederation of otherwise independent faculties. The largest institutions, with more than ten thousand students each, are the National University of Mexico and the Universities of Havana, Buenos Aires and La Plata. Argentina has at least three other universities with between five and ten thousand students each, and Uruguay, Chile and Peru one university each of comparable size.

Nearly all of them have important features in common—they are part of the State system of education, their powers and functions are carefully prescribed by law, and they are mostly subject to direct interference by the president of the nation, the ministry of education, or some governmental equivalent. The exceptions are the so-called *universidades particulares*, or private universities, of which the University of Concepcion, Chile, is the best secular example. The majority are Roman Catholic (for example, Santiago de Chile, Lima, Bogota), either concerned with the education of priests or founded to preserve the faithful from the militant secularism characterizing some of the State universities, which were controlled by positivists, humanists and others hostile to clerical influences in education. A certain measure of government control is nevertheless exercised through the State recognition of their degrees.

State control is also clearly seen in finance. Universities generally are dependent on the State for practically three-quarters of their annual income.

As in Spain and Portugal, the teacher in Latin America, whether at school or university level, enjoys a degree of respect, almost veneration, unknown to his counterparts in Anglo-Saxon countries, but the esteem in which he is held is in inverse proportion to the rewards of his profession. University teaching therefore becomes a part-time occupation, as few men of standing would be content to exist on a meagre university salary. Most teachers are professional men—lawyers, doctors, engineers, or even novelists or journalists—who spare a few hours a day for their classes, or perhaps leave them to a trusted assistant.

Most students come from the urban conglomerations around the university and live at home or with relatives. Newly planned campuses now include *residencias*, but these are exceptional. Usually, the student has some part-time employment, often connected with the profession for which he is preparing himself, and, towards the end of his course, he may be married, with a young family of his own. Lack of continuity often characterizes a student's career, as his circumstances or predilections change, and he may remain a student for a surprisingly long time. This, in some measure, explains the high enrolment figures announced by some institutions. The University of Mexico City thus claims more than 22,000 students, a high proportion of whom are unlikely to be full-time.

OVERSEAS SERVICE IN BRITISH COLONIAL TERRITORIES

THE Overseas Service Bill, which received an unopposed second reading in the House of Commons on January 21, is an enabling Bill to implement the policy outlined in the White Paper of May 1956 on the Overseas Civil Service. In moving the second reading, the Secretary of State for the Colonies, Mr. A. Lennox-Boyd, said that formidable difficulties had been encountered in the proposed policy for a central register and pool, particularly in guaranteeing a continuing career, that is, a succession of jobs of ascending importance and level of responsibility for an officer recruited into the central pool initially for a particular job in a particular territory. On March 26, 1957, the Lord Privy Seal had announced that the creation of a pool of administrative and technical officers must await evidence of substantial demand for their services and that regular employment for them could be foreseen for several years. Meanwhile, Clauses 2 and 3 of the Bill provided for the making of Orders to govern pensions earned while in the Overseas Service and for the preservation of pension rights already acquired. When the Bill became law the Governments of the Colonies would be asked to enact comparable legislation. Clause 4 contained special provisions relating to police officers and Clause 6 covered the appointment of officers to a wide variety of public services under overseas Governments, municipal or local authorities or public corporations or to any Federal Government or outside authority such as the East African High Commission.

Mr. Lennox Boyd said that at the constitutional conference last June he had signed agreements for special lists with the four Nigerian Governments but so far only about 120 out of the 2,000 eligible pensionable officers in the service of these Governments had applied to join. Sir John Martin was in Nigeria examining the position, and the application of the special list procedure was the subject of current negotiations with the Government of Malaya. In conclusion, Mr. Lennox Boyd said that, in 1957, 1,689 officers were selected for appointment to the administrative or professional branches compared with 1,467 in 1956, and of these, 284, mostly on contract, were to Nigeria. Mr. Lennox-Boyd and other speakers paid warm tribute to the work, the loyalty, the efficiency, the integrity and the quality of the Overseas Service. In replying to the debate, he added that, although there was a substantial gap between demand and supply, we were recruiting at four times the pre-war rate over the whole field. At the end of 1957 there were 130 vacancies in administration and 1,384 in all branches, compared with 170 and 1,456, respectively, in 1956, and the proportion of vacancies to the total number of overseas officers in the service was now about 7 per cent. In Ghana, about 400 officers, or 50 per cent of those entitled to compensation, had retired since July 1955. Mr. Lennox-Boyd defended the Government's policy in regard to compensation as holding a reasonable balance between justice to those officers who wished to retire and the duty to try to induce them to stay. He explained that the recruitment and employment of experts under the technical co-operation scheme were covered by administrative action and it was not intended to change this procedure. Foreign Office appointments to South East Asia Treaty Organization posts were normally filled by secondment, but if a person from the Overseas Civil Service were recruited the provisions of the Bill could be applied if necessary.

MANAGEMENT TRAINING

IN the fourth Graham Clark Lecture to the Institution of Civil Engineers on December 17, on "The Engineer and Management", Sir Ewart Smith said that while science and its practical applications through engineering and chemical technology had shown that we were potentially able to meet any standard of national welfare mankind could desire, subject to some limit to world population with regard to natural resources, the rate of advance in science and technology was not being matched by progress in our ability to control and manage. Sir Ewart suggested that this might be due to our neglect in human affairs and organization of the guiding principles of simplicity, symmetry (or balance) and continuity. More research, better analysis and far better teaching in management subjects were needed, and it did not seem to be appreciated that the very growth of complexity and specialization increased the need to train with great care those who will have the responsibility of training the specialists.

Discussing selection and training for management, Sir Ewart emphasized the importance of regular, multiple and independent assessments of ability to men and management alike. Far too much weight was often placed on written examinations during the period of formal training, and in industry there was usually little systematic study of people to assess their potential and the best lines for their development. A main responsibility of the highest management should be to pick its own potential successors and to train them with the utmost care, from the early years of service, and Sir Ewart welcomed recent discussion on the general content of educational courses; it should be a question of how science and the humanities could be reunited in everyone who claimed to be reasonably educated, and he thought that the main change had to take place in the schools rather than in the universities. It was a mistake to think that three years was still an adequate period for a full university course in scientific and technological subjects, and Britain was almost unique among the great nations in its failure to make the changes in this respect which modern conditions demanded. More time should be spent in teaching people how to use knowledge, and where they could find it in codified form when they required it in their working life. Good education, moreover, depended primarily on good teachers and relatively little on buildings and equipment. Emphasizing the importance of the engineer in management, Sir Ewart suggested that the main reason for our failure to utilize their services here has been the present acute shortage of technologists, which tends to confine them to specialist work. There was no reason to suppose that the incidence of natural ability, initiative and enthusiasm had diminished, but for Britain to attain her full economic strength the engineer must play a full part in leadership and in developing the most effective forms of organization and methods of management for a changing world.

THE LINNAEUS TRADITION AND OUR TIME

IN his presidential address to the Swedish Academy on December 20, Mr. Dag Hammarskjöld took as his subject "The Linnaeus Tradition and our Time". He considered Linnaeus's contribution towards the development of values which it is the task of the Academy to safeguard. Freshness and precision, enthusiasm without lyricism, an instinctive eye for meaning and causality raised the great travel accounts and his other Swedish writings far above the criticism he himself foresaw, and enriched his country's literature by values as essential to our emotions as the Nature they mirror. Nevertheless, his style would scarcely have found its freshness had he not been guided by his sense for the striking and for the unexpected associations of humour. Linnaeus's Swedish works are perhaps read to an increasing extent even outside the circle of experts.

The relationship of a nation—and a generation—to older literature tells something about the continuity of spiritual life. Outside the limits of *belles lettres*, the works of Linnaeus occupy a place of their own in Sweden, whereas other books which have much to offer are neglected.

One possible reason for the estrangement from the past is disquieting. In a mass culture, where publicity, working in the interest of sales, is constantly harping on the idea that the latest must be best, books are often relegated to the ranks of disposable and rapidly ageing consumer goods, which may lead to an industrialization of literature. The risk is enhanced when, at the same time, the position of the written work is becoming more precarious by reason of new forms of expression and communication —films, radio, television.

We are faced with the question of intellectual climate and what determines it. The present has given unusual weight to material progress ; it is also influenced by political factors. Europe has lost much of the powerful position she occupied for centuries and a wave of nationalism has swept the continents. If she understands how to maintain and develop the values which are the foundation of her spiritual greatness she can still maintain a place worthy of her traditions.

When Linnaeus received tempting offers to remain in Holland he declined because "a higher urge pulled him towards his Fatherland". The scholar, however, knew no national frontiers. He was a European, and, as a European, a citizen of the world. Much has changed, but it is still possible to balance and reconcile home and world, heritage and task, in this manner. This can provide an answer to even larger problems than those of the individual.

STRESS IN HYPOTHERMIA

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THE induction of hypothermia in homoiotherms consists essentially in a suppression of the thermoregulatory defence by anæsthetics followed by intense cooling of the body. While cold stimulus in unanæsthetized homoiotherms inevitably evokes a general stress response[1], there is a considerable degree of controversy as to whether or not hypothermia involves stress. Changes in the amount and distribution of the adrenal cortical lipids suggestive of stress have been reported to result from hypothermia of a few hours duration in dogs[2]. On the other hand, the recent observations that the adrenal venous blood output of 17-hydroxycorticoids is decreased in hypothermic subjects[3,4], while the peripheral serum-levels[5] and urinary excretion[6] of the adrenal cortical steroids remain substantially unaltered, have been interpreted as indicating that there is no actual stress response to hypothermia.

The present study was undertaken to elucidate the stress response in dogs subjected to graded hypothermia, with or without subsequent rewarming. Thirty-five dogs, apparently healthy and 'unstressed' individuals, were anæsthetized with pentobarbitone, either alone or in combination with diethyl ether, or nitrous oxide–oxygen and D-tubocurarine. Some of the dogs were subjected to minor vascular surgical procedures prior to cooling. The dogs were cooled in an ice bath (4–8° C.). With a few exceptions, pulmonary ventilation was assisted during cooling and hypothermia. Rewarming was accomplished in a warm bath (about 40° C.). Changes in the amount and distribution of the sudanophilic adrenal cortical lipids and in the white blood picture were used as methods of computing the stress response.

In all but four of these thirty-five dogs there was evidence suggestive of stress response, so far as could be judged from the adrenal cortical lipid patterns. In eight dogs there was lipid depletion particularly in the zona fasciculata and zona reticularis, which is indicative of the alarm reaction[1]. In twelve dogs an increase of lipids throughout the whole adrenal cortex characteristic of the stage of resistance[1] was apparent. In ten dogs the adrenal cortical lipid patterns were suggestive of transitory stages between the normal state and the stage of alarm reaction, on one hand, and those between the alarm reaction and the stage of resistance, on the other. In one dog, signs of alarm reaction bordering on the stage of exhaustion were apparent.

The dogs that did not show an adrenal cortical response had been anæsthetized with pentobarbitone alone and then cooled, without assisting ventilation, until death ensued (at 20·3–25·3° C.) after 2–4 hr. However, all the other dogs anæsthetized with pentobarbitone in combination with ether, or nitrous oxide–oxygen and curare, and then cooled until death (at 14·0–33·5° C.) within the same, a somewhat longer, or an even shorter period, showed a definite adrenal cortical response varying from an early alarm reaction to an early stage of exhaustion. The actual degree of cortical response did not appear to be influenced by variables in the mode of respiration. Nor could any clear-cut aggravation of the response be detected in the dogs that had been subjected to minor vascular surgery prior to cooling. The dogs that had been anæsthetized with pentobarbitone in combination with nitrous oxide–oxygen and curare showed evidence of a progression of the cortical response in accord with an increase in the cooling period, whereas in the dogs in which ether had been used as a supplementary anæsthetic such a correlation was less evident. In one series of experiments the dogs were kept for 4 hr. near body temperatures of 22·0° and 27·0° C. and then killed. In another series the dogs were kept for 2–6 hr. at a body temperature of about 22·0° C., rewarmed and then killed at the termination of rewarming, or 3–7 days thereafter. Pentobarbitone supplemented with ether had been used for anæsthesia in these experiments. The terminal pattern of the adrenal cortical lipids in all these experiments was indicative of stress. Surprisingly, however, the cortical responses were of the same variable degree as those in the acute experiments ending in death.

The behaviour of the white blood picture during cooling, with or without subsequent rewarming, was followed in twelve dogs. Cooling resulted in a progressive fall in the total leucocyte count, averaging from 12,870 per mm.^{3} (at 37·5° C.) to 4,508 per mm.^{3} (at 21·0° C.) ; but the relative counts of eosinophils, lymphocytes and other types of leucocytes remained substantially unaltered. In the stable period of hypothermia (at about 22·0° C.) lasting up to 6 hr., the white blood picture remained essentially stationary. Accordingly, during cooling the counts of eosinophils and lymphocytes did fall in proportion to the drop in the total leucocyte count. Since, on the other hand, no further changes could be found in the stable period of hypothermia, it is doubtful whether these hæmatological changes could be properly interpreted to imply that stress was present. Nevertheless, in the same dogs, after cooling periods of varying duration, the stress response became clearly demonstrable by the adrenal cortical lipid assay. On rewarming, the white blood picture initially showed a trend to normalization. In the late rewarming period (at 35·0° C.), however, neutrophilic leucocytosis (averaging 15,400 per mm.^{3}) with both relative and absolute eosinopænia and lymphopænia became apparent. These hæmatological changes ensuing in the late rewarming period may be regarded as strictly indicative of stress[1]. The same dogs, when killed at the termination of rewarming, showed a definite stress response as estimated from the adrenal cortical lipid patterns.

Summarizing, the present results, supported by some earlier observations[2], strongly suggest that the induction of hypothermia evokes a general stress response. It became evident, however, that this response is not inevitable, but is largely influenced by the anæsthetics used to assist the induction of hypothermia. Barbiturates, for example, appeared to inhibit the stress response to cooling. The stress manifestations were particularly evident at the termination of rewarming and persisted for several days thereafter.

The recent claims that hypothermia does not involve stress are based on observations that the adrenal venous blood output of the adrenal cortical steroids is decreased by hypothermia[3,4], while their peripheral serum-levels[5] and urinary excretion[6] remain unchanged. In view of the fact that hypothermia is known to be accompanied by profound changes in metabolic activity, circulatory dynamics and renal function, it may be questioned whether the assays mentioned afford a true picture of the situation in the particular experimental conditions of hypothermia. It may be recalled that even in the present experiments, in which the experimental variables were the same as in the aforementioned studies, there was no definite hæmatological evidence of stress during cooling and hypothermia, although at the same time the stress response was clearly demonstrable by the adrenal cortical lipid assay. Moreover, it has been found that after rewarming, when the metabolic, circulatory and other physiological functions are restored, a rise may occur in the adrenal venous blood output[4] and peripheral serum-levels[5] of the adrenal cortical steroids. Finally, the pathological changes found in the present[7,8] and later[2] experiments on hypothermia are essentially similar to those seen in states of acute severe stress of varying origin[1,9].

The present results will be described and discussed in detail elsewhere.

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EFFECT ON RADIOSENSITIVITY OF INERT GASES

Effect of Inert Gases on Oxygen-dependent Radiosensitivity

LIKE many other tissues, the meristem of the main root of the broad bean seedling (*Vicia faba*) is two to three times more sensitive to X-rays in the presence of oxygen than in its absence. In the experiments to be described, the measure of radiosensitivity is the reduction in growth-rate of the root, which is believed to be due predominantly to death of the cell following upon chromosome damage. There is no qualitative difference in the damage caused by irradiation in the presence or in the absence of oxygen, the oxygenated condition acting as a simple multiplying factor upon dose[1].

We have found that if inert gases are added to the air in which bean roots are exposed to X-rays, the sensitivity of the roots decreases until at sufficient concentration of the inert gas it reaches the anoxic level. We have not observed any effect of the gases on the radiosensitivity of roots in the absence of oxygen. Similar results have been obtained with cells of the Ehrlich ascites tumour of the mouse irradiated *in vitro*. We conclude that inert gases at high concentration can displace oxygen from sites within cells at which oxygen molecules can increase radiosensitivity, and that this phenomenon occurs in cells of widely different kinds.

Bean roots. The pressure vessel and the procedure used in the treatment of bean roots, and some of the results, have been described[2]. 190-kV. X-rays at 6 m.amp. were used at a dose-rate of 1·84 r./sec. Filtration was 1 mm. copper, 0·5 mm. aluminium and 3 mm. mild steel. Gas pressures up to 120 atm. had at most only slight and transient effects on the roots, and did not affect radiosensitivity if applied before or after exposure to radiation. Hydrostatic pressure of 105 atm. was also not in itself damaging, and was without effect on radiosensitivity, as observed for yeast cells by Burns[3].

Irradiated roots showed a reduced growth-rate which reached a minimum six to nine days after exposure. The minimum growth-rate, compared with appropriate controls, was taken as a measure of radiation damage[4]. To provide an estimate of relative sensitivity in different gases, we established a dose-effect curve for irradiation in air at 1 atm. The curve was found to be linear over the useful range, that is, 40–150 r., and was described by the equation:

$$\text{minimum growth rate} = 167 - 1{\cdot}49 \times \text{dose in röntgens}$$

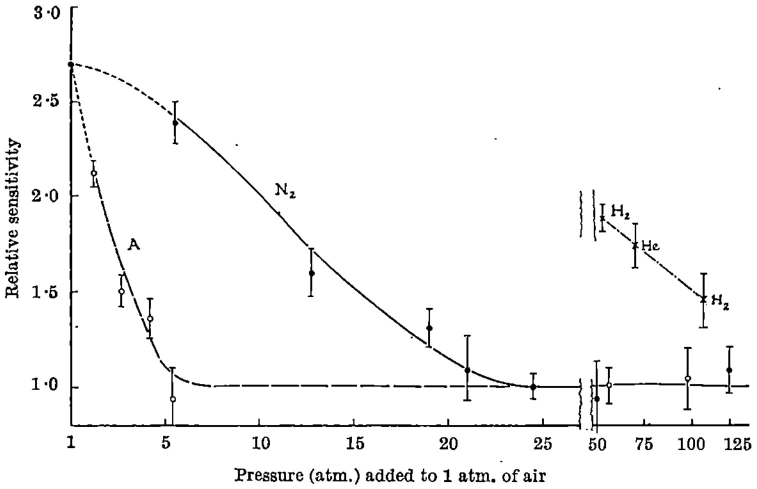

Fig. 1. X-ray sensitivity of bean roots irradiated in 1 atm. air plus other gases. Abscissæ: pressure of added gas in atmospheres. Ordinates: relative radiosensitivity

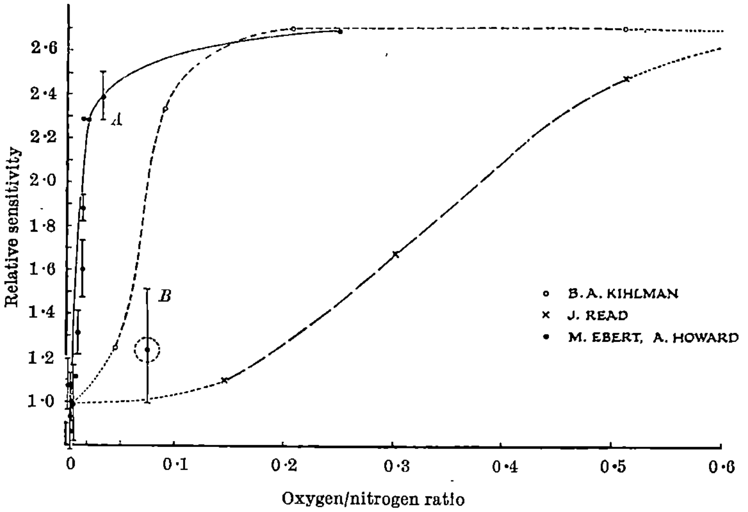

Fig. 2. Radiosensitivity of bean roots as a function of the ratio of oxygen to nitrogen. O, B. A. Kihlman (1955); ×, J. Read (1952); *A*, present observations at 0·2 atm. oxygen; ●, present observations at 1 or 2 atm. oxygen; *B*, present observations at 0·07 atm. oxygen

From this equation we calculated the dose in air, D_A, required to give an effect equal to that produced by dose D in any set of experimental conditions, and the ratio D_A/D gave the sensitivity relative to that in air. In order to express this in terms of the anoxic sensitivity, the ratio D_A/D was multiplied by the factor 2·69, since the effectiveness of a given dose was observed to be 2·69 times smaller in anoxic conditions (or in air plus high pressures of nitrogen or argon) than in air, in agreement with results of Read[1]. Thus 'relative sensitivity' is defined as $D_A/D \times 2{\cdot}69$. The standard errors of the relative sensitivity values shown in the accompanying figures were estimated from the standard errors (in terms of dose) of the experimental observations, and the overall error (± 2·64r.) in the air dose-effect curve.

We have studied the action of hydrogen, helium, nitrogen, argon, krypton and xenon, the effect of all of which is qualitatively the same. In Fig. 1, relative sensitivity is plotted against the pressure of gas added to 1 atm. of air. It can be seen that argon at 5 atm. reduces sensitivity to the anoxic level, whereas nitrogen must be present at 21 atm. to be equally effective. Hydrogen and helium are much less effective. To give a comparison of the effectiveness of the different gases, Table 1 shows the pressure required to reduce the relative sensitivity to 1·85, that is, the part of the effect dependent upon oxygen to one half. The values were derived by linear interpolation and are approximate.

When relative sensitivity is plotted against the ratio of the partial pressures of oxygen to nitrogen (Fig. 2), radiosensitivities for all treatments in which the partial pressure of oxygen (pO_2) was 0·2 atm. or more lie on a smooth curve. For one observation made at $pO_2 = 0{\cdot}07$ atm. (total pressure 1 atm.), however, the relative radiosensitivity did not fall on this curve but was much lower. These results suggest an adsorption phenomenon in which nitrogen displaces oxygen from a specific site. The second observation demonstrates the limiting condition in which the partial pressure of oxygen is small compared with that required to saturate the adsorbing site.

In Fig. 2 are plotted also the results obtained by Kihlman[5] for chromosome aberrations induced in bean roots by X-rays at various oxygen tensions: the values have been scaled down to a total oxygen effect of 2·69 for the purpose of this comparison. Kihlman bubbled through the vessel before and during irradiation a stream of gas of the desired oxygen/nitrogen mixture at 1 atm. Our observation at $pO_2 = 0{\cdot}07$ atm. gave a value close to Kihlman's curve; this is less steep than ours at $pO_2 = 0{\cdot}2$, and more steep than that obtained by Read[1], who irradiated roots in closed vessels in which the oxygen tension had been previously adjusted to a desired level. Read's paper contains a discussion of the extent to which the water surrounding the roots must have become deoxygenated through oxygen consumption before and during irradiation. We think that the differences between the three sets of observations shown in Fig. 2 are satisfactorily explained by differences in the amount of oxygen present.

These considerations indicate that radiosensitivity is a function of oxygen/nitrogen ratio only when

Table 1. EFFECTIVENESS OF VARIOUS GASES IN REDUCING THE OXYGEN-DEPENDENT RADIOSENSITIVITY OF *Vicia faba* ROOTS

Gas	Pressure in atm. for 50 per cent effect	Partition coefficient lipid/water (ref. 12)
Helium	55	1·7 (37° C.)
Hydrogen	55	2·3 (22° C.)
Nitrogen	12·5	3·5 (22° C.)
Argon	2	4·0 (22° C.)
Krypton	2	7·5 (22° C.)
Xenon	1·1	14·5 (22° C.)

sufficient oxygen is present throughout the root to confer full sensitivity, and that oxygen-dependent sensitivity is determined by the absolute amount of oxygen present in the cell or some part of it. This amount can be reduced by lowering the oxygen tension at the cell, or by displacing the oxygen from a site within the cell by a sufficient concentration of another gas.

Oxygen is supplied to the root tip by diffusion through the gas spaces in the root and through the liquid layers surrounding the root and the meristematic cells. Diffusion of gases through the liquid phase is not appreciably influenced by pressures of a few hundred atmospheres. On the other hand, the diffusion-rate of one gas through another is inversely proportional to the total pressure. The calculated diffusion constants of oxygen at 0·2 atm. differ according to the identity of the other gas present: these differences are not, however, in the same sequence as that of the effectiveness of other gases in reducing oxygen-dependent sensitivity[6]. It is thus very unlikely that the inert gases act by reducing the rate at which oxygen moves through liquid or gaseous intercellular spaces in the root. It appears that they must act at the cellular level.

Tumour cells of the mouse. To test this point and to extend our observations to other material, we carried out experiments with suspensions of mouse Ehrlich ascites tumour cells. Six days after mice had been inoculated, ascitic fluid was collected and stored in crushed ice. Samples were irradiated as a layer 2 mm. deep in flat 'Polythene' dishes within a pressure vessel, after being exposed to the chosen gas mixture for 20 min. with stirring. Gas equilibration and irradiation were carried out at 0–2° C. to reduce the oxygen consumption of the cells and so avoid the depletion of oxygen which would otherwise occur in the deeper cell layers during irradiation. (In a control experiment we measured the time required by washed ascites cell suspensions in a potassium phosphate buffer (*p*H 7·2) to reduce added hæmoglobin, and found that the utilization of oxygen at 0°–2° C. is at least twenty times slower than at 20° C.) The irradiated cells were inoculated into fresh hosts (0·2 ml. intraperitoneally), the hosts were killed after 18 hr. and the tumour cells fixed in acetic acid-ethanol (1 : 3 v/v). Four different doses of X-rays were given with each gas mixture investigated. The fraction of normal anaphases was an exponential function of the dose. The exponent was determined from at least six samples of 200–300 anaphases each. The best fit for the exponential function was calculated using the formula given by Lea and Catcheside[7]. The ratio of the doses required to reduce the fraction of normal anaphases to the arbitrary value of $10^{-1/2}$ was used to calculate the radiosensitivity under different treatments. The results (Table 2) showed that when cells were irradiated in the presence of a partial pressure of 0·2 atm. oxygen, the oxygen-dependent part of the radiosensitivity was reduced to 54 per cent by the addition of 110 atm. of hydrogen, and to 38 per cent by 110 atm. of nitrogen; with 21 atm. of argon the radiosensitivity was the same as that of cells irradiated in anoxic conditions.

Bacteria. A preliminary experiment with *Shigella flexneri Y6R* (carried out in collaboration with Miss Tikvah Alper) showed that argon was more effective than nitrogen in reducing the oxygen-dependent part of the radiosensitivity of this organism. It was, however, necessary to use 0·01 atm. partial pressure of oxygen (sufficient to confer 95 per cent of the oxygen-dependent sensitivity[8]) and much higher ratios of argon or nitrogen to oxygen than were required to give the same effect in bean roots.

Table 2. EFFECT OF GASES ON THE RADIOSENSITIVITY OF EHRLICH ASCITES TUMOUR CELLS

Experiment	Gas mixture pressure in atm.	Dose in r. to reduce normal anaphases to 31·6 per cent	Relative sensitivity
I	No air + 93 nitrogen	768 ± 32	1·0 ± 0·04
I	No air + 100 hydrogen	798 ± 36	0·96 ± 0·06
I	1 air + 110 hydrogen	418 ± 12	1·84 ± 0·05
I	1 air + 110 nitrogen	595 ± 27	1·29 ± 0·06
I	1 air	225 ± 15	3·40 ± 0·08
II	No air + 100 nitrogen	680 ± 18	1·00 ± 0·03
II	1 air + 21 argon	705 ± 30	0·97 ± 0·05

Effect on oxygen consumption. It was of interest to establish whether the effect of inert gases could be explained either by an increased rate of utilization of oxygen or by interference with the free passage of oxygen through the cell membrane. We therefore examined the rate of utilization of oxygen by Ehrlich ascites or by bacterial cells when exposed to 1 atm. of air plus 20 atm. of either nitrogen or argon. Washed suspensions of cells, at *p*H 7·5, were put into two identical 'Perspex' pressure vessels, with hæmoglobin as an oxygen indicator. One vessel served as control, and to the other was added either 20 atm. of nitrogen or 20 atm. of argon, and both vessels were shaken gently. The time taken for reduction of the hæmoglobin, as observed by hand spectroscope, afforded an estimate of the rate of utilization of oxygen by the cells to an accuracy of approximately ± 15 per cent. It was found for both Ehrlich ascites tumour cells and for *Shigella* that the rate of utilization of oxygen was influenced neither by nitrogen nor by argon at pressures at which these gases affected oxygen-dependent radiosensitivity. It was concluded that oxygen must have been present inside the cells under our experimental conditions, and that the protective effect of the inert gases was not due to a greatly enhanced utilization of oxygen. The evidence therefore suggests very strongly that the inert gases act intracellularly.

Conclusion. We may postulate that specific and finite sites exist within the cell at which oxygen must be present to confer oxygen-dependent sensitivity, and that inert gases can displace oxygen from these sites. That oxygen and the other gases compete for the same sites is indicated by the experimental finding with bean roots that sensitivity is governed by the ratio of oxygen to the other gas provided that the partial pressure of oxygen is sufficient to guarantee saturation of the site. Furthermore, when the oxygen effect was blocked by one gas (20 atm. of nitrogen), the addition of an excess of another protecting gas (100 atm. of argon) did not further reduce the radiosensitivity. This result suggests one mechanism for both gases, and is consistent with a displacement adsorption phenomenon at a defined site.

Some inert gases are known to be anæsthetic, and many years ago it was postulated that this property is related to their lipid-water partition coefficients[9]. Table 1 shows that a parallel exists also between these coefficients and the effectiveness of the gases in reducing radiosensitivity in bean roots. The apparent discrepancy between the very different effectiveness of nitrogen and argon and their rather similar partition coefficients may perhaps be explained by the fact that argon is approximately twice as soluble as nitrogen both in water and in lipid.

The relationship with anæsthetic effect led us to test the commonly used anæsthetic gas cyclopropane: we found that, at 2 atm. added to 1 atm. of air, it blocked the oxygen-dependent sensitivity of bean roots by about 50 per cent. Cyclopropane is 34·4 times more soluble[10] in olive oil than in water at 37° C.

The parallel shown in Table 1 suggests that the site from which oxygen is displaced may be associated with some lipid-like material in the cell. We know from the unchanged rate of utilization of oxygen under 20 atm. of nitrogen and argon that the site is unlikely to be one of the main cytoplasmic organelles which utilize oxygen. Read has shown (below) that the damage caused in bean roots by 8-ethoxycaffeine, which is known to be dependent on an intact respiratory mechanism[11], is not influenced by argon; this is a further indication that the inert gases do not interfere with this mechanism. The site of action of inert gases may be a lipid-water interface or an area or volume in the lipid fraction of the cell. Since the type of radiation damage which we have been measuring is expressed in the nucleus, and is believed to be the result of energy absorbed there, the site may well be within the nucleus or associated with the nuclear membrane.

We wish to thank Mr. Paul Murfin for his technical help throughout these experiments.

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Effect of a Combined Treatment with 8-Ethoxycaffeine and Argon on the Roots of *Vicia faba*

IF roots of *Vicia faba* are irradiated with X-rays when in the normal state of aeration, they are much more sensitive than they are when no oxygen is present. To produce the same damage in the absence of oxygen we must increase the dose by a factor[1] of almost 3. Ebert, Hornsey and Howard have shown (preceding communication) that if a sufficiently large pressure of an inert gas is added to the normal atmosphere in which the roots are irradiated, the damage corresponds to the anærobic sensitivity, although the normal amount of oxygen is present in the gas phase.

The influence of oxygen on the X-ray sensitivity of the roots has a parallel in its influence on their sensitivity to 8-ethoxycaffeine. Kihlman[2] first showed that if *Allium* roots were immersed in an ærated 8-ethoxycaffeine solution for a few hours, chromosome aberrations were produced, but if the solution was free from oxygen there was virtually none. Later[3] he obtained the same result with *Vicia faba* roots. Read and Kihlman[4] then showed that a marked reduction in growth also occurred after a treatment in an ærated solution at 10° C., but if the solution was free from oxygen there was no detectable effect. In these cases, therefore, the influence of oxygen is more marked than when X-rays are used since the reduction is to zero instead of to approximately one-third.

The question naturally arises whether an added pressure of one of the inert gases will abolish the influence of oxygen on the action of 8-ethoxycaffeine, as it does in the case of X-rays. This has been tested in the same high-pressure chamber as was used by Ebert, Hornsey and Howard. It was arranged vertically with the top cover removed. Into it 200 c.c. of 7×10^{-3} *M* 8-ethoxycaffeine solution chilled to near 0° C. was poured, and a group of nine roots was put into the top end so that they did not reach to the level of the solution. The top cover was bolted on and 5 atm. pressure of argon was slowly added to the normal atmosphere in the chamber. The chamber was then placed in a rocking cradle immersed in a trough of water kept at 10° C., and the treatment was commenced by tipping it so that the solution flooded over the roots on its way to the lower end. The tipping was continued at intervals of a minute so that the roots were alternately wetted by the solution and exposed to the gas pressure. After four hours the chamber was removed with the solution drained to the end remote from the roots. The pressure was slowly released, the end cover removed, and the roots extracted. They were rinsed under the cold tap and returned to the culture tank.

Other groups of roots were exposed in a similar manner: (*a*) to 200 c.c. of the same solution without the addition of the argon pressure; (*b*) to 200 c.c. of tap water with the addition of 5 atm. pressure of argon, and (*c*) to 200 c.c. of water without the argon pressure.

The mean growth-rates of these groups of roots have been expressed as percentages of the mean growth-rate of a similar untreated group which co-existed in the culture tank. They are plotted in Fig. 1 against time before and after treatment, which occurred at time zero on the abscissa scale. Roots exposed in water without added argon showed a check in growth only on the day of treatment, due partly to the handling and partly to the four hours at low temperature (10° C.). Roots exposed to the 5 atm. pressure of argon while intermittently flooded with water were more affected, but they had recovered their normal growth-rate after 3–4 days. Ebert, Hornsey and Howard subjected their roots to pressure for periods of only 15–30 min. compared with 4 hr. here, so that it is understandable that they observed no harmful effect unless X-rays were also used. On both occasions when the ethoxycaffeine solution was used the growth-rate curve was of the type already found by Read and Kihlman[4] and the minimum value was about the same as they measured after 4 hr. immersion in 7×10^{-3} *M* solution at 10° C. The two curves, one obtained with added argon and the other without it, do not differ appreciably, and

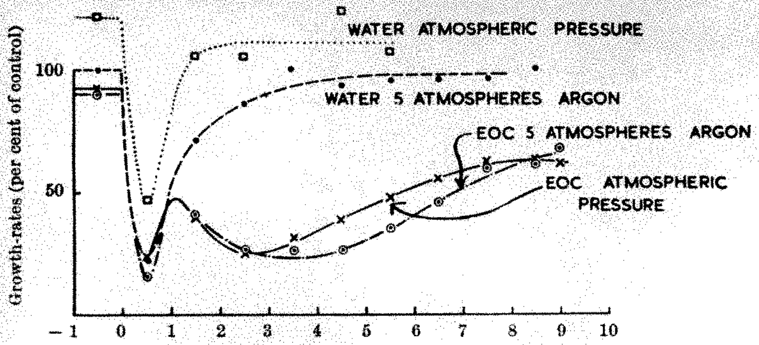

Fig. 1. Ethoxycaffeine and 5 atm. argon (4 hr.)

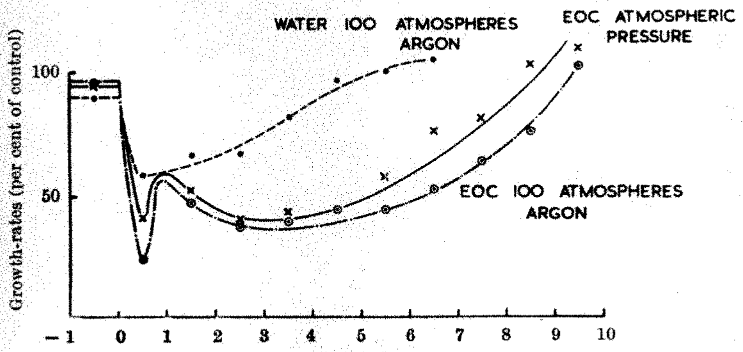

Fig. 2. Ethoxycaffeine (EOC) and 100 atm. argon (3 hr.)

the tentative conclusion is that the argon pressure had no effect on the sensitivity of the roots to 8-ethoxycaffeine. Perhaps there is such an effect, but the threshold pressure is greater than when X-rays are the injurious agent. To test this, the experiment was repeated, but 100 atm. pressure of argon was introduced. As the control roots had already reacted unfavourably to 4 hr. in 5 atm. pressure, the duration of the treatment was reduced to 3 hr. in an attempt to reduce this unwanted effect. The growth-rate curves are shown in Fig. 2. The argon treatment alone reduces the growth-rate, but there is complete recovery after 4–5 days. At this time the roots treated with 8-ethoxycaffeine still have a much-reduced growth-rate (about 50 per cent normal), and there is little difference between those treated with the added argon and those without it.

The conclusion is that argon pressures which completely annul the enhanced sensitivity to X-rays produced by oxygen have no effect on the sensitivity to 8-ethoxycaffeine, although this sensitivity also depends on the presence of oxygen. This conclusion cannot be drawn with the certainty we would like, because the control roots were adversely affected by the argon pressure, but it seems to be the most probable interpretation of the results. Its importance is that the site of action of oxygen in the X-ray case would then be different from that involved with 8-ethoxycaffeine. Kihlman[5] has shown that sodium azide, which inhibits cytochrome oxidase and thereby respiration, suppresses the power of 8-ethoxycaffeine to cause chromosome breakage as completely as anærobic conditions. The effect is also suppressed by 2.4-dinitrophenol, which uncouples phosphorylization from oxidation. These observations suggest that the site of action of oxygen in this case is the mitochondria, that is, in the cytoplasm. On the other hand, the respiratory mechanism seems not to be involved in the X-ray breakage of chromosomes, and there is reason to believe that both the oxygen and the track of ions must be in the immediate vicinity of the chromosomes, that is, in the nucleus. Ebert, Hornsey and Howard (*loc. cit.*) have shown the importance of the lipid/water partition coefficient of the added gas and have suggested that it excludes oxygen from some lipid/water interface which "may well be within the nucleus or associated with the nuclear membrane". Kihlman[6] reported that a considerable number of purine derivatives could produce chromosome aberrations in plant chromosomes, and these could be divided into two classes. The first, of which 8-ethoxycaffeine is an example, acts in relatively high concentration and short exposure times, whereas the second acts in dilute solution applied for times of the order of the mitotic cycle. If a concentrated solution of the second class is used, less effect on the chromosomes is produced, but there is a marked inhibition of mitosis. Kihlman made a strong case for the view that compounds of the first type could pass through the nuclear membrane, whereas those of the second could not, but produced their effect only on the chromosomes of dividing cells. He then showed that the first class had a lipid/water solubility ratio greater than unity, ranging up to about 10, whereas those of the second class had a ratio less than unity, ranging down to 0·04. He concluded from this that the nucleus was surrounded by a lipid/water interface which he called the "perinuclear layer". This might well be the "lipid/water interface . . . associated with the nuclear membrane" suggested by Ebert, Hornsey and Howard.

This work has been done in the laboratory of the Research Unit in Radiobiology of the British Empire Cancer Campaign at the Mount Vernon Hospital and the Radium Institute, Northwood, while on sabbatical leave from the New Zealand Branch. I thank the director, Dr. L. H. Gray, for the facilities he has given me, and the New Zealand Branch for making the visit possible. The high-pressure chamber was loaned by the Experimental Radiopathology Research Unit of the Medical Research Council, for which I am grateful to the director, Dr. G. Popjak.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Ultra-structure of the Insect Ear

Light microscope studies[1-4] have long established that the sensory unit (chordotonal sensillum or *stiftführendes Organ*) of the insect ear consists of three cells, namely, the bipolar neuron, the axon of which runs directly to the central nervous system, the sheath cell, which surrounds the dendrite of the neuron, and the attachment cell, which appears to anchor the whole assembly to the ear-drum. The approximate topographical arrangement of these cells and their inclusions are shown in Fig. 1. Examination of fresh material with the phase-contrast microscope by one of us (E. G. G.) has demonstrated that, though the vacuole (*v*) is a fixation artefact, the scolopale and the axial fibre are distinguishable *in vivo*. It is with the fine structure of the latter that this communication is principally concerned. All material has been taken from the auditory ganglia of adult female locusts (*Locusta migratoria migratorioides*) and fixed with 1 per cent osmium tetroxide buffered at *p*H 7·4 with veronal acetate. Each ganglion contains about eighty sensory units of the type described.

We confirm that the axial fibre enters the central end of the scolopale (Fig. 1) and reaches far up its axis, though we have not yet been able to trace it to contact with or passage through the cap. At the level indicated in Fig. 2 a transverse section discloses that the fibre (Fig. 2,*b*) consists of an outer ring of nine fibrillar elements and an inner group which may be two pairs of fibrils. At the level of the central end of the scolopale, this fibrillar structure is lost and the axial fibre becomes a single solid rod with cross-striations of dense lines (period 700 A.) with two wider and less dense bands between each pair of lines (Fig. 3). As this rod approaches the nucleus of the neuron it splits repeatedly into rootlets (Fig. 4). As many as forty rootlets have been counted in transverse section and each has a similar periodic structure to the parent rod.

The axial fibre therefore conforms closely, in the structure of both its distal and proximal parts, with what has been shown to be the fundamental structure of animal (and plant) cilia, and flagella[5,6]. Sjöstrand[7] has shown that the outer segment of the rod of the mammalian retina is connected with the inner by a cylinder of nine pairs of fibres with a striated root, and it is probably relevant that rods and cones are derived from the ciliated epithelium of the neurenteric canal. Wersäll[8] has found essentially the same structure (but without the striated root) in the kinocilia of the mammalian crista. Motility has been asserted of the kinocilia in the cristæ of lower vertebrates, but it has not been confirmed for mammals and it would in any event not necessarily exclude a sensory function. It seems that, when a ciliary effector is transformed into a receptor in the course of ontogeny, the fundamental structure of the cilium sometimes persists: and its retention in these cases suggests that, whatever role is ascribed to it in ciliary activity, it can play the same part but in a reversed sense in the receptor process.

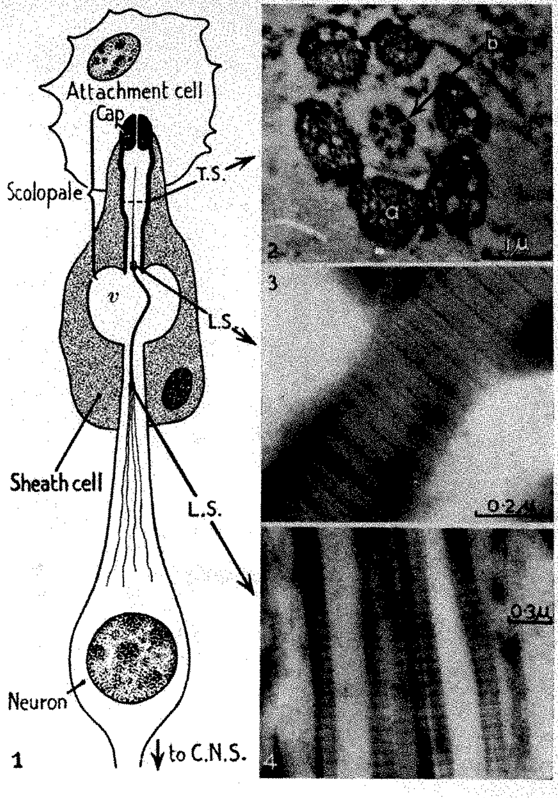

Fig. 1. (1) Diagram of light microscope preparation showing one sensory unit of the locust ear (Bouin fixed: hæmatoxylin and eosin stained). Figs. 2–4. Sections at various levels of Fig. 1 (electron microscope). Fig. 2,*a*, one of six or more pillars of finely vesiculated material forming the wall of scolopale

In insects, ciliary and flagellar effectors (except for the tails of spermatozoa in some genera) are wholly lacking in all members of the class and at every stage in the life-cycle. There is here no question of their transformation into receptors during the development of an individual. The occurrence in insects of the ciliary ultra-structure in what are unquestionably receptor cells of extremely high mechanical sensitivity is therefore of considerable interest.

We are much indebted to Prof. J. Z. Young for providing facilities and equipment for this work, to the Anti-Locust Research Centre for a constant supply of fresh material and to Dr. J. D. Robertson for much helpful advice.

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Relation between Nucleolar Volume and Cell Body Content of Ribonucleic Acid in Supra-optic Neurones

During an investigation of the influence of increased functional activity on the ribonucleic acid in neurosecretory cells of the supra-optic nucleus of the rat, an observation of more general interest was made. The amount of ribonucleic acid in the cell bodies was measured microchemically[1] and the volumes of their nucleoli were determined on stained slides. Cells from control animals were investigated as well as from animals that had been subjected to administration of sodium chloride for two months. Apart from the finding that increased functional load (increased hormone production) gives rise to statistically significant increases in amounts of ribonucleic acid and nucleolar volumes, it was found that the ribonucleic acid content per cell body was directly proportional to the nucleolar volume (Fig. 1). The ribonucleic acid content per cell body nearly equals that of the cytoplasm in these cells, so it is apparent that there is a proportionality between nucleolar volume and cytoplasmatic content of ribonucleic acid. On the other hand, it can be shown that it is unlikely that proportionality between nucleolar volume and nucleolar amount of ribonucleic acid should exist as well as proportionality between nucleolar and cytoplasmatic amounts of ribonucleic acid.

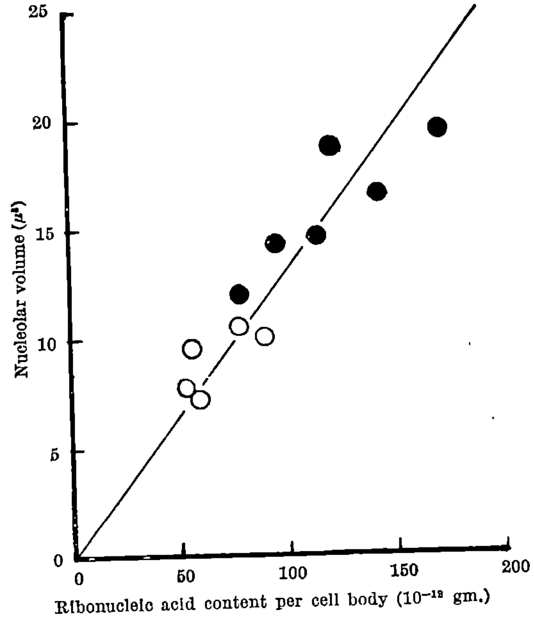

Fig. 1. Values for nucleolar volumes plotted against values for ribonucleic acid content in cell bodies of supra-optic neurones. Mean values per animal are given. Open circles designate controls, filled circles experimental animals

It is of interest to note that LaVelle[2], from a study of stained slides, came to the conclusion that there exists a proportionality between the size of the nucleoli and the amount of Nissl substance in nerve cells proper. As the basophilia of the Nissl substance is due to ribonucleic acid, these results are in good agreement, indicating that the relations may have more general application.

A full account of this investigation, which was supported by grants from the Swedish Medical Research Council and Deutsche Forschungsgemeinschaft, will be given in *Zeitschrift für Zellforschung*.

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Antigenicity of Avidin

Avidin has been shown to bind the vitamin biotin, but the mechanism of binding is still unknown. Modification of the avidin molecule by acetylation, esterification or by blocking the amide, guanidyl, imidazole and phenolic groups did not result in a loss of its ability to bind biotin[1].

The mechanism and site of binding of an antigen by its homologous antibody is also largely unknown. In an effort to answer the question whether the locus (loci) of binding of biotin by avidin (on the avidin molecule) was (were) the same or one of the loci binding antiavidin to avidin, we have studied the specific precipitation of avidin by rabbit antiavidin serum in the presence and absence of biotin. Avidin concentrates were prepared according to Dhyse[2], and adult male rabbits were immunized by bi-weekly parenteral administration of these concentrates mixed with Freund's adjuvant supplied by the Difco Co. In all, two courses of immunization were employed. The avidin used for the precipitin reaction was obtained by dialysis of these concentrates, when avidin formed a precipitate. The dialysis was carried out against distilled water over a 48-hr. period with 3–4 changes of the water. The precipitin reaction was carried out according to standard methods[3] first at 37° C. for 3 hr. and then at 5° C. for 48 hr. The results are given in Table 1.

Protein was estimated according to Lowry *et al.*[4] In one series (*A*) of experiments the precipitation of avidin in the absence of biotin was studied as a control. In the *B* series, 5γ of biotin were added to the avidin and incubated at 37° C. for 1 hr. At the end of this period, antiserum was added and the incubation continued for 3 hr. at 37° C., and the precipitation continued for 48 hr. in the refrigerator. In the *C* series, precipitation of avidin was effected first and then 5γ of biotin were added. The results do not show any marked enhancement or inhibition of precipitation of avidin by its homologous antiserum, in the presence or in the absence of biotin. The binding of the antibody was not affected by the previous formation of the avidin–biotin complex

Table 1. Precipitation of Avidin by Rabbit Antiavidin

No.	Amount avidin (γ)	Total protein precipitated, using 1 ml. of serum		
		Exp. *A*	Exp. *B*	Exp. *C*
1	29·6	430	345	364
2	59·2	705	690	664
3	88·8	940	920	1,004
4	118·4	1,100	1,265	1,284
5	148·0	1,530	1,505	1,484
6	222·0	1,635	1,605	1,689
7	296·0	1,605	1,695	1,914

(Exp. *B*). It is rather hard to be definite about this for the following reasons :

(1) The best preparation of avidin binds only about 1/120 of its weight of biotin, whereas many more times its weight of antibody is bound.

(2) The binding site of biotin may be only one of the several patches where antiavidin is bound. Loss of one of these loci may not affect the precipitin reaction to a significant extent. Also, at higher concentrations of antigen, the antigen–antibody complex will become more soluble.

However, as shown by our preliminary experiments, the ability of avidin to bind biotin was not lost by previous precipitation of this protein by its antibody. Our preparations of antisera did not cross-react with ovomucoid or lysozyme, but do show a certain amount of cross-reaction with ovalbumin. Further, it is interesting to speculate whether biotin might not act as a hapten if the avidin–biotin complex were used as the antigen and if this complex were not cleaved by the intact rabbit, when administered parenterally.

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Cortisone–Glucose Tolerance Test in Normal and Thyroxine-treated Rabbits

In hyperthyroidism a decreased glucose tolerance with a diabetic-like glycæmic curve has been found by some authors[1–3]. Some of them ascribe this change to the damage caused to the pancreas by the toxic effect of thyroxine on β-cells of Langerhans islets[4,5], others to the relative or absolute insulin deficiency[1]. However, Amatuzio *et al.*[6,7], in their studies on patients with hyperthyroidism, showed that both the rate of disappearance of glucose during the intravenous glucose tolerance test and the glucose tolerance are normal or increased. This observation has been confirmed by my own studies on patients and experimental animals[8]. Recently, Conn and Fajans[9,10] have suggested the use of the cortisone–glucose tolerance test for investigating the latent insufficiency of insulin secretion in the non-diabetic relatives of known diabetics. Since the rapid intravenous glucose tolerance test in animals with hyperthyroidism was within the normal range[8], the cortisone–glucose tolerance test was employed for ascertaining the latent damage to the pancreas.

Table 1. Values of the Assimilation Coefficient of Glucose in the Intravenous and Cortisone–Glucose Tolerance Test in Normal and Thyroxine-treated Rabbits

State	No.	Test	Assimilation coefficient	*P*
Normal	7	GTT*	1·16 ± 0·18	—
Thyroxine-treated	7	GTT*	1·29 ± 0·25	>0·1
Normal	7	C–GTT†	1·10 ± 0·16	>0·1
Thyroxine-treated	7	C–GTT†	2·01 ± 0·52	<0·01

* Intravenous glucose tolerance test. † Cortisone–glucose tolerance test.

In a group of normal rabbits and rabbits with experimental hyperthyroidism (induced by treatment with 0·25 mgm./kgm. body-weight thyroxine per day for 10 days) a rapid intravenous glucose tolerance test was performed and the tolerance was evaluated by determining the assimilation coefficient of glucose[11–13]. In the cortisone–glucose tolerance test 5 mgm. of cortisone acetate were administered intramuscularly 4 hr. before the intravenous glucose tolerance test. The results of our observation are given in Table 1. In normal rabbits the average value of the assimilation coefficient of glucose is 1·16 ± 0·18 ; after treatment with cortisone it was found to be slightly, though not significantly, decreased to 1·10 ± 0·16. In rabbits with hyperthyroidism it was 1·29 ± 0·25. This did not decrease even after administering cortisone (which would point to a latent insulin deficiency), but actually increased by a significant amount to 2·01 ± 0·52, which shows an accelerated rate of disappearance of glucose, increased rate of utilization of glucose and improved glucose tolerance. The exact nature of this change of assimilation coefficient of glucose cannot as yet be explained fully. It may occur in one of the following ways : either the organism of thyroxine-treated rabbits is in a state of excessive excitement[14], so that slight hyperglycæmia after the administration of cortisone causes an increased secretion of insulin which accelerates the rate of disappearance of glucose, or thyroxine affects the response of carbohydrate metabolism to cortisone.

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A Highly Sensitive Assay for Œstrogens

The accepted criterion of response in the intravaginal Allen–Doisy assay is cornification of the vaginal epithelium, which occurs 48–54 hr. after administration of an effective dose of œstrogen[1,2]. Cornification is the end-point of a lengthy chain of events involving cell multiplication and growth of the epithelium.

Biggers and Claringbold[3] have shown that, in the mouse, the earliest morphological response to the intravaginal administration of œstrone, is an increase in the mitotic rate of the vaginal epithelium. After a latent period of about 12 hr. the mitotic rate increases exponentially until 30–36 hr. after injection. Since it is probable that œstrogens act by stimulating cell division, without having any other effect on the cornifying cells, it was thought that a quantitative investigation of the mitotic rate of the vaginal epithelium 17–24 hr. after hormone administration might throw some light on the primary action of œstrogens.

Randomly bred ovariectomized albino mice have been used in this study. Two weeks before use they were primed by the subcutaneous injection of 1 μgm. œstrone in peanut oil. Individual animals were allotted to the experimental groups with tables of random numbers. Œstrogens were administered in one intravaginal injection of 0·01 ml. distilled water. 7 hr. before each animal was killed 0·1 mgm. colchicine, in 0·05 ml. distilled water, was injected subcutaneously, in order to arrest mitoses. 24 hr. after injection, the vagina was removed, fixed in Barr's fixative and embedded in wax. Transverse sections 6μ thick were stained in Heidenhain's hæmatoxylin. All observations were made with a binocular microscope (× 720). For each animal five fields were selected at random from the sections. The total number of arrested mitoses were counted in each field, the final score for each animal being the sum of five counts. A transformation $Y = \log_{10}(Z + 2)$ (where Z was the number of mitoses per field) was applied to the data, and analysis of variance was carried out.

Fig. 1 shows the response to various doses of œstrone. It can be seen that a maximum response is elicited by 8×10^{-5} μgm. œstrone, response being approximately linearly related to log dose in the range $0\cdot5 \times 10^{-5} - 8 \times 10^{-5}$ μgm. œstrone. The low dose required to elicit a maximum response at 24 hr. confirms the suggestion of Biggers and Claringbold[4] that the greater part of a singly cornifying dose is ineffective, being lost from the vagina.

A number of assays have been carried out; the results are summarized in Table 1. Although day-to-day variations in mean response are significant, day-to-day variations in slope and variance are not. In experiments III and IV no significant difference was found between the slopes of œstrone and œstradiol-3 : 17β.

The relative potency of œstradiol-3 : 17β, in terms of œstrone, was found to be 1·68 (0·93–3·03); the 5 per cent fiducial limits follow the estimate. Biggers[5], using 500 animals, with cornification as the criterion of response, found œstradiol-3 : 17β to be significantly more active than œstrone (relative potency 1·75 (1·15–2·66)), an estimate not in discord with the above ($\chi^2_{[1]} = 0\cdot0042$, $P > 0\cdot95$).

Table 1

Experiment	Substances tested	No. of animals	Slope	Standard error of slope	Relative potency
I	Œstrone	8	105·0	23·26	—
II	Œstrone	24	121·4	25·96	—
III	Œstrone and œstradiol-3 : 17β	48	123·0	18·41	1·74 (0·97–3·49)*
IV	Œstrone and œstradiol-3 : 17β	32	83·3	16·55	1·50 (0·50–5·00)*

* The 5 per cent fiducial limits follow the estimate. Mean relative potency = 1·68 (0·93–3·03).

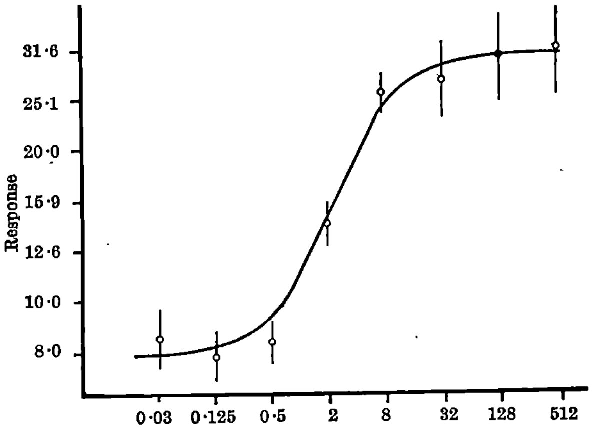

Fig. 1. The relationship of response (mean number of arrested mitoses per field) to log dose of œstrone (10^{-5} μgm.), 24 hr. after administration of the hormone. The vertical lines through the observations indicate plus and minus one standard error of the mean. The errors vary since more animals were used on the linear segment of the curve than elsewhere

The method of assay described in this communication, therefore, appears to be ten times as sensitive and four times as precise as the standard intravaginal assay under optimum conditions[4]. Preliminary work with entire immature mice suggests that the slope is doubled. Further work is being carried out with the object of increasing both slope and sensitivity of the assay method.

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Serological Determination of Developing Muscle Protein in Chick Embryo

Myosin in the heart muscle of a chick embryo of about 16 hr. after incubation was determined first by Ebert[1]. Further experimental work on myosin during embryonic development was published by Rudnick[2] and Grunwaldt[3] from histochemical points of view. Csapo and Herrmann[4] found a protein with solubility and viscosimetric characteristics similar to myosin in chick muscle on the ninth day of development, suggesting the possibility of its existence at earlier stages. Herrmann[5], however, reported later that muscle protein was not detectable until about the fourteenth day.

We obtained pure actin and actomyosin from the pectoral muscles of White Leghorns by Straub's method[6,7]. This protein, at a concentration of about 15 mgm. per ml., was injected intravenously into rabbits at 3-day intervals, until it reached a total of 60 mgm. The rabbits were bled by heart puncture on the fifth day after the last injection, and the serum obtained was used for the precipitin reaction with saline extracts from chick embryos[8]. We checked failure due to antigen-excess by using a constant volume of serum and progressively decreasing amounts of antigen.

Table 1. Results of Precipitin Reaction with Actin Anti-serum and Saline Extracts of Chick Embryos

Hours after incubation	No. of embryo	Antigen concentration 4 ×	8 ×	16 ×	32 ×	64 ×	128 ×	Note
24	8	− −	− −	− −				4 embryos mixed
48	8	− −	− −	− −	− −			
72	4	+ +	− ±	− −	− −	− −	− −	2 embryos mixed
96	2	+ ++	++ +++	+++ +++	++ ++	++ +	+ +	*
144	2	+ +	+ +	+ +	+ ++	++ ++	+++ +++	*
216	2	+ +	+ +	+ +	+ +	++ ++	++ +++	*
Control (non-fertilized)	8	− −	− −	− −				4 brastodics mixed

* The heart tissue was sufficiently excised.

Actin from the heart tissue and that from the striated muscle showed no difference in the reaction of anti-serum.

Table 2. Results of Precipitin Reaction with Actomyosin Anti-serum and Saline Extracts of Chick Embryos

Hours after incubation	No. of embryo	Antigen concentration 4 ×	8 ×	16 ×	32 ×	64 ×	128 ×	Note
48	12	− −	− −	− −				6 embryos mixed
72	72	− −	− −	− −	− −			* 32 embryos mixed * 40 embryos mixed
96	56	+ +	− +	− −	− −	− −		* 24 embryos mixed * 32 embryos mixed
120	6	+ +	± +	− −	− −	− −	− −	* 3 embryos mixed
168	3	+ ++ ++	++ ++ +	+ + +	− − −	− − −	− − −	* * *
240	3	+ ++ ++	++ ++ +++	+++ ++ +++	++ + ++	+ + ++	+ + +	* * *
Control (non-fertilized)	12	− −	− −	− −				6 brastodics mixed

* The heart tissue was sufficiently excised.

It was found that actin became detectable first in the chick embyro 72 hr. old (Table 1)[9]. In contrast, in the striated muscle, actomyosin was detected about 96 hr. after incubation (Table 2).

It may therefore be concluded that the stages of appearance of heart myosin, actin and actomyosin in the striated muscle occur, respectively, at about 16, 72 and 96 hr. after incubation in chick embryos. It seems that, in the heart, myosin appears before the formation of actin, while the order may be reversed in striated muscle.

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A Special Reaction of the Complement Fixation Test applied to the Study of Tumours

In the course of immunological research on cancer it was observed that the foot and mouth disease virus can act as antigen in a special reaction of the complement fixation test.

For the reaction the blood serum must be fresh, correctly diluted, and not inactivated, and the reactive antigen is the foot and mouth disease virus type *O*, variation 2, obtained from a buffered extract of artificially infected bovine tongue epithelium which has been biologically titred and sterilized by filtration and is not inactivated. The other reaction elements are more or less the same as those of the normal complement fixation test: guinea pig complement and a hæmolytic system with sheep red cells and rabbit hæmolytic serum. The incubation at 37° C. is as usual.

A high proportion of normal subjects, and those suffering from various non-cancerous diseases, gave a positive serological reaction, while subjects suffering from malignant tumours, especially of epithelial origin, nearly all gave a negative serological reaction (Table 1).

Table 1

	Total No.	Positive reaction		Doubtful reaction		Negative reaction	
		No.	Per cent	No.	Per cent	No.	Per cent
Apparently normal subjects	931	911	97·85	9	0·96	11	1·18
Subjects suffering from various non-tumour diseases	367	303	82·56	20	5·44	44	11·98
Subjects suffering from malignant tumours of epithelial nature	101	6	5·94	3	2·97	92	91·08
Total*	1,309						

* The other 105 cases out of the 1,504 tested were 33 pregnant women, 35 cases not accountable at present, and 37 cases of malignant or non-malignant, non-epithelial neoplasia, and of emolymphoblastosis, which we do not discuss because of the limited number of cases.

The tongue epithelial extracts of healthy cattle or of those infected with *A* or *C* virus of foot and mouth disease and their variants did not show any antigen property in this reaction. Similarly, other antigen-viruses, such as those of fowl pox, Newcastle disease, hog cholera, herpes simplex, parotitis, yellow fever, influenza (*A*, *B*, *C* types) had no activity.

1,504 subjects of both sexes were tested, giving a total of 1,709 reactions. A number of cases were tested several times at intervals. Table 1 shows that in 97·85 per cent of apparently normal subjects the serological reaction was positive. The positivity of the reaction was not affected by age or pregnancy. For 82·56 per cent of patients suffering from various non-neoplastic diseases, both acute and chronic, the reaction was positive. The diseases included those affecting, for example, the heart, blood vessels, the respiratory system, the digestive system, the liver, the urinary system, bones and articulations, the nervous system, as well as the endocrinal diseases, infectious diseases, traumatic cases, etc., and especially syphilis and tuberculosis. This percentage may be higher, since there is the possibility of undiagnosed cancer. On the other hand, for 91·08 per cent of subjects suffering from malignant tumour of epithelial nature the serological reaction was negative.

Similar results were obtained in preliminary experimental researches on animals. Healthy rats (Spague-dowle blood stock, male) gave positive serological reactions, while rats of the same stock, carriers of Walker tumours for twenty days, gave a negative serological reaction.

From researches recently started on the components of the complement, the C_3—C_4 components seem to have an important function in the mechanism of the reaction.

The diagnostic interest of this special reaction of the complement fixation test is evident. From the biological point of view a special reactive fraction is obviously deficient or inactive in the subjects suffering from malignant tumours of epithelial nature.

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Effect of Aldosterone Monoacetate and Deoxycorticosterone Acetate on Alkaline Phosphatase Activity in the Liver of Rats

Recent histochemical studies have demonstrated that aldosterone increases phosphatase activity in the kidney of rats[1]. The present communication records the influence of aldosterone monoacetate and deoxycorticosterone acetate on alkaline phosphatase activity of the liver of rats.

Young male albino rats, weighing 49·4 ± 8·9 gm., were injected subcutaneously with *d,l*-aldosterone-21-monoacetate in a daily dosage of 10 μgm. per animal for a period of 16 days. Deoxycorticosterone acetate was administered similarly (10 μgm. daily/16 days) to another group of rats. The animals were killed 24 hr. after the final injections. The liver was homogenized with water (100 ml./gm. fresh tissue), centrifuged for 5 min. at 2,000 r.p.m., and the clear supernatant was finally processed for estimation of enzyme activity according to the method laid down by Hawk *et al.*[2]. Gomori's technique[3] was used for histochemical localization of alkaline phosphatase activity. The results are presented in Table 1.

Table 1. Alkaline Phosphatase Activity in the Liver of Rats Treated with Aldosterone Monoacetate

Treatment	Alkaline phosphatase activity in the liver (mgm. phosphorus/gm./1 hr.) with S.E.*
Controls (solvent only)	2·05 ± 0·16 (7)
Aldosterone monoacetate (10 μgm. daily/16 days)	1·76 ± 0·34 (6)
Deoxycorticosterone acetate (10 μgm. daily/16 days)	1·10 ± 0·08 (7)

* Figures in parentheses indicate the number of animals.

Treatment with aldosterone monoacetate causes some inhibition of alkaline phosphatase activity in the liver albeit not in a statistically significant manner (Table 1). Deoxycorticosterone acetate evokes a similar but highly significant reduction in enzyme activity ($P < 0·001$). The difference between the two hormone-treated groups in this respect is, however, statistically insignificant. On a percentage basis, deoxycorticosterone acetate causes as much as 46 per cent inhibition, whereas aldosterone monoacetate evokes only a 14 per cent loss of enzyme activity. This suggests that deoxycorticosterone acetate is about three times as active as aldosterone monoacetate in inhibiting alkaline phosphatase activity in the liver. Histochemical preparations of liver do not show any change in the activity of this enzyme after treatment with aldosterone monoacetate, but in the deoxycorticosterone acetate group the endothelium of the vascular sinusoids reacts in a faint manner.

The present results indicate that the qualitative effect of the two hormones on alkaline phosphatase activity in the liver is more or less similar, but they differ with respect to degree. A somewhat similar view has been expressed by Loustalot and Meier[1].

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Conversion of 3-Hydroxyanthranilic Acid to Quinolinic Acid in Presence of Rat Liver treated with 2-Acetylaminofluorene

THE reactions reported here are considered to be the final steps in the chain of reactions whereby tryptophan is converted into vitamin[1]; it shows the inhibitory action of the carcinogenic substance 2-acetylaminofluorene on the reaction 3-hydroxyanthranilic acid→quinolinic acid.

The effect of a high-protein diet on the development of tumours, when 2-acetylaminofluorene is used as the carcinogenic compound, has not as yet been clarified. Morris *et al.*[2] reported that rats maintained on a diet containing 18–24 per cent casein, after administration of 2-acetylaminofluorene, showed a high number of tumours when compared with rats maintained on a 12 per cent casein diet.

Engel *et al.*[3] noticed that the number of weaned rats in which mammary tumours caused by 2-acetylaminofluorene were observed, decreased when casein was increased in the diet. Harris[4] states that the development of liver tumours due to 2-acetylaminofluorene does not depend on the protein-level of the diet.

Dunning *et al.*[5] investigated the connexion between diet and incidence of cancer due to 2-acetylaminofluorene. They found that bladder cancer arose in all rats (Fisher stock 344) which were fed on a diet containing large amounts of tryptophan (1·4–4·3 per cent). Rats fed on a diet containing smaller amounts of tryptophan showed no development of bladder cancer.

The high level of tryptophan in the diet necessary for the development of tumours recalls that the two *o*-aminophenols, that is, 3-hydroxyanthranilic acid and 3-hydroxykynurenine, formed in the degradative metabolism of tryptophan possess carcinogenic activities. Yet if 2-acetylaminofluorene induced a biochemical lesion at a stage when one of the transformation reactions of these two compounds takes place, it would be possible to formulate a hypothesis on the mechanism of the carcinogenic activity of 2-acetylaminofluorene on the bladder, based on the accumulation of one or both of these *o*-aminophenolic derivatives.

Our experiments were conducted on liver of rats maintained on a diet containing 2-acetylaminofluorene of Hoffmann–La Roche (0·1–0·2 per cent in the diet) for periods varying from 2 to 6 days.

Liver taken from rats of the same stock, of similar weight and age, fed on the same diet but without 2-acetylaminofluorene, was tested for its capacity to convert, under the same experimental conditions, 3-hydroxyanthranilic acid (3 mgm.) into quinolinic acid (incubation time always 1 hr.).

The method used for determining quinolinic acid was a slight modification of that of Rabinovitz, Fineberg and Greenberg[6,7].

The results of these experiments clearly demonstrate that, after administration of 2-acetylaminofluorene, the enzymic reaction, that is, the conversion of 3-hydroxyanthranilic acid to *o*-quinoneiminic compound, in liver tissue is highly inhibited; this inhibition results in an average value of about 50 per cent. In one of the experiments 504 µgm. of quinolinic acid was formed in the presence of normal rat liver; 210 µgm. quinolinic acid was formed in the presence of liver of a rat treated with 2-acetylaminofluorene.

The following possible mechanism would explain the carcinogenic activity of 2-acetylaminofluorene: 2-acetylaminofluorene inhibits the conversion of 3-hydroxyanthranilic acid to the *o*-quinoneiminic compound and causes an accumulation of 3-hydroxyanthranilic acid and 3-hydroxykynurenine. These physiological metabolites could in certain conditions lead to tumour formation.

It is important to notice that the reaction of 3-hydroxyanthranilic acid is already inhibited 24 hr. after administration of 2-acetylaminofluorene, while according to Wilson *et al.*[8] tumours arise only after 3–4 months. Therefore the biochemical lesion caused by the carcinogenic compound would appear very early.

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Demonstration of Antibody in Passive Transplantation Immunity to Crocker Tumour in Mice, using the Schultz–Dale Technique

MITCHISON[1] reported a simple and effective procedure for passively transferring transplantation immunity to a mouse lympho-sarcoma by injecting minced, regional lymph nodes intraperitoneally and draining the grafted areas of actively immunized mice. This phenomenon was later confirmed by Billingham *et al.*[2] using skin homografts. They preferred to call it 'adoptively acquired immunity'. Using the same technique[1], a similar transfer of passive immunity to homologous or heterologous tumour transplantation was conferred upon rats[3,4]. The criteria of immunization adopted in these experiments was the ability of the animal to cause regression of a viable implant of the tumour, or to hasten the breakdown of the skin homografts.

Recently, Makari[5] introduced the Schultz–Dale technique for the detection of specific soluble antigen in the sera of carcinoma patients using uterine horns of female guinea pigs. Fink *et al.*[6] extended it to detect antibody production against tumours in mice.

Using the Schultz–Dale technique, we have made attempts to demonstrate the presence of antibody in the host during this passive transplantation tumour immunity. The criterion of immunization taken here is the ability of the host's uterus, sensitized in this way, to produce a contraction when exposed to the homologous tumour antigen *in vitro* in the Dale bath.

Pure line strains of Strong-*A* and *C*57 black mice were used and Crocker tumour was grafted into the subcutaneous tissues of both flanks. 6 draining axillary lymph nodes, 2 spleens, 1 kidney, ⅓ of a liver and 3 c.c. of serum were obtained from mice with 10–12-day-old growing Crocker tumours. These

Table 1

Treatment	Uterus from Strong-*A* mouse, grafted intraperitoneally five days before, with draining lymph nodes from Strong-*A* mice, bearing Crocker tumour (12 days old)	Normal Strong-*A* mouse uterus, similarly treated with normal mouse lymph nodes
1. *Rd*/3 rat tumour soluble protein	0	0
2. Normal mouse organ (liver, spleen, kidney) soluble protein	++	0
3. Desensitization with normal mouse organ soluble protein		
4. Crocker mouse tumour soluble protein	++++	±
5. Crocker mouse tumour soluble protein (heated)	±	0
6. Desensitization with Crocker mouse tumour soluble protein		
7. Crocker mouse tumour soluble protein	±	0
8. Acetylcholine (10 μgm./ml.)	++++	++++

were minced and injected intraperitoneally into normal female mice of the same strain. Controls were treated similarly with tissues from normal mice. Animals were killed at intervals, the uteri were removed immediately and tested in the Dale bath for sensitization, by exposing them to different test antigens and recording the reaction on a kymograph. Soluble protein, lipoprotein[7] prepared from fresh or lyophilized Crocker mouse tumour, *Rd*/3 rat tumour and normal mouse organs were used as test antigens. After contraction with one antigen, a uterus was washed completely and the same antigen was added repeatedly to test for desensitization. The reactivity of the tissue was tested with acetylcholine at the end of each experiment.

It was found that draining lymph nodes and spleens from tumour-bearing mice are very effective; the uterus so sensitized gives a positive reaction when exposed to Crocker tumour soluble protein, lyophilized Crocker tumour extract and Crocker tumour lipoprotein. After heating, the antigens do not have this effect. Other organ-grafts are not effective. No such contraction is seen in the uterus when exposed to normal mouse organ soluble protein, lyophilized normal mouse organ extract and soluble protein from *Rd*/3 rat tumour as test antigens. Heating of the lymph nodes prior to grafting also abolishes this effect. The reaction appears on the second day after grafting and disappears completely after 3 weeks. This reaction has no strain specificity; lymph nodes from Strong-*A* mice bearing Crocker tumours, grafted into *C*57 black mice and *vice versa*, also give a positive reaction.

A typical result is given in Table 1.

It was shown previously that the host animal (rat and mouse) reacts to a progressively growing transplanted tumour by developing a characteristic plasma-cellular reaction in the draining lymph node and spleen[3,8], which can be correlated with the increase of deoxyribonucleic acid and thus with protein synthesis in these organs[9]. It was suggested that the plasma-cellular response is the morphological manifestation of a systemic immune reaction, due to the antigenic stimulation from the graft, and that plasma cells are involved in the production of antibodies against the tumour[8]. Evidence has been presented by Billingham *et al.*[2] that this heightened resistance in 'adoptive immunity' is not due to passive transference of any preformed antibody from the primary hosts, but of immunologically activated tissue, which continues to function in these secondary hosts after transfer.

Although these experiments do not throw any light on this question, they demonstrate that the presence of antibody in the host is the basic mechanism involved in this passive tumour transplantation immunity. This investigation, which will be published later in detail, also confirms observations[1,3,8] that the regional lymph nodes and spleen are important seats of the host's reaction against tumour homografts, that they form antibodies and that plasma cells play an important part in their production.

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Anti-allergic Effect of Cortisone

Investigations on the release of histamine and slow-reacting substance from the perfused anaphylactic lung of the guinea pig reveal that cortisone is not inhibitory to the release of either substance. On the other hand, in as low a concentration as 1 in 140,000 the response of the guinea pig gut to histamine and slow-reacting substance is greatly reduced if the cortisone is left in contact with the gut for 1–3 min. Contact for 10 sec. is without significant effect so that assay of the output of histamine and slow-reacting substance is satisfactory on the isolated gut of the guinea pig. This effect, owing to the delay, may be due to intracellular action of cortisone on the effector organ.

This peripheral depressant action, which is not reported as being significant in man from clinical observations, has probably not been observed because of the concentration required to produce it. More soluble cortisone preparations, now available, should show whether this has clinical significance, since larger rapid intravenous dosage is now possible. Lower dosage of cortisone is known to inhibit antibody production and so produce a more gradual reduction in sensitivity.

These experiments will be described in detail elsewhere.

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Quantitative Determination of Cholinesterase Activity in Individual End-plates of Normal and Denervated Gastrocnemius Muscle

It has been reported[1,2] that as late as two months after denervation of the gastrocnemius muscle the end-plates still reacted positively to a histochemical test for cholinesterase. The test was made by the thiocholine method of Koelle and Friedenwald[3]. Recent development of the diver technique for quantitative determination of cholinesterase activity in individual cells[4,5] has made it possible to record quantitatively the observed histochemical reaction of the end-plates after denervation.

The cholinesterase activity of end-plates from the diaphragm and the gastrocnemius muscle was first determined in normal animals. Albino mice were killed by strangulation. The diaphragm or the gastrocnemius was removed and placed for 10 min. in the incubation medium for histochemical visualization of end-plates. The medium used was essentially similar to that recommended by Koelle[6]; but the required volume was made up with 0·9 per cent saline instead of 25 per cent sodium sulphate. Inspection of the gross substance after incubation revealed the accumulated end-plates as whitish bands extending across the muscle. A small piece of the histochemically active area was cut out with scissors and was placed under the microscope on a hollow slide containing 0·9 per cent saline. Single end-plates were dissected free with the aid of a micromanipulator and were placed in divers for quantitative determination of cholinesterase activity[5]. A 5×10^{-3} *M* acetylthiocholine iodide solution was used as substrate and the measurements of activity were carried out at 25° C. The activity was calculated as the amount of carbon dioxide liberated from the bicarbonate buffer during 1 hr.

Table 1. Cholinesterase Activity of End-Plates isolated from Normal Diaphragm and Gastrocnemius Muscle and from Denervated Gastrocnemius Muscle

Mouse No.	End-plates isolated from	Cholinesterase activity of single end-plates (expressed in 10^{-5} μl. carbon dioxide per hr.)
	Diaphragm	
4		400
5		320, 350
6		420*
7		450*
	Gastrocnemius	
8		580, 500
10		1,000, 1,000
11		740, 750
12		740, 1,200, 710
	Gastrocnemius: days after denervation	
13	75	200
14	80	510, 430
15	85	170, 170

* In these experiments two end-plates instead of one were placed in the diver; the respective readings were 940×10^{-5} and 900×10^{-5} μl. carbon dioxide per hr.

Table 1 shows that end-plates isolated from gastrocnemius muscle had higher cholinesterase activity than end-plates from the diaphragm, and that the variations in the enzymic activity were considerable. It is further seen that 80 days after gastrocnemius denervation the end-plates still displayed appreciable cholinesterase activity. (The denervation was performed under ether anæsthesia; a section of the left sciatic nerve, about 10 mm. in length, was excised at mid-thigh level.)

More detailed study of the cholinesterase activity variations in end-plates and a correlation with the cholinesterase activities of the associated neurites will be attempted in later investigations.

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Metabolism of the Perfused Cat Brain during Metrazol Convulsions and Electroshock

There are a number of reports in the literature that during metrazol convulsions the rate of cerebral oxygen consumption increases[1-3]. It is also generally accepted that normally cerebral oxidations proceed almost exclusively at the expense of glucose. In a previous report[4], however, it was demonstrated with the aid of radioactive glucose that, in the case of cat brain perfused with 'simplified blood' (bovine red blood corpuscles suspended in Ringer's solution containing albumin), only about 30 per cent of the carbon dioxide produced by the brain comes from the blood glucose, while the rest of the carbon dioxide is derived from the combustion of endogenous substrates. This communication reports experiments showing an increase in production of carbon dioxide by the perfused cat brain following convulsions induced by metrazol and following electroshock. The results indicate that the major part of the excess carbon dioxide is derived from unknown endogenous substrates.

Isolation of the cerebral circulation of the cat was carried out according to the method described by Geiger and Magnes[3]. Perfusion of the brain at a constant rate of blood flow and the experimental technique generally were as described previously[5]. After 34 min. perfusion, 0·6–1·2 ml. of a 1 per cent solution of crystalline metrazol in saline was injected into the perfusing blood just before it entered the carotid arteries. The injection took about 1 min. Convulsive activity was almost immediate and continued for variable short periods after the injection. It was always accompanied by typically convulsive electrocortical activity and a slight transient fall in cerebral vascular resistance.

Results from a typical experiment are given in Fig. 1. It may be seen that the convulsive episode was accompanied and followed by an increased rate of carbon dioxide production, and the percentage of carbon dioxide produced by the brain, which is derived from the blood glucose, dropped considerably. Recovery was complete in about 12 min.

The passage of electric current through the brain (10 volts, 60 cycles from a condensor stimulator) by means of electrodes placed on the exposed skull produced similar metabolic changes. The current was applied three times during the course of 2 min. for a total of 30 sec. Each time the current was switched on an immediate and rapid rise of cerebral vascular resistance was evidenced by an increase in perfusion pressure, which returned to its previous value very rapidly when the current was switched off. During the passage of current the animal showed severe

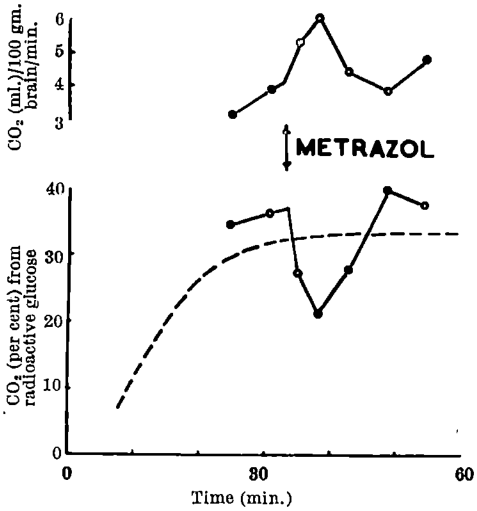

Fig. 1. Effect of metrazol on total carbon dioxide produced by cat brain perfused with simplified blood containing radioactive glucose and on percentage carbon dioxide derived from radioactive glucose. Broken line, average results of a number of control experiments (5)

tonic spasms which ceased very shortly after break of the current. In contrast to the situation prevailing after metrazol administration, electrocortical recordings following electroshock did not show evidence of convulsive activity.

Fig. 2 illustrates the rise in the rate of carbon dioxide production and the abrupt fall in the radioactivity of the carbon dioxide produced by the brain in consequence of the application of electric current. This was followed by a recovery period of about 10 min. and a subsequent 'overshoot' of short duration.

From these results it would appear that the augmented metabolic activity of the brain occurring as a result of metrazol convulsions or of electric shock, is accompanied, and possibly supported, by the oxidation of endogenous substrates within the brain. The exact nature of these substrates is not known, however, the work of Hyden on nerve cells subjected to stimulation[6], of Mullins on peripheral frog nerve[7] and of Abood and Geiger with glucose-free perfusion of cat brain[8], all seem to point to the likelihood that breakdown and oxidation of proteins or lipids may occur in association with increased neural activity.

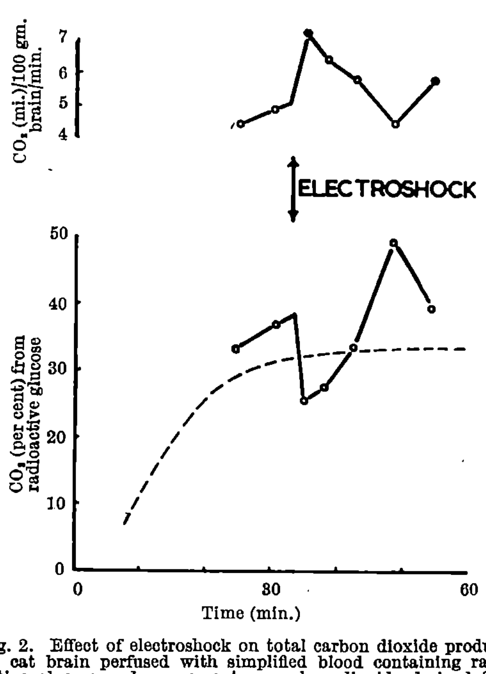

Fig. 2. Effect of electroshock on total carbon dioxide produced by cat brain perfused with simplified blood containing radioactive glucose and on percentage carbon dioxide derived from radioactive glucose. Broken line, average results of a number of control experiments (5)

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*Iso*citritase in Germinating Marrow Seeds

Heumann[1] showed that the conversion of fat to cellular constituents must occur during the germination of seeds of *Cucurbita pepo* (pumpkin). A route for such a conversion has been demonstrated in germinating castor beans by Kornberg and Beevers[2] which requires for its operation, in addition to the enzymes of the tricarboxylic acid cycle, *iso*citritase and malate synthetase.

$$\text{Fatty acids} \xrightarrow{\beta\text{-oxidation pathway}} \text{acetyl coenzyme } A \quad \text{oxaloacetate} + \text{acetyl coenzyme } A \rightarrow \text{citrate} \rightarrow \textit{iso}\text{citrate}$$

$$\textit{iso}\text{citrate} \xrightarrow{\textit{iso}\text{citritase}} \text{succinate} + \text{glyoxylate}$$

$$\text{glyoxylate} + \text{acetyl coenzyme } A \xrightarrow{\text{malate synthetase}} \text{malate} \rightarrow \text{oxalo-acetate}$$

Net result: 2 acetyl coenzyme $A \rightarrow$ succinate

The presence of *iso*citritase in germinating marrow seeds (another variety of *Cucurbita pepo*), and the variation of its activity with the stage of germination, suggest that this pathway may operate in the seedlings of the marrow.

Glyoxylic acid (L. Light and Co., Ltd.) was assayed by the permanganate method of Long[3], and a standard curve constructed using the colorimetric 2 : 4-dinitrophenylhydrazone method of Friedemann and Haugen[4]. A variation of the latter method, taking into account the ratio of absorption at 420 mμ and 520 mμ was used for determining total keto-acid and glyoxylic acid in mixtures of glyoxylic acid and α-ketoglutaric acid.

Seeds were germinated in darkness in vermiculite at 30° C. for periods of 1–6 days. Extracts were then prepared as follows. The testa and, when appreciable in size, the radicle and most of the hypocotyl of each seed were removed, and the remainder, virtually only cotyledons, ground at 0° C. with phosphate buffer, 0·1 M, pH 7·5 and fine

Table 1. TOTAL KETO-ACID AND GLYOXYLIC ACID PRESENT IN µMOL./GM. UNGERMINATED SEED-WEIGHT/HOUR WHEN SEED EXTRACTS WERE INCUBATED WITH VARIOUS SUBSTRATES

Incubation	1 hr.				1 hr.				nil	
Substrate	None		Citrate		*cis*aconitate		30 µmol. DL-*iso*citrate		30 µmol. DL-*iso*citrate	
Seedling age (days)	Total keto-acid	Glyoxylic acid	Total keto-acid	Glyoxylic acid	Total keto-acid	Glyoxylic acid	Total keto-acid	Glyoxylic acid	Total keto-acid	Glyoxylic acid
0	0·74	0·1	1·8	0·9	1·7	0·7	1·8	0·7	0·46	0·1
1	0·68	0·3	2·3	1·5	4·2	3·5	4·4	3·5	0·20	0·1
2	1·9	1·0	15·6	11·0	35·0	33·0	37·3	35·0	0·63	0·5
3	2·4	0·2	20·4	17·0	48·6	48·0	48·4	48·0	1·1	0·4
4	3·2	2·0	26·0	24·0	45·0	43·0	48·6	48·0	1·5	0·7
5	2·9	1·0	22·6	19·0	51·5	49·0	53·5	51·0	1·7	0·3
6	3·9	2·0	25·6	21·0	59·0	56·0	70·7	67·0	1·0	0·7

sand. Debris was removed by centrifugation for 15 min. at 1,500 × *g* ('International' refrigerated centrifuge), and smaller particles by high-speed centrifugation at 52,000 × *g* for one hour ('Spinco' ultracentrifuge).

Incubation was carried out under nitrogen at 25° C., each tube containing 145 µmol. 0·1 *M* potassium phosphate buffer, *p*H 7·6, 10 µmol. magnesium chloride, 10 µmol. glutathione, and 15 µmol. substrate in 1·8 ml. solution. Reaction was initiated by addition of 0·2 ml. extract, and stopped by 0·5 ml. 30 per cent trichloracetic acid, which precipitated proteins. These were centrifuged down, and the supernatant analysed for total keto-acids, and for glyoxylic acid, by the modified Friedemann and Haugen technique[4]. Chromatography of the keto-acid 2 : 4-dinitrophenylhydrazones from incubation, with known markers, using Whatman No. 3 paper and butanol/3 per cent ammonium solvent[5] showed no perceptible trace of any keto-acid other than glyoxylic and α-ketoglutaric acids.

Glyoxylic acid was further characterized by reduction of the 2 : 4-dinitrophenylhydrazone, eluted from the butanol/ammonia chromatogram, to amino-acid, using Adams's catalyst and hydrogen[6], and chromatography of the product in phenol/borate buffer[7], *p*H 9·3, with known samples of several amino-acids as markers. The chromatogram was developed by spraying with 0·1 per cent ninhydrin, 10 per cent glacial acetic acid, 4 per cent collidine in ethanol, which gave a purple spot for glycine marker. The presence of a corresponding spot for the unknown product of 2 : 4-dinitrophenylhydrazone reduction proved conclusively that there was, in fact, glyoxylic acid in the resultant solution from the incubation.

The result of the incubation was calculated as µmol. glyoxylate present in the incubated mixture per gm. ungerminated seed-weight, and tabulated (Table 1).

The extract from six-day-old seedlings was also incubated in a series of different dilutions, and the activity plotted as µmol. glyoxylate formed per hour against volume of six-day extract used. The results suggested that a linear relationship exists between these functions in the range studied, and that activity (Table 1) is proportional to concentration at all ages.

Superficial observation of the seeds during germination revealed little or no obvious change at one day, the development of radicle up to about 3 cm. long at two days, and after that the emergence and rapid elongation of the hypocotyl. On the whole the results show good correlation of *iso*citritase activity with the age and development of the seedling. The results also correspond to those of Heumann[1] for rate of increase of non-fatty dry weight of seeds of *Cucurbita pepo*, the two remaining almost proportional as the seedling develops.

The above results support the view that *iso*citritase is an enzyme of importance in the conversion of fat to carbohydrate in germinating marrow seedlings.

Thanks are due to the many who have offered advice during this investigation, especially to Dr. F. A. Isherwood for his assistance in the characterization of glyoxylic acid, Dr. G. D. Greville for a gift of sodium *cis*aconitate and for his interest, and Prof. F. G. Young for permission to carry out the research in this Department.

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Coenzyme *A* and Aldolase in Rubber-bearing Plants

THERE is evidence that the biosynthesis of rubber from carbon dioxide and water in *Parthenium argentatum*[1] may proceed through acetate and β-methylcrotonate, and that acetate can also act as a precursor of rubber in *Hevea brasiliensis*[2]. Coenzyme *A* probably plays a vital part in the process. Information on the enzyme systems operating and on the co-factors actually present in rubber-bearing plants is very scanty. Coenzyme *A* has been reported[3] to be present in the seeds of *Cryptostegia* spp., of *Hevea*, and in various organs of *Taraxacum kok-saghyz*. The complete enzyme system required to incorporate acetate into rubber hydrocarbon is present in *Hevea* latex[2]; but its make-up is not yet known. This communication reports observations on coenzyme *A* in *Hevea* and *Taraxacum*, and also on aldolase, which was originally selected for study as an enzyme capable of forming carbon–carbon linkages.

Cook and Sekhar[4] have separated *Hevea* latex by ultra-centrifugation into one minor and three major fractions. Of these, 'bottom fraction' represents the sedimentable non-rubber particles of the latex, and '*C*-serum' the non-sedimentable aqueous phase. A rubber-free fluid known as '*F*-serum'[5] is obtained from latex by the more drastic procedure of coagulation by prolonged freezing. It is believed[6] to contain some of the components of both bottom fraction and *C*-serum.

Freeze-dried latex fractions have been supplied to the Birmingham laboratories by the Rubber Research Institute of Malaya, where these fractions, along with fresh *C*-serum, were also later examined for aldolase activity. In Birmingham, small quantities of fresh latex were obtained from 4-year-old *Hevea* trees grown in glasshouses; *Taraxacum kok-saghyz* plants were harvested on the point of flowering.

Coenzyme *A* was determined by the method of Hübscher, G., and Wakil, S. J. (unpublished work). The fatty acid-activating enzyme prepared from ox liver[7] was used to catalyse the reaction between sorbic acid and coenzyme *A* to give sorbyl–coenzyme *A*, the formation of which can be measured spectrophotometrically at 295 mμ. Under the test conditions all the coenzyme *A* present is transformed into sorbyl–coenzyme *A*.

The coenzyme *A* content of some *Hevea* and *Taraxacum* materials is shown in Table 1.

Table 1

Material	Coenzyme *A* content in μmol. per 100 mgm. (dry weight)
Freeze-dried *F*-serum (*Hevea*)	
2·5 yr. after preparation	0·02
7 months after preparation	0·10
2 months after preparation	0·16
Fresh latex (dialysed)	0·66
Taraxacum kok-saghyz roots	0·27

A modification of the method of Herbert *et al.*[8] was used for detecting and estimating the level of aldolase activity. The solution (2 ml.) to be tested was incubated for 20 min. at 30° with sodium fructose-1 : 6-diphosphate solution (1 ml. 0·031 *M*) and a sodium borate buffer (2 ml.) containing hydrazine as ketone fixative. The borate–hydrazine solution had *p*H 8·5 and was 0·3 *M* with respect to BO_3^- and 0·14 *M* with respect to hydrazine. After incubation alkali-labile phosphate was estimated on aliquots of the deproteinized mixture. Unit aldolase activity was defined as the formation of 0·10 mgm. of alkali-labile phosphorus. Table 2 shows the activities observed.

Table 2

Material	Activity (units/mgm.)
Hevea	
Ammonium sulphate precipitate from aqueous extract of freeze-dried bottom fraction	0·03
Freeze-dried *F*-serum (old sample)	0·03
Freeze-dried *C*-serum (5 samples)	0·09*
Freeze-dried *F*-serum (4 samples)	0·06*
Freeze-dried bottom fraction (4 samples)	below 0·02*
Acetone precipitate from *C*-serum	0·80
Seed cotyledons	very low
Fresh latex (in Birmingham)	0·16
Taraxacum roots–ammonium sulphate ppt. of aqueous extract	0·01

* Mean values.

Aldolase of *Hevea* latex was first detected in material precipitated by ammonium sulphate (between 35 and 65 per cent of saturation) from an aqueous extract of freeze-dried bottom fraction. Examination of other latex fractions (see Table 2) suggested that the enzyme was located mainly in the aqueous non-sedimentable phase (*C*-serum) rather than in the sedimentable particles. It will be noted that *F*-serum is less active than *C*-serum, as expected from the mode of preparation.

The activity present in *C*-serum was largely precipitated by ammonium sulphate between 35 and 65 per cent of saturation. A better fractionation of *C*-serum was, however, achieved by treating it with increasing amounts of acetone at 0°. The material precipitated between 30 and 50 per cent (v/v) of acetone was dissolved in water and, after removal of insoluble matter, freeze dried. The product (see Table 2) had 8–9 times the activity of unfractionated freeze-dried *C*-serum.

In the light of recent publications[1,2] on rubber biogenesis it seems unlikely that aldolase is directly involved in the synthesis of the hydrocarbon, but it is of considerable interest as a key enzyme in the carbohydrate metabolism of latex. So far as we are aware, coenzyme *A* has not been directly demonstrated in *Hevea* latex hitherto, although the results of Teas and Bandurski[2] seem to imply its presence.

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Para-Amino-Benzoic Acid and Sulphanilamide in the Nutrition of *Neurospora crassa*

THE action of sulphanilamide, an antivitamin of *p*-amino-benzoic acid, has been traced to an impairment of the synthesis of methionine and adenine, besides some other compounds[1]. In some cases *p*-amino-benzoic acid could reverse the inhibitory effects of sulphanilamide, whereas folic acid could not[2]. In our present work, we studied the reversal of the toxicity of sulphanilamide in *Neurospora crassa* 8*a* (wild) and the substitution of *p*-amino-benzoic acid in a strain without the acid (No. 1633) of the same mould.

The cultures were grown with sulphanilamide or with *p*-amino-benzoic acid, as shown in Tables 1 and 2, on the usual basal medium (Horowitz and Beadle, 1954). The *p*H of all media was adjusted to 6·8 before autoclaving. Volatile and heat-labile substances were added after sterilization by filtration through a Seitz pad. The cultures were grown at room temperature (26–28° C.) for three days and then the mats were filtered, dried and weighed.

Table 1. REVERSAL OF THE TOXICITY OF SULPHANILAMIDE TO *N. crassa* 8a
(10 ml. medium with 5 mγ biotin. 72-hr. growth)

No.	Additions	Weight of mycelium (mgm.)
1	Basal medium	47·5
2	(1) + 5 mgm. sulphanilamide	0·6
3	(2) + 10γ *p*-amino-benzoic acid	39·2
4	(2) + 2 mgm. adenine	10·3
5	(2) + 2 mgm. guanine	8·5
6	(2) + 2 mgm. uracil	6·1
7	(2) + 2 mgm. choline	11·6
8	(2) + 2 mgm. threonine	0·6
9	(2) + 2 mgm. valine	9·5
10	(2) + 2 mgm. methionine	12·8
11	(2) + 1 mgm. each of adenine, guanine and uracil	14·3
12	(2) + 1 mgm. each of valine, threonine and methionine	9·7
13	(2) + 1 mgm. each of adenine, guanine, uracil, valine, threonine and methionine	34·1
14	(2) + 80 mgm. vitamin-free casein hydrolysate	24·1
15	(14) + 2 mgm. each of adenine, guanine, and uracil	39·5

These results indicate a broad spectrum for the antivitamin action of sulphanilamide. Thus, while methionine, valine, threonine, adenine, guanine and uracil were active by themselves to a certain extent in reversing the growth inhibition of the sulpha drug, a mixture of these six compounds was almost as active as *p*-amino-benzoic acid itself. The ability of casein hydrolysate to reverse this toxicity to a greater extent than a mixture of the above three amino-acids may suggest a synergistic role for other amino-acids in reversing the action of the sulphanilamide. My unreported results show that while hypoxanthine was active to a certain extent in reversing the toxicity of sulphanilamide, neither xanthine nor uric acid was active. Also, while folic acid was a complete substitute for *p*-amino-benzoic acid in mutant 1633, it was of limited activity in reversing the effects of sulphanilamide. Glutamic acid (cf. Table 2) could replace *p*-amino-benzoic acid to a slightly greater extent than aspartic acid could. In *E. coli* the inhibition of 2-chloro-4-aminobenzoic acid could be reversed by *p*-amino-benzoic acid, methionine or pantothenic acid[3]. My present results (cf. Table 1) show that the toxic effects of the sulpha drug are counteracted almost completely by a mixture of valine, threonine, methionine, adenine, guanine and uracil. This may very likely mean that the toxicity of sulphanilamide in this case is entirely confined to the synthesis of C_1 units.

The results on the replacement of *p*-amino-benzoic acid (cf. Table 2) show that methionine was a complete substitute for the acid. This may denote that the metabolic block in this mutant is at the level of the synthesis of methionine, especially as the other amino-acids and purine and pyrimidine bases were not active. Strehler[1] found that folic acid, methionine and *p*-toluidine are capable of replacing *p*-amino-benzoic acid in *Neurospora* 8043 *M*. He found that in the presence of sulphanilamide the mutant will not grow on adenine or other purines, although all were active in combination with methionine. Again, in my experiments, aspartic and glutamic acids were active to a certain extent in replacing *p*-amino-benzoic acid. This result is difficult to interpret since these two amino-acids are not known to contribute C_1 units to any significant extent. Koft *et al.*[4] found that α-ketoglutaric acid, pyruvic acid and lactic acid replaced *p*-amino-benzoic acid in the early growth of *Lactobacillus arabinosus*. However, lactic acid was inactive in my experiments with *Neurospora crassa* 1633.

Table 2. REPLACEMENT OF *p*-AMINO-BENZOIC ACID IN THE NUTRITION OF THE MUTANT WITHOUT *p*-AMINO-BENZOIC ACID (1633)
(10 ml. medium with 5 mγ biotin. 72-hr. growth)

No.	Addition to the basal medium	Weight of mycelium (mgm.)
1	None	Negligible
2	*p*-Amino-benzoic acid (10γ)	25·6
3	Methione (2 mgm.)	27·4
4	Valine (2 mgm.)	0·8
5	Threonine (2 mgm.)	0·8
6	Adenine (2 mgm.)	1·1
7	Guanine (2 mgm.)	2·0
8	Uracil (2 mgm.)	Negligible
9	Choline (2 mgm.)	Negligible
10	Folic acid (100γ)	23·8
11	Lactic acid (10 mgm.)	2·5
12	Casein hydrolysate (vitamin free, 80 mgm.)	20·4
13	Calcium pantothenate (100γ)	Negligible
14	Aspartic acid (5 mgm.)	12·3
15	Glutamic acid (5 mgm.)	17·0

2 mgm. of each (separately) of the following compounds did not support the growth of this mutant in the absence of *p*-amino-benzoic acid: serine, cystine, tyrosine, histidine, arginine and tryptophan.

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Ferulic and *p*-Coumaric Acids in Pineapple Tissue as Modifiers of Pineapple Indoleacetic Acid Oxidase

PINEAPPLE stem tissue has been shown[1] to contain a powerful indoleacetic acid oxidase system and a polyphenolic-type inhibitor. Other reports demonstrate the ability of certain phenols to stimulate or inhibit the indoleacetic acid oxidases of peas[2], lentils[3], wheat[4], a fungus[5], and lupins[6], though none of the phenols has been shown to accompany these systems.

We have now found that two cinnamic acid derivatives accompany and modify the activity of the indoleacetic acid oxidase in both pineapple stem and basal leaf tissue. Both occur naturally as esters which are extractable into ether from aqueous tissue homogenates at *p*H 2·5. With ascending paper chromatography in 8/1/1 *iso*propanol–28 per cent ammonia–water, the esters have an R_F of approximately 0·05–0·2, and in 4/1/1 butanol–acetic acid–water, an R_F of approximately 0·85, with considerable overlapping of the two esters.

The ether extractives were hydrolysed with *N*/10 sodium hydroxide at 100° C. for 2 hr., the *p*H adjusted, and the free acids extracted into ether. Chromatography now showed the disappearance of the original material and the appearance of two adjoining spots at a higher R_F (0·37–0·45) in the alkaline solvent. These two areas were identical with ferulic and *p*-coumaric acids in R_F, colour of ultra-violet fluorescence, and acidic and basic colours with diazotized sulphanilic acid and diazotized *p*-nitroaniline sprays. The ultra-violet absorption spectra of the liberated acids were superimposable on those of the known compounds following double chromatography with *iso*propanol–ammonia–water. The presence of *p*-coumaric acid was further demonstrated by absorption spectra in alcoholic sodium ethoxide, chromatography in a number of solvents, by isolation and formation of derivatives[7].

Enzyme extracts were treated with $M/200$ hydrogen peroxide to destroy the inhibitor and stimulator by peroxidative action. In the absence of a suitable phenolic compound, no enzyme activity occurred, whereas with added *p*-coumaric acid, treated extract equivalent to 2·4 mgm. wet tissue and containing 14γ protein destroyed 262γ indoleacetic acid in 10 min. Assays showed that *p*-coumaric acid or its naturally occurring ester is loosely combined as a coenzyme for and in mass action equilibrium with pineapple indoleacetic acid oxidase. Ferulic acid at low levels can stimulate partial enzyme activity when little or no *p*-coumaric acid is present; at higher levels, ferulic acid or its ester is a powerful enzyme inhibitor.

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In vitro Culture of Ovaries of *Iberis amara* L.

FRUIT culture, perhaps better termed ovary culture, aims at studying the growth pattern and nutritional requirements of growing ovaries. Two pioneer attempts in this direction were those of Jansen and Bonner[1] and Nitsch[2,3], but these workers did not follow the changes taking place in the ovules. Recently, Anantaswamy Rau[4] reared the ovaries of *Phlox* in artificial cultures. Although the fruits grew appreciably in all these cases, the extent of growth never equalled that in Nature. The size of the fruits obtained was always much smaller than that of fruits produced in Nature.

We cultured ovaries of *Iberis amara* and studied the effect of several chemicals on the development of the pericarp as well as the ovule.

In Nature the ovaries become double their initial size in a week after pollination, and the fruits attain their maximum size at the end of two weeks. Further changes, such as the differentiation of pericarp and the maturation of the seeds, continue for another week.

We took flowers one day after pollination (Fig. 1, 1), when the ovules contain a zygote or a 2-celled proembryo and a varying number of endosperm nuclei. The flowers were sterilized with 'Chlorox' and planted in Nitsch's basic medium supplemented with vitamins. The development obtained in this medium compared very favourably with that in Nature. Here the ovaries matured and the ovules showed normal embryos and endosperm on dissection.

Having obtained normal growth in the above medium, our next problem was to analyse the minimal requirements for fruit growth. Ovaries were cultured in water; sugar + agar; sugar + agar + minerals (made according to Nitsch); sugar + agar + minerals + vitamins[5]; sugar + agar + minerals + vitamins + indolylacetic acid; and so on.

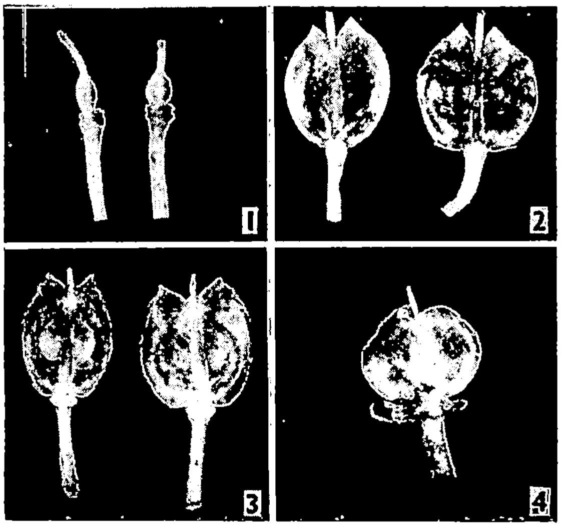

Fig. 1. (1) Ovaries at the time of planting of flowers (one day after pollination) (× *c.* 2). (2) Two-week old control fruits (× *c.* 2·2). (3) Two-week old *in vitro* fruits grown on Nitsch's basic medium supplemented with indolylacetic acid 5 mgm./l. (× *c.* 2). (4) Three-week old fruit grown on a medium containing 0·5 mgm./l. of kinetin and 2 mgm. of 2,4-dichlorophenoxyacetic acid. The ovules failed to mature into seeds in this series (× *c.* 2·7)

We maintained two sets in water: one with single flowers and the other in which whole inflorescences were taken. The initial size of the ovaries was 3·7 mm. × 2 mm. Growth was poor in both cases and ceased completely at the end of one week. As expected, the fruits on the inflorescences were larger (5·4 mm. × 3 mm.) than those formed from single flowers (4·6 mm. × 2·5 mm.). Microtome sections revealed that in the case of single flowers there was no formation of embryo or endosperm. In ovaries collected from inflorescences the embryo had grown to the globular stage and was quite healthy, but the endosperm, especially in the neighbourhood of the embryo, had started degenerating.

Ovaries cultured on 5 per cent sugar solidified with 0·6 per cent agar grew to double their initial size in 13 days, but the fruits were extremely cartilaginous and the seeds thin and papery and devoid of an endosperm or embryo.

A marked improvement over the sugar + agar medium was seen on the addition of minerals according to Nitsch's formula. The average size of the ovary (8·6 mm. × 6·2 mm.) almost approached that of the controls (9·1 mm. × 7·6 mm.) as measured after two weeks. The growth of the embryo and the endosperm was also satisfactory.

Almost exact duplication of fruit growth as it is in Nature was achieved with sugar + agar + minerals + vitamins. Ovaries sown in this medium became almost double in size after a week. The calyx and corolla persisted for well over a week. Later the calyx turned yellowish and was shed; the corolla stayed on longer. The growth of the ovary was completed in about two weeks, when it started turning yellow (this compared well with the condition in Nature) and the seeds became brownish. Fruits maintained in culture for 36 days showed no appreciable increase in length but only slight increase in breadth. As already mentioned the embryo and the endosperm were quite comparable to those in Nature.

Next it was considered worthwhile to investigate the effect of removal of the calyx and corolla. When this was done, the growth of the ovaries always received a setback. Ovaries with calyx and corolla intact always outgrew those in which these organs had been removed. This confirms that they are not meant just to protect the essential organs but actively contribute to their development.

When indolylacetic acid (5 mgm./l.) was added to Nitsch's basic medium we obtained fruits (Fig. 1, 3) which were sometimes even larger than those set in Nature (Fig. 1, 2). Dissections of 2-week old ovaries showed normal embryo and endosperm.

The addition of kinetin alone (ranging from 0·1 to 0·6 mgm./l.) as well as in combination with indolylacetic acid (5 mgm./l.) also seemed to improve the growth of the ovaries only slightly.

On the other hand, ovaries cultivated on Nitsch's basic medium supplemented with 2,4-dichlorophenoxyacetic acid (2·0 mgm./l.) and kinetin (0·5 mgm./l.) (Fig. 1,4) showed arrested growth of both endosperm and embryo. Since growth in the kinetin medium alone is normal the retarding effect may be attributed to the 2,4-dichlorophenoxyacetic acid alone or possibly to the combined effect of 2,4-dichlorophenoxyacetic acid and kinetin.

The results described above show for the first time that not only the growth of the ovary but also that of the ovules can be maintained in an artificial medium. While the results achieved so far are significant, it remains to be seen whether unfertilized ovaries can also be grown to maturity along with concurrent growth of the ovules into viable seeds containing parthenogenetic embryos.

This work was done under a scheme of research on the chemical stimulation of ovary and ovule financed by the Indian Council of Agricultural Research. We are indebted to Prof. P. Maheshwari for his guidance and to Dr. R. C. Sachar for his active co-operation.

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Formation of Oxalacetate and Aspartate from Phospho-Enol-Pyruvate in Spinach Leaf Chloroplast Extract

WHILE investigating the ability of water extracts[1] of spinach leaf chloroplasts to catalyse 'dark' carboxylation reactions, we have found that the addition of phospho-enol-pyruvate and $^{14}CO_2$ to the colourless chloroplast extract causes the accumulation of labelled oxalacetate and labelled aspartate in the reaction mixture. Bandurski and Greiner[2] using spinach leaves, Tchen and Vennesland[3] using wheat germ and spinach leaves, and Utter *et al.*[4] using bird liver, have described enzyme preparations which catalyse irreversible and reversible carboxylations of phospho-enol-pyruvate to oxalacetate. The formation of oxalacetate in our experiments indicates the presence of a phospho-enol-pyruvate carboxylase in the chloroplast. Aspartate can then be formed by transamination of oxalacetate. The rate of carbon fixation was increased when, in addition to phospho-enol-pyruvate, either alanine, glutamine or aspartic acid was added to the reaction mixture.

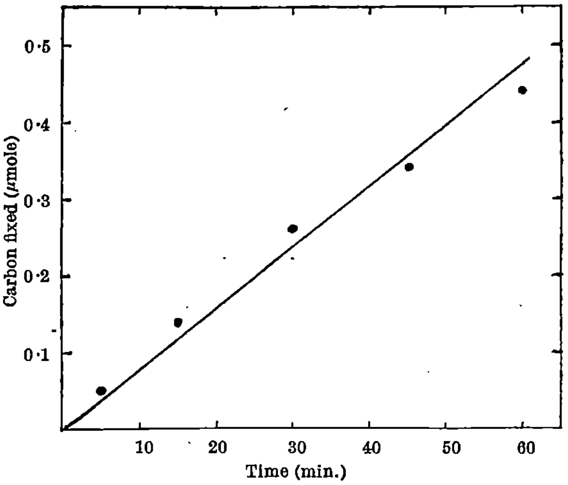

Fig. 1. Fixation of $^{14}CO_2$ into aspartate by phospho-enol-pyruvate and chloroplast extract in the dark. The composition of the reaction mixture was as follows and the components were added in the order listed: *Tris*, *p*H 7·4, 80 µmol. in 0·4 ml.; magnesium sulphate, 10 µmol. in 0·1 ml.; water, 1·1 ml.; phospho-enol-pyruvate, 6 µmol. in 0·2 ml.; chloroplast extract 1·0 ml. corresponding to 2 mgm. chlorophyll. The tube was stoppered and 3 µmol. carbon-14 labelled Na_2CO_3 (3 × 10^6 c.p.m.) in 0·2 ml. injected through the rubber stopper by syringe

Fig. 1 shows the time course of carbon fixation in an experiment with phospho-enol-pyruvate and chloroplast extract. At intervals, small samples were withdrawn from the rubber-stoppered reaction tube by syringe and added to equal volumes of 4 per cent trichloracetic acid solution. The extent of carbon fixation was estimated by counting aliquots of the acidified samples which had been plated on metal planchets and quickly dried under a heat lamp.

Samples of the reaction mixture acidified at 60 min. were chromatographed on paper in two dimensions with the solvent systems phenol/water (80/20) and butanol/acetic acid/water (52/14/35). Radio-autographs of these chromatographs showed only one radioactive spot with R_F of 0·19 in the phenol/water direction and 0·43 in the butanol/acetic acid direction. These co-ordinates suggested that the material in the radioactive spot was aspartic acid, and this was confirmed by co-chromatography with authentic aspartic acid. Like aspartic acid, the material when eluted was unchanged by heating at 100° C. in 2 *N* sulphuric acid for one hour or by treatment with alkaline phosphatase.

It should be noted that the extent of carbon fixation as determined for the experiment in Fig. 1 is underestimated to the extent that oxalacetate exists in the reaction mixtures. Oxalacetate is decomposed by the heat-drying treatment on metal planchets and loses its β-carbon as $^{14}CO_2$; it is into the β-position of oxalacetate that carbon dioxide is fixed during the enzymatic carboxylations of phospho-enol-pyruvate which have been described[2–4]. The fact that no spot corresponding to oxalacetate appears on the radioautographs is probably due to the decomposition of oxalacetate during the chromatographic procedures employed.

To determine the quantity of oxalacetate present in the reaction mixtures, samples were acidified with trichloracetic acid, a carbon dioxide–nitrogen mixture was bubbled through to remove trace amounts of $^{14}CO_2$, carrier oxalacetate was added and the samples were decarboxylated with either aluminium ions[5] or with aniline citrate[6]. The liberated $^{14}CO_2$ was collected in a solution of sodium hydroxide, converted to carbonate, and counted on planchets. Results of such experiments showed that the radioactivity originally present and due to aspartate was not affected by the decarboxylation, and that oxalacetate was formed in the reaction mixtures in concentrations about 1·3 times that of aspartate. Thus, the aspartate which was counted on heat-dried planchets represented only about four-tenths of the total carbon dioxide fixed.

When either glycerate-3-phosphate or glycerate-2-phosphate was added to the reaction mixture described earlier, oxalacetate and aspartate were formed but at a slower rate than when phospho-enol-pyruvate was used. The glycerate phosphates were probably first converted to phospho-enol-pyruvate by the action of glyceric acid mutase and enolase in the chloroplast extract. When either ribulose-1-5-diphosphate or ribose-5-phosphate plus adenosine triphosphate was added, and the reaction mixture chromatographed, labelled carbon appeared in both glycerate-phosphate and aspartate. In view of the fact that these substances are among the compounds formed when whole isolated chloroplasts fix carbon dioxide in the light[7] and since Fuller and Anderson[8] suggest the importance of aspartic acid formation as an early photosynthetic event in photosynthetic purple sulphur bacteria, we find it interesting that carboxylations in chloroplasts can lead to the rapid formation of an amino-acid.

We are indebted to Dr. Clinton Ballou for the sodium salts of phospho-enol-pyruvate and glycerate-2-phosphate.

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Histogenesis of Osteoclastomata

Two of the main problems concerning the histogenesis of giant cell tumours of bones have been: (1) the nature and function of the giant cell—this has been variously classified as an endothelial cell, a foreign body giant cell, a megakaryocyte, an osteoclast or as a giant cell formed by agglomeration or fusion of stromal cells; (2) the histogenesis of the giant cell—the overwhelming consensus of opinion among the supporters and opposers of the osteoclast nature of the giant cell[1-5] suggests that the giant cells are formed from the spindle-shaped stromal cells.

In two cases of osteoclastomata recently investigated I have observed a strong acid phosphatase in the cytoplasm of the giant cells. The stromal cells gave a negative reaction. The presence of this enzyme was demonstrated both with the lead phosphate and azo-dye coupling techniques. Inhibition by 0·01 *M* sodium fluoride excluded the possibility of non-enzymatic impregnation of the giant cells[7]. Using *o*-acetyl-5-bromoindoxyl as substrate for esterases, both the stromal and the giant cells were negative for these enzymes.

These findings suggest that the giant cells are not in any way related to the stromal cells. It might be argued that the stromal cells are precursors of the giant cells with different enzyme reactions, but all the histochemical and biochemical evidence points to the fact that the enzyme systems of parent cells and their descendants are the same.

It has also been stated that the giant cells, because of their apparent age, show signs of early degeneration[2]. Histochemically, however, it would appear as if the giant cells are very active cells (probably osteoclasts) and the stromal cells inactive with regard to phosphatase and esterase activities.

Details concerning these findings and further experimental work will be published elsewhere.

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Inhomogeneity of α-Casein from Goat Milk

It is now known that α-casein from cow milk, which appears electrophoretically homogeneous under many different conditions, consists of at least two compounds which have been designated α- and *k*-casein[1]. α-Casein from goat milk, which has similar properties to that from cow milk[2] and the same phosphorus content[3], showed signs of inhomogeneity during electrophoresis by the moving-boundary method[2]. Using zone electrophoresis on filter paper it has now been found that the α-component of freshly prepared goat casein does consist of at least two electrophoretically distinct fractions which, until further characterization, will be called α_1- and α_2-casein in order of decreasing electrophoretic mobility.

The experiments were made with unfractionated casein, which was obtained in the usual way by acid precipitation, and with α-casein, which was prepared from it by Warner's method[4], and had the same phosphorus and nitrogen content as α-casein prepared from cow milk.

Electrophoretic runs were made on Whatman No. 3 paper with veronal buffer, *p*H 7·6, $\mu = 0{\cdot}1$, at 3 V./cm. for 15 hr. After staining with naphthalene black 12*B* 200 the electropherograms were scanned. The scanning patterns obtained

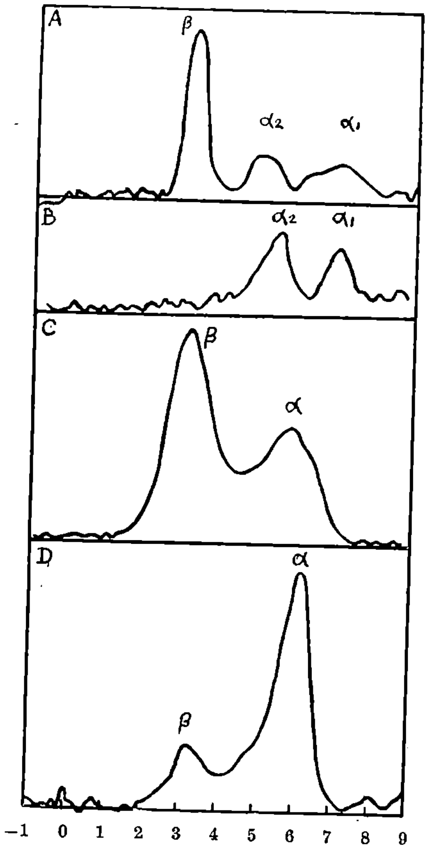

Fig. 1. Electrophoretic patterns of: *A*, unfractionated goat casein; *B*, α goat casein; *C*, unfractionated goat casein after treatment with alcohol and ether; *D*, unfractionated cow casein

are shown in Fig. 1. The patterns of undried freshly prepared unfractionated casein and of α-casein showed the complete separation of the α_1 and α_2 peaks (Fig. 1,*A* and *B*). However, after drying the caseins with alcohol and ether (the usual procedure for preparing them for storage), this separation no longer occurred (Fig. 1,*C*). The drying procedure presumably led to denaturation and thus to an aggregation of the α_1- and α_2-components which was irreversible, at least under the conditions of the experiment. This was borne out by a quantitative evaluation of the scanning patterns. The results are shown in Table 1. The dried casein contained approximately 42 per cent of the α- and 58 per cent of the β-compound, while the fresh unfractionated casein contained about equal amounts of the α_1- and α_2-components and 60 per cent β-casein. The relative amounts of the α- and the β-fractions were slightly different from those found by Dovey and Campbell[2], namely, 40 per cent α and 60 per cent β as against 49 per cent α and 51 per cent β.

Freshly prepared α-casein from cow milk did not show this separation into two components under a variety of conditions of *p*H, buffer concentration and voltage gradient, although it is known to be inhomogeneous[1]. A scanning pattern of a typical experiment with unfractionated cow casein is included in the figure for comparison (Fig. 1,*D*). It shows that the mobility of the cow α-casein was intermediate between those of the goat α_1 and α_2 fractions, while the mobility of the β-caseins was approximately the same. This latter result is in agreement with the findings of Dovey and Campbell[2]. The quantitative distribution of the α- and β-components of cow casein agrees reasonably well with that found by other authors.

Table 1. Electrophoretic Distribution of Cow and Goat Casein (in per cent Total Protein)

Casein	α_1	α_2	β
Goat unfractionated fresh	18·6	20·9	60·4
Goat α fresh	47–49	51–53	—
Goat unfractionated dried	42		58
Cow unfractionated fresh	78		22

The distribution of the various components in the cow and goat caseins is quite different. While Waugh and von Hippel[1] found that cow casein consists of 55 per cent α-casein, 30 per cent β-casein and 15 per cent *k*-casein the present results for the goat protein show the presence of 19 per cent α_1-casein, 21 per cent α_2-casein and 60 per cent β-casein. It is hoped in further experiments to compare some of the chemical and physical properties of the various components of the caseins from the two species.

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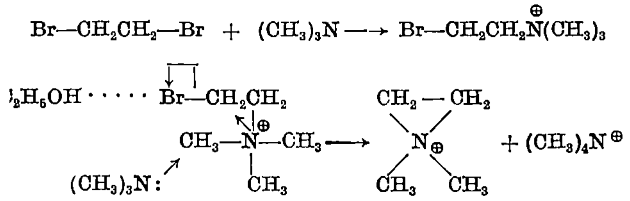
Reaction of Ethylene Bromide with Trimethylamine and the Neuromuscular Blocking Activity of Ethylene*bis*-(Trimethylammonium)

Although the neuromuscular blocking properties of alkylene*bis*-(trimethylammonium) salts have been much studied since the important, simultaneous reports of Barlow and Ing[1] and of Paton and Zaimis[2], the relative potency of ethylene*bis*-(trimethylammonium) (I) appears to have remained doubtful. In brief, I-dibromide, prepared by the reaction of ethylene bromide with trimethylamine, was reported to have unusually high activity comparable to that of tetramethylammonium (II)[1,3,4]. This was most remarkable in that the C_3, C_4 and C_5 *bis* salts were found to be almost inert. On the other hand, I-diiodide, prepared from ethylenediamine and methyl iodide[5], was reported to display only a weak action, like that of its immediate *bis*-quaternary homologues[2].

It appeared probable to us that the source of the confusion was the chemical identity of the ethylene*bis*-(trimethylammonium) tested. In particular, the reaction of ethylene bromide with trimethylamine has long been known[6] to produce a mixture of salt products. Moreover, neither Barlow and Ing[1] nor Schueler[3] (whose salt was used by Thesleff and Unna[4]) reported acceptable analytical data for the I-dibromide prepared by this method. It was therefore deemed of value to pursue this question further.

Essentially as described[1], an ethanol solution of ethylene bromide and excess trimethylamine contained in a pressure bottle was heated for 12 hr. at 80° to yield a mixture of salt products, purifiable only with difficulty. Repeated fractional crystallization afforded fractions with ionic bromine contents ranging from 43 to 62 per cent. A fraction corresponding most closely with that obtained by Barlow and Ing was selected for study. It soon became evident that this material was not I-dibromide, but was apparently tetramethylammonium (II)-bromide. Barlow and Ing reported no m.p. below 280° for their material. Our salt did not melt below 360° (copper block). In agreement with Lawson and Collie[7], authentic II-bromide likewise did not melt below 360°. Found: C, 31·55; H, 7·81; Br (ionic), 51·23, 51·46. Found (Barlow and Ing[1]): C, 31·5; H, 7·9. $C_4H_{12}BrN$ (II-bromide) requires: C, 31·18; H, 7·85; Br, 51·88. On the other hand, $C_8H_{22}Br_2N_2$ (I-dibromide) would have required: C, 31·38; H, 7·25; Br, 52·21. It thus appears that Barlow and Ing's salt and, no doubt, Schueler's salt as well, was actually II-bromide rather than I-dibromide, which would explain the published results.

The II-bromide could have arisen *via* a transmethylation process, for example:



$$Br{-}CH_2CH_2{-}Br + (CH_3)_3N \longrightarrow Br{-}CH_2CH_2\overset{\oplus}{N}(CH_3)_3$$

The dimethylethylenammonium salt presumed to be formed in this reaction would, of course, react further to give other products.

Authentic ethylene*bis*-(trimethylammonium) diiodide was obtained by a two-step process. Exhaustive methylation of ethylenediamine by the Eschweiler–Clarke method afforded ethylene*bis*-(dimethylamine), b.p. 120–122° (lit. b.p. 121–121·5°). This, with excess methyl iodide in *iso*propyl alcohol solution in a pressure bottle, heated for 8 hr. at 75°, and the resultant precipitate washed with acetone and twice recrystallized from methanol, yielded 66 per cent of I-diiodide, decomposing with gas evolution at 282° (lit.[5] 265° dec.). Found: C, 24·28; H, 5·23; I (ionic), 62·96. $C_8H_{22}I_2N_2$ requires: C, 24·01; H, 5·55; I, 63·44.

Neuromuscular blocking activities were determined on these and related salts in order finally to resolve the question. Tetramethylammonium bromide and decamethonium bromide were obtained from commercial sources. The other bromide salts were analytically pure samples prepared by standard procedures.

The compounds were tested in mice using the inclined screen procedure of Thompson[8], as modified by Hoppe[9]. 50–80 mice, run in groups of 5, were used for each determination (*ED*50 and *LD*50). Those mice which became paralysed and slid off the screen within 20 min. after the intravenous administration of the test compound were considered positive reactors for calculating the *ED*50. The *LD*50 values were calculated on the basis of deaths occurring within a 24-hr. period. The *ED*50 and *LD*50 values were calculated by the method of Behrens[10].

It can be seen from Table 1 that the Barlow and Ing salt (2*x*) has indeed high neuromuscular blocking activity comparable to that of tetramethylammonium (II). The fact that 2*x* seems to be roughly 50 per cent less effective suggests, perhaps not surprisingly, that it may not be quite pure II. Authentic C_2 salt, however, has less than one-tenth the activity of 2*x* and, in approximate agreement with Paton and Zaimis[2], is a relatively weak agent of the same order of potency as its immediate homologues.

Table 1. COMPARISON OF INTRAVENOUS *LD*50 AND *ED*50 VALUES OF POLYMETHYLENE-*bis*-(TRIMETHYLAMMONIUM) SALTS,

$(CH_3)_3N^+{-}(CH_2)_n{-}\overset{+}{N}(CH_3)_3.$
(Results in terms of cation weight)

n	2	2*x**	3	4	6	10	II†
*LD*50	21·7	0·99	42·5	73·8	10·5	0·46	0·79
*ED*50	4·9	0·46	19·0	33·5	7·25	0·17	0·31

* The material comparable to that of Barlow and Ing (ref. 1), that is, tetramethylammonium.

† Authentic tetramethylammonium.

Mention should be made of the very poor quantitative correlation between our mouse data for the C_3–C_6 salts and that previously reported[3,4]. This may possibly be ascribed to differences in experimental techniques. The present results indicate that activity diminishes in a gradual, orderly fashion in going from the C_2 to the C_3 to the C_4 salt and that there is a minimum in activity at C_4. With the premise that a primary factor in neuromuscular blocking efficacy is a favourable lipophilic–hydrophilic balance in the *bis*-quaternary ammonium cation[11], this behaviour could be a result of increased interaction between juxtaposed charged nitrogens. As the linking chain is shortened from C_4 to C_3 to C_2, the cationic groups act progressively less like two independent ions and approach, in effective physicochemical behaviour, a single doubly-charged ion in a single solvent cage; it is suggested that this effect more than counterbalances the concomitant (disadvantageous) loss in lipophilic bulk.

We are grateful to Dr. C. J. Cavallito for his interest in and criticisms of this work.

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Activation of a Permeability Factor in Plasma by Contact with Glass

IT has been shown previously that contact of blood plasma with glass and with certain other surfaces leads to the formation of an unstable substance which accelerates coagulation[1]. This reaction was found to be similar to the production of a uterus-stimulating and pain-producing substance by glass contact[2]. Subsequent work showed that both these changes are induced by a common initial reaction in which an inactive precursor is converted into an active agent referred to as the 'contact factor'[3]. The purpose of the present communication is to demonstrate that yet another biological activity is induced in cell-free plasma or serum by contact with glass. The investigation was suggested by the work of Miles and Wilhelm, who found that a substance which increases capillary permeability (permeability factor) is formed when plasma or serum is diluted with physiological saline[4].

Blood was obtained from guinea pigs by cardiac puncture under ether anæsthesia. Cell-free, citrated plasma was obtained by the method previously described[1]. Cell-free serum was prepared as follows: blood collected into chilled tubes was centrifuged at 3,000 r.p.m. for 30 min. at 0° C. The upper two-thirds of the plasma were carefully removed and allowed to clot at 37° in siliconed tubes, the successive crops of fibrin being removed with a wooden applicator. The resulting serum was mixed with 20 per cent trisodium citrate (0·2 ml./5 ml. serum). Throughout all operations involving the collection of blood, contact of plasma and serum with glass was avoided by using siliconed apparatus. The samples were activated by rotation with an equal weight of glass 'ballotini' (surface area 200 cm.^{2}/gm.) and tested without delay. Permeability experiments were conducted according to methods of Miles and Wilhelm[4]: albino guinea pigs were 'blued' by intravenous injection of pontamine blue (50–70 mgm./kgm.) and injected intradermally with 0·1 ml. amounts of the test preparations. The degree of induced permeability was assessed by measuring the diameter and estimating the intensity of blueing around the site of injections 8–10 min. after administration of the test substances.

In most of the guinea pigs samples of plasma or serum which had not been in contact with glass produced only slight blueing, 1–4 mm. in diameter. A small proportion of animals showed a more intense reaction with homologous, but not with autologous, samples. This was, presumably, due to individual incompatibility and these animals were not further used. Samples exposed to glass ballotini produced an area of moderate to intense blueing 6–10 mm. in diameter which began to appear within 3 min. of injection and reached maximal intensity within 10 min. Serum was usually more effective than plasma. The greatest effect was obtained after approximately 2 min. contact with glass. Removal of the ballotini at this time was followed by a rapid decay of activity which fell to pre-activation level within a further 3–5 min. This instability made it necessary to test the glass-treated samples with the minimum of delay. Continued exposure to glass led to the complete and irreversible exhaustion of activity within 20 min. (Table 1, Fig. 1). When plasma or serum were pre-heated at 56° for 20 min. activation was not affected but decay and exhaustion were slowed. Heating above 60° prevented activation by glass. Adsorption with aluminium hydroxide produced no change in response (Fig. 1). The reaction did not occur if soybean trypsin inhibitor (Light and Co., conc. 1 mgm./ml.) was added before or immediately after contact with glass.

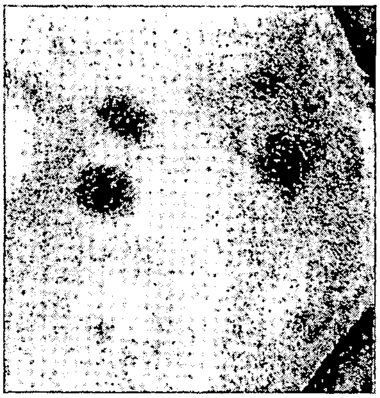

Fig. 1. Effect of citrated serum on permeability: Left, non-adsorbed; right, adsorbed with aluminium hydroxide. Glass contact, from top to bottom: 0 min., 2 min., 20 min. Photographed 20 min. after injections

Table 1. Effect of Glass Contact on the Permeability-inducing Action of Citrated Serum (Results Read 8 min. after Each Administration)

Treatment of serum samples	Diameter and intensity of blueing	
Glass, 0 min.	2 mm.	(+)
Glass, 2 min.	8 mm.	(++)
Glass, 2 min., then silicone, 4 min.	2 mm.	(+)
Glass, 10 min.	5 mm.	(+)
Glass, 20 min.	3 mm.	(±)

These observations are very similar to those on the initiation of clotting and the formation of pain-producing substance. They suggest that the agent which induces permeability is activated by the same, or a very similar, mechanism. The relation between the permeability factor which is activated by glass on one hand and by dilution on the other is not yet clear. We know that dilution of plasma also accelerates clotting[5] and liberates a pharmacologically active substance similar to pain-producing substance[6]. It may therefore be significant that, after the plasma has been exhausted by contact with glass, its dilution no longer leads to the formation of uterus-stimulating substance (unpublished observations). This suggests that contact with glass and dilution may act on the same plasma components.

I am indebted to Prof. C. A. Keele and Prof. A. A. Miles for their kind help and advice, to Dr. G. S. Dawes for the facilities at the Nuffield Institute, where this work was begun, and to Mr. J. Charles for technical assistance. The work was supported by a research grant from the Royal Australasian College of Physicians.

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α-Picoline from *Rumex obtusifolius* L.

α-Picoline has been isolated from the leaves of the dock, *Rumex obtusifolius* L. There are isolated instances where pyridine and simple derivatives have been found to occur in Nature, for example, pyridine in *Aplopappus hartwegi*[1] and 3-methoxypyridine in *Equisetum arvense*[2]. This would appear to be the first record of the presence of α-picoline in a natural source. The base was isolated in 0·1 per cent yield from an aqueous extract of the leaves and characterized as its hydrochloride (m.p. 200° anhydrous), picrate (m.p. 165–166°) and methiodide (m.p. 226–227°).

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Interaction of Hormone and Photoperiod in an Early Variety of Rice

THE interaction of hormone and photoperiod has been studied in cocklebur[1-5], Biloxi soybean[5] and Orchad grass[6]. In the present investigation the effect of the hormones in relation to photoperiodism has been studied in an early variety of rice, *N*136, which has been found to be intermediate in its photoperiodic behaviour[7]. Graded seeds of this pure strain were soaked on December 10, 1956, with 500 p.p.m. of the three plant-growth substances, β-indolylacetic acid (IAA), α-naphthylacetic acid (NAA) and 2,3,5-tri-iodobenzoic acid (TIBA), for 72 hr., a treatment which was found to be effective in earlier studies[8,9]. The grains were next thoroughly washed in water and sown in earthenware pots containing a mixture of loamy garden soil and cow-dung manure. The pots were divided into two series. In series 1 the plants simply grew after the initial hormone seed-treatment. In series 2 the plants also received an 8-hr. photoperiod (6 a.m.–2 p.m.) from the twenty-first day until panicle emergence. Two other series of unsoaked seeds were used. In series 3 the plants were given the short photoperiod as in series 2. In series 4, plants remained as untreated controls. The results are shown in Tables 1 and 2.

Table 1. LENGTH OF THE VEGETATIVE GROWTH PERIOD AND OTHER CHARACTERISTICS OF VEGETATIVE GROWTH AT THE FINAL STAGE (AVERAGE OF TWENTY-FOUR PLANTS)

Treatment	No. of days to ear emergence	No. of tillers per plant	Total No. of green leaves per plant	No. of leaves on the main shoot	Height per plant (cm.)
Seed soaked with :					
IAA	78·71	5·29	20·58	8·29	69·77
NAA	85·88	6·17	25·25	9·13	63·54
TIBA	82·96	5·58	20·54	8·63	68·35
IAA plus 8-hr. photoperiod	84·58	6·42	29·21	10·29	70·71
NAA plus 8-hr. photoperiod	91·08	9·17	38·88	12·50	65·92
TIBA plus 8-hr. photoperiod	89·04	7·21	30·63	10·92	62·65
8-hr. photoperiod alone	82·75	7·33	27·50	11·08	70·50
Controls	78·25	6·54	23·08	9·50	71·83

Analysis of the data shows that :

(1) Ear emergence was significantly delayed in the plants which were subjected to simple α-naphthylacetic acid treatment, and in those where this was followed by short photoperiod. The delay was more in the latter case than in the former, that is, the effect of the short photoperiod was additive to that of the hormone. Possibly this is due to the formation during the photoperiodic treatment of a substance or substances the influence on flowering of which is similar to that of the hormone itself.

(2) With regard to vegetative growth the plants subjected to the short photoperiod alone showed, in later stages, increased tillering and formed a larger number of leaves, though the elongation of the shoot was not much affected. Where the treatment consisted of only soaking the seed in hormone the plants in general showed less vegetative growth, while where the hormone treatment was supplemented with the short photoperiod the plants treated with α-naphthylacetic acid exhibited the greatest vegetative growth and plants treated with β-indolylacetic acid the least.

(3) Grain yield was significantly higher in plants which were treated simply with β-indolylacetic acid solution and in those which were given the α-naphthylacetic acid treatment plus the short photoperiod. In general, the plants given the short photoperiod exhibited better grain yield than those grown with a natural day-length.

(4) The higher grain yield is due mainly to a larger number of panicles and to a better percentage of grain setting.

We thank the Utkal University for the award of a Government of India Senior Research Scholarship to one of us (G. S.), the Jnan Vijnan Parishad Fund for a grant-in-aid, and Prof. B. Samantarai for providing facilities for carrying out this investigation.

Table 2. GRAIN YIELD AND ITS COMPONENTS

Treatment	Grain yield per plant (gm.)	No. of panicles per plant	Length of panicle (cm.)	No. of spikelets per panicle	No. of grains per panicle	Percentage of grain setting	1,000 grains weight (gm.)
Seed soaked with :							
IAA	2·80	4·33	17·43	74·59	45·30	60·73	14·25
NAA	2·57	4·17	17·36	76·52	46·27	60·38	13·45
TIBA	2·42	3·96	17·99	78·98	44·66	56·49	13·54
IAA plus 8-hr. photoperiod	2·81	4·83	17·42	63·32	42·55	67·55	13·65
NAA plus 8-hr. photoperiod	3·64	5·21	18·18	66·78	51·56	77·43	13·59
TIBA plus 8-hr. photoperiod	2·38	4·20	17·07	64·00	43·34	68·69	12·74
8-hr. photoperiod alone	2·84	4·63	17·86	67·48	44·97	66·67	13·67
Controls	2·20	4·46	17·83	82·74	35·98	43·75	13·59

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Elimination of Dialysis in the Preparation of Hydrophobic Sols

THE preparation of hydrophobic colloidal solutions by double decomposition, as, for example,

$$\mathrm{AgNO_3 + KI \rightarrow AgI + KNO_3}$$

is greatly complicated by the elaborate process of dialysis necessary to remove the unwanted electrolyte, in this case potassium nitrate. The sols purified by electrodialysis usually contain a considerable quantity of polyvalent ions, drawn from the water used in the dialysis into the colloidal solution. These ionic contaminants are strongly adsorbed to the sol particles and it is often difficult to eliminate them.

The following procedure, tested in our laboratory with good results, avoids the formation of a foreign electrolyte and therefore avoids subsequent dialysis.

A cation exchange resin ('Dowex' 50) was loaded with 200 m.equiv. silver ion by treating the hydrogen-exchange resin with a solution of 200 m.mol. of silver nitrate.

$$R\mathrm{H + AgNO_3 \rightarrow} R\mathrm{Ag + HNO_3}$$

In order to eliminate the electrolyte (nitric acid) the resin was washed several times with distilled water.

Then 1 litre of solution containing 200 m.mol. of potassium iodide was added to the silver resin; at once a colloidal solution of silver iodide was formed.

$$R\mathrm{Ag + KI \rightarrow} R\mathrm{K + AgI}$$

The reaction being complete, a highly concentrated sol (about 200 m.mol. silver iodide/l.) was obtained in one operation.

Conductivity measurements showed that it contains very little electrolyte ($\sigma = 3 \cdot 1 \times 10^{-5}$ ohm^{-1} cm.$^{-1}$), which compares favourably with the degree of purity of electrodialysed sols; the risk of contamination of the sol by polyvalent ions was excluded. The stability of the sols thus prepared was also excellent.

This sol, which we called a potassium sol (the counter-ions of the sol particles are formed by potassium ions), can be converted in a hydrogen sol or a barium sol by sending it over a cation-exchanger saturated with hydrogen or barium ions.

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Separation, Detection and Estimation of C21 17 : 20-Dihydroxy-20-methyl-steroids

A NUMBER of C21 steroids characterized by the 17 : 20-dihydroxy-20-methyl side-chain at C17 have been isolated from the urine of normal people[1,2] and from the urine of patients with adrenocortical hyperplasia[3] or adrenocortical tumours[4] (see Table 1). The separation and identification of members of this group of steroids is necessary for the study of their normal and abnormal metabolic formation and excretion; the following is a method which is capable of separating, detecting and estimating quantitatively all such urinary steroids so far isolated.

The known steroids of this series are detectable on dried paper chromatograms using the 70 per cent phosphoric acid test described for pregnane-3α : 17α : 20α-triol-11-one[5] and pregnane-3α : 17α : 20α-triol[8]. The results of the colour test on the 17 : 20-dihydroxy-20-methyl-steroids are shown in Table 1. An approximate estimate of the amounts of such steroids on a paper chromatogram may be obtained from the intensity of the colour or fluorescence and the size of the spots. The relative sensitivity of the colour test for the different steroids is indicated in the table; amounts of up to about ten times the minimum can be judged from the intensity and size of spot.

Some of the compounds in Table 1 have been separated on paper chromatographic systems of the Zaffaroni type[6] (compounds I and V) or the Bush type[2] (compounds I, II, III). Paper chromatographic studies of mixtures of all the steroids I–VI have shown that complete separation of the compounds is possible in a descending chromatogram, run with the solvent system benzene/formamide for 12 hr. on a 35-cm. long Whatman No. 1 paper at 25° C. The rates of movement of the steroids relative to pregnane-3α : 17α : 20α-triol are shown in Table 1. Compounds II and IV move closely together, but under the above conditions separate completely; the largest amounts of each steroid used in these tests corresponded to about 12 μgm./cm. width of paper. Mixed with neutral chloroform extracts, prepared from urine treated with β-glucuronidase preparations for hydrolysis of steroid conjugates, compounds I–VI continued to give satisfactory chromatographs and moved at the same relative rates as were found with the pure steroids.

A general method for the estimation of 17 : 20-dihydroxy-20-methyl-steroids and its application to urinary extracts has been described[7]; this method is based on the formation of acetaldehyde from the C17 side-chain of these steroids ('acetaldehydogenic steroids') when oxidized with periodic acid. As steroids with other C17 side-chains are not estimated and do not interfere in this estimation, it is particularly suitable for the assay of the steroids listed in Table 1, after their separation by paper chromatography. It has been found that this estimation of 'acetaldehydogenic steroids' may be carried out without modification directly on dried portions of paper chromatograms (benzene/formamide system); elution of the steroids from the paper prior to oxidation is not necessary. Amounts of steroid down to about 2 μgm. can be estimated quantitatively on the paper.

Table 1. SEPARATION AND DETECTION OF 17 : 20-DIHYDROXY-20-METHYL STEROIDS

Steroid	Movement of steroid on chromatogram in solvent system benzene/formamide relative to steroid *I* = 1·00	After heating on paper with 70 per cent phosphoric acid		
		Colour in daylight	Fluorescence in ultra-violet light (3660 A.)	Minimum amount clearly detectable (μgm./sq. cm.)
I Pregnane-3α : 17α : 20α-triol	1·00	Purple	Pink	1–2
II Pregnane-3α : 17α : 20β-triol	1·22	Purple	Violet–pink	1–2
III Pregn-5-ene-3β : 17α : 20α-triol	0·91	Purple	Yellow	2–4
IV Allopregnane-3α : 17α : 20α-triol	1·14	Purple	Pink–brown	1–2
V Pregnane-3α : 17α : 20α-triol-11-one	0·24	None	Blue–violet	0·3–0·6
VI Pregnane-3α : 11*B* : 17α : 20α-tetrol	0·1	Purple	Pink	1–2

The above technique provides a complete method for the separation, detection and estimation of the known urinary 17 : 20-dihydroxy-20-methyl-steroids. Use of the method in estimating these steroids and in detecting new compounds in the urine of normal and diseased people will be described in detail elsewhere.

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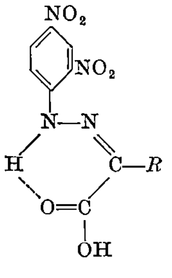
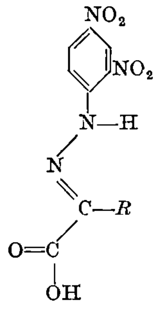
A New Reaction for the Differentiation of *cis*- and *trans*-Isomers of Nitrophenylhydrazones of some α-Keto Acids

RECENTLY, it has been reported by several investigators that there exist *cis*- and *trans*-isomers in 2 : 4-dinitrophenylhydrazones of pyruvic acid[1,2], benzoylformic acid[3] and α-keto-β,β-dimethyl-γ-butyrolactone[4] as shown in (I) and (II) respectively. This was supported by infra-red spectra, since the wave-numbers of the stretching bands of CO and NH of the *cis*-form were smaller than those of the *trans*-form. Our interest in the structures of the isomers of these hydrazones has led us to the discovery of a new chelating reaction, capable of differentiating the two forms.



(I)



(II)

When 0·1 gm. of zinc powder was added to a mixture of 10 μmoles of nickel chloride and 30 μmoles of the *cis*-hydrazone in 5 ml. of 70 per cent aqueous ethanol (the reaction never occurred in absolute alcohol) and shaken for a few minutes, a red colour appeared. This did not happen with the *trans*-hydrazone. Maximum coloration was obtained at a 3 : 1 molar ratio of hydrazone to nickel. No coloration was produced when the nickel chloride solution was added to a hydrazone solution which had been shaken with zinc powder and then filtered to remove the powder. From these facts, the coloration is presumed to result from chelation of nickel with the carboxyl group and with a metastable group produced by the reduction of the nitro group. Nickel was found to be replaceable by cobalt, iron and mercury. These colouring reactions were also observed with several other nitro-compounds (Table 1). The shifts in the value of $\lambda_{\max.}$ on chelation with nickel were as follows. Pyruvic acid 2 : 4-dinitrophenylhydrazone : *cis*, 370 mμ to 380 mμ ; *trans*, 356 mμ to 358 mμ. Benzoylformic acid *o*-nitrophenylhydrazone : *cis*, 425 mμ to 447 mμ ; *trans*, 412 mμ to 365 mμ. The chelated compounds of the *cis*-forms showed more intense absorption in the longer wave-length region than those of the corresponding *trans*-forms.

Table 1. COLOUR REACTIONS WITH SOME NITROPHENYLHYDRAZONES AND NITROPHENOLS

Compounds		Colouring reaction
2 : 4-Dinitrophenylhydrazone of pyruvic acid	*cis*	+
	trans	–
2 : 4-Dinitrophenylhydrazone of benzoylformic acid	*cis*	+
	trans	–
o-Nitrophenylhydrazone of benzoylformic acid	*cis*	+
	trans	–
m-Nitrophenylhydrazone of benzoylformic acid	*cis*	–
	trans	–
p-Nitrophenylhydrazone of benzoylformic acid	*cis*	–
	trans	–
o-Nitrophenol		+
m-Nitrophenol		–
p-Nitrophenol		–

Judging from the results shown in Table 1, the presence of a nitro-group at the *ortho* position in the benzene ring is indispensable for this colour reaction. Furthermore, this colour reaction is confined to α-keto acids, in which the nitro- and carboxyl-groups are situated in positions suitable for chelating around the nickel atom. Thus in the hydrazones of symmetrical keto acids only that of mesoxalic acid (α-keto acid) shows a positive reaction, whereas acetonedicarboxylic acid (β-keto acid) and γ-ketopimelic acid (γ-keto acid) give a negative reaction.

This reaction can be used to differentiate the geometrical isomers of 2 : 4-dinitrophenylhydrazones of α-keto acids, but it is less effective if the hydrazone isomerizes rapidly.

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The α-β Transformation in Keratin

BENDIT[1] has recently underlined the necessity for refinement of some of the earlier ideas[2] on the mechanism of the α–β transformation in wool keratin. The problem of a precise quantitative investigation of the transition is difficult, largely because of the intervention of relaxation and creep, the effects of which on the crystalline phases are unknown. Recently[3], a technique for obtaining the desired diffraction data in a short time has been described, and its use, together with standard diffractometric technique, has enabled some interesting preliminary results about the transformation to be obtained.

In view of the importance which knowledge of this mechanism has in a wider context it is thought worth while to record a summary of the conclusions from X-ray and related elastic data. It must be underlined that some of the assumptions on which the deductions are made may be suspect; but in the light of consistent correlationships with other factors they appear quite reasonable.

The following, then, is a tentative summary of the salient features of the transformation, the stretching being carried out in water at 50° C., sufficient time being allowed for relaxation to be nearly complete before the X-ray results were obtained.

A quantitative X-ray investigation of the α–β transformation in Lincoln wool keratin has been made using a Hilger double-beam diffractometer. It is deduced that the reaction proceeds through an intermediate phase β* of less order than either the α or β phases according to the scheme

$$\alpha \rightleftharpoons \beta^* \rightleftharpoons \beta$$

The regions which contribute to stress during the transformation are only slightly perturbed from the crystallographically well ordered.

There is a close correlation between the elastic properties and changes in discrete X-ray diffraction intensities.

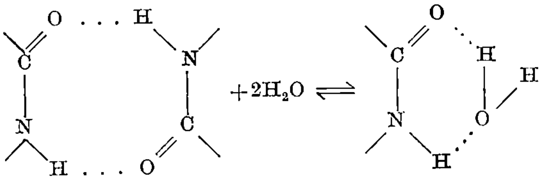
The α phase, representing approximately 60 per cent (linear measure) of the fibre, is in series with a less extensible γ phase, which requires severe disulphide bond fission to enable it to be strained; these phases being those referred to as α and γ keratose elsewhere[4].

It is suggested that the broad diffuse equatorial reflexion about 10 A. is a doublet formed from two reflexions the values of which are 10·7 A. and 9·55 A. The first reflexion is variable and probably relates to the assumed helical structure[5], while the second is invariant and may be caused by the γ keratose.

The extensibility predicted for the α phase (0·88) is in fair agreement with that observed[2] (1·27). The fraction of β material present at an extensibility x is given by

$$\beta = 1{\cdot}225\,x + 0{\cdot}0816$$

The essential feature of the initial change is a hydration effect accompanying chain straightening according to the scheme



Interchain hydrogen bonding is initially absent in the β form but appears after steam-setting and prolonged relaxation. The difference in entropy between the α and β phases is small. The entropy contribution to load deduced from the X-ray data agrees with direct measurements[6]. The difference in energy between the α and β phases is 1·45 kcal. gm.mol.$^{-1}$. Potential barriers of approximately 20 kcal. gm.mol.$^{-1}$ and 260 kcal. gm.mol.$^{-1}$ exist for extensions from ≃ 0–30 and ≃ 30–60 per cent. Both relate to a helical transformation. Above these extensions an exceedingly high barrier must be overcome under normal conditions, due to the necessity to deform the γ phase.

Observations from supercontraction experiments[7] are also compatible with the present phase structure.

An extended account of this investigation is at present being prepared for publication.

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Polynuclear Aromatic Compounds in Coal

IN a recent communication, Friedel[1] compared the specific extinction coefficients of coal at two wave-lengths with those of various polynuclear aromatics and found the values for coal (a Pittsburgh vitrain containing 84 per cent carbon) 30–40 times lower than those for the model substances. From these data Friedel concluded that the concentration of polynuclear condensed aromatics in coal is low.

In our opinion, the reason for this great difference lies in the fact that coal is a very complicated mixture of aromatic compounds. The extinction values of the aromatics quoted by Friedel are the peak values of the strongest band in the spectra of single compounds. The extinction at wave-lengths off the peak is often 10–100 times smaller, so that in a complicated mixture in which all the components have bands at different wave-lengths the average specific extinction coefficient is much below the peak values for the single components. The spectrum gradually loses its band structure as the mixture becomes more complicated. The specific extinction of these complicated mixtures at a certain wave-length will depend mainly on the average number of condensed aromatic rings per molecule.

We compared Friedel's results on Pittsburgh coal with the absorption values of a mixture of twenty-three polynuclear aromatic compounds and of two pitch fractions. The specific extinction coefficients K (in litre/gm. cm.) for the two wave-lengths quoted in ref. 1 are stated in Table 1.

The mixture was prepared by mixing equal amounts by weight of the compounds mentioned in Table 2. The average number of aromatic rings per molecule is 4. The spectrum of this dark brown

Table 1. SPECIFIC EXTINCTION COEFFICIENTS OF COAL COMPARED WITH THOSE OF PITCH FRACTIONS AND A MIXTURE OF POLYNUCLEAR AROMATICS

	No. of aromatic rings	K in litre/gm. cm.	
		4000 A.	4920 A.
Mixture of 23 aromatic compounds (see Table 2)	4	5·2	0·4
Pitch fraction M = 249	5·1	12	1·7
Pittsburgh vitrain, 84 per cent carbon, according to Friedel (ref. 1)	5–6	10	5·6
Pitch fraction M = 587	6·7	27	11
Peak values for Friedel's model substances (ref. 1) (violanthrene, dibenzopyrene)		295	200

Table 2. COMPONENTS OF THE MIXTURE OF TWENTY-THREE AROMATIC COMPOUNDS

1, Acenaphthene
2, Acridine
3, Anthracene
4, Brazane
5, Carbazol
6, Chrysene
7, Coumarone
8, Decacyclene
9, 1,2,5,6-Dibenzanthracene
10, Difluorenyl
11, 2,6-Dimethylnaphthalene
12, Dinaphthylenethiophene
13, Diphenyl
14, Fluoranthene
15, 2-Methylnaphthalene
16, Naphthalene
17, Perylene
18, Phenanthrene
19, Pyrene
20, *p*-Terphenyl
21, Triphenylene
22, *α*-Truxene
23, *β*-Truxene

mull was taken in a cyclohexane solution at a concentration of 0·1 and 0·01 gm./l. (Fig. 1).

The pitch fractions were prepared in our laboratory by Mr. F. J. Huntjens by fractional precipitation from a chlorobenzene solution with petroleum ether. The ebullioscopic average molecular weights M are listed in Table 1. The spectrum of the low molecular weight fraction was taken in a n-heptane solution, that of the high molecular weight fraction in a benzene solution, both solvents containing 0·3 per cent by volume of pyridine. In both cases the concentration was about 0·01 gm./l. (see the spectra, Fig. 1).

The number of aromatic rings per structural unit was determined by refractometric constitution analysis[2]. The number of aromatic rings for the coal sample is that of a pure vitrinite with the carbon content as mentioned[3].

The peak values of the model substances used by Friedel for the wave-lengths 4000 and 4920 A. are also included in Table 1.

From the collected data it is seen that in the 4000–5000 A. region the specific extinction of coal is in good agreement both with those of the two pitch fractions and with that of the mixture of polynuclear aromatics, all having a comparable number of aromatic rings per structural unit or per molecule.

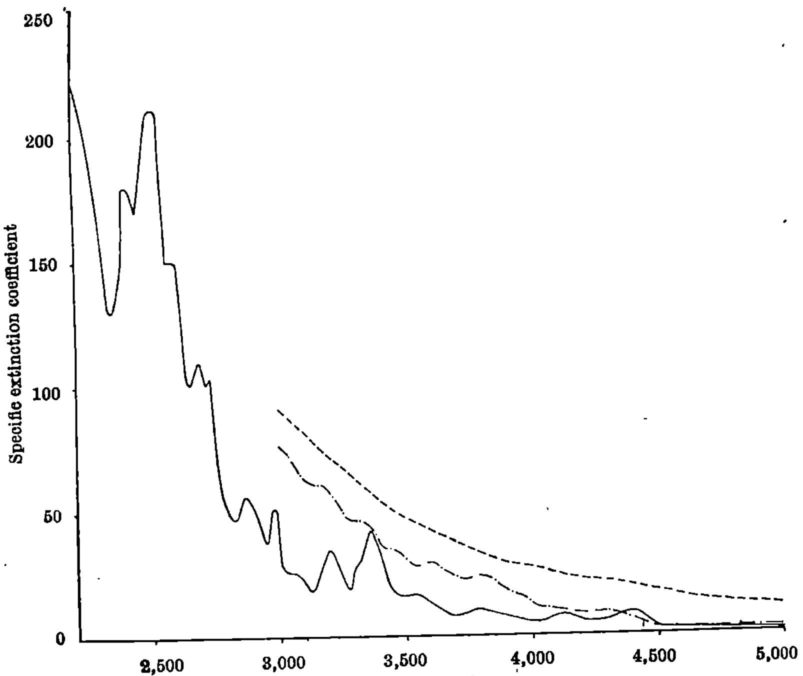

Fig. 1. Ultra-violet spectra of two pitch fractions and a mixture of aromatic compounds. - - -, Pitch fraction $M = 587$; —·—, pitch fraction $M = 249$; ——, mixture of 23 aromatic compounds (see Table 2)

On the other hand, it may be anticipated that a complicated mixture of 9-ring aromatics (such as violanthrene) will have a higher extinction at 4920 A. However, such a mixture should not be compared with a coal sample having only 5–6 rings per unit, corresponding to a carbon content of 84 per cent.

Therefore, it must be concluded that Friedel's extinction data provide no evidence for a low content of polynuclear aromatics in coal.

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Identification of *M*-Regions on the Sun

FROM observations of magnetic disturbances on the Earth, Bartels[1] suggested the existence of M-regions on the Sun. Attempts have been made to associate these M-regions with other solar phenomena. Allen[2] tried to show that coronal streams and M-regions are identical; he also concluded that M-regions avoid spot groups or are even destroyed by them. This conclusion was implicitly modified by the results of Denisse[3] and Becker[4]. Identification of M-regions with regions of unusually weak corona emission was recently suggested by Bell and Glazer[5]. Kiepenheuer[6] arrived at the conclusion that filaments are the possible source of M-disturbances. As a result of measurements of the solar magnetic field, Babcock and Babcock[7] believed that the observed unipolar magnetic regions are M-regions. With these measurements M-regions may have ceased to be hypothetical in character. Whether or not this is so, it is still of interest to continue the study of M-regions relative to other solar phenomena.

I have investigated M-regions in their relationship to sunspots. A phase lag method was used. It consists of the analysis of cross-correlograms obtained from daily values of the final Zurich sunspot number Z and the planetary K-index, ΣK_p. Both variables are known to have a pronounced periodicity due to the rotation of the Sun. With certain assumptions regarding constant mean time of travel of particles and a prevalence of their radial emission from the Sun, the phase lag between Z and ΣK_p data can be interpreted in terms of a displacement in solar longitude between Z- and M-regions.

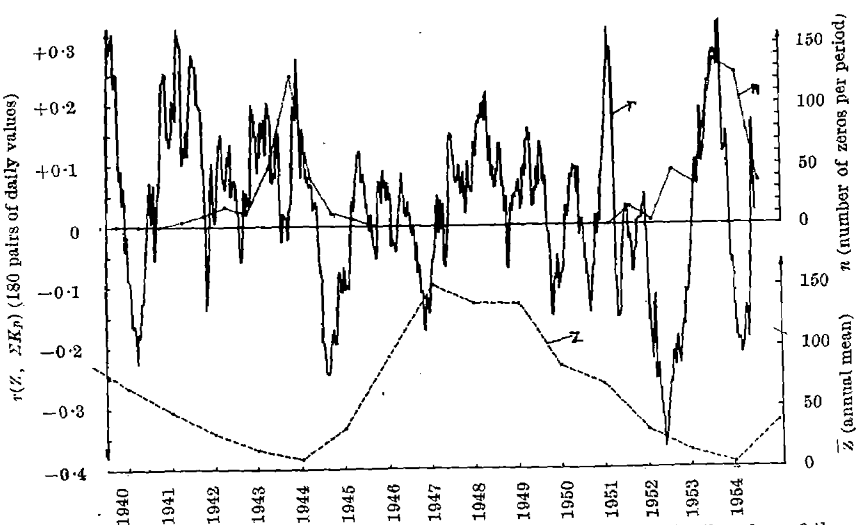

Fig. 1. Variations during the sunspot cycle of the correlation coefficient r of daily values of the geomagnetic index ΣK_p and the final Zurich sunspot number Z with six-month correlation intervals

Correlation intervals of six months were chosen. The period between 1940 and 1954 was investigated by obtaining successively overlapping correlation coefficients r in ten-day steps. The r-distribution throughout this period is shown in Fig. 1. Values are positive as well as negative. Neglecting for the moment that one is dealing with time series and not with randomly selected pairs, each value of r is determined by the 'true' correlation between the variables and by the trend due to their periodicity. The latter contribution is in principle invariant to displacements which are multiples of the period of synodic rotation. A reliable interpretation of the variations of r with the sunspot cycle, as shown in Fig. 1, is therefore difficult. This difficulty is also amplified by the questionable validity of tests of significance for correlation coefficients between time series. It is possible, however, to study the phase relationship between the variables involved. In this case considerations of statistical significance can be circumvented by obtaining cross-correlograms and selecting those which are regular so that the locus of r is a smooth and periodic curve. Z-data were therefore made to lag with respect to ΣK_p-data from -10 to $+35$ days in one-day steps. 558 such cross-correlograms were obtained. Their periodic regularity was a necessary but not sufficient condition for the interpretation of the phase lag as given by the position of the maximum of r in terms of the longitudinal displacement of M-regions and sunspots. Ascertaining that the position of the maximum of r is not attributed to few extreme values of Z and ΣK_p, cross-correlograms of running means of five were used for comparison. They revealed much larger magnitudes of r. Provided the previous distributions of r were regular, the identical displacements of the maxima of r were considered further evidence for a significant determination of the longitudinal displacement between sunspots and M-regions. Additional confirmation for a valid interpretation was found in the variations of the solar rotational period during the sunspot cycle. The results seemed consistent with the knowledge of the latter dependence upon latitude and the latitude shifts of spots with the sunspot cycle.

Fig. 2 shows the relative positions of M-regions and sunspots as obtained by this method. Sunspots are at a fixed position of relative zero longitude assuming the mean time of travel of particles to be zero. If they require 1½ days for their passage from Sun to Earth, the indicated sunspot position is to be displaced in a clockwise sense by about 20° of solar longitude. Each dot indicates a mean position of an M-region. They seem randomly arranged relative to sunspots. This leads one to believe in the existence of two causative mechanisms. The indication of an accumulation of M-regions antipodal to spots can perhaps be attributed to the latter destroying the former.

If other solar data like corona, filaments, etc., are studied in the same manner, a further contribution to the identification of M-regions can be expected.

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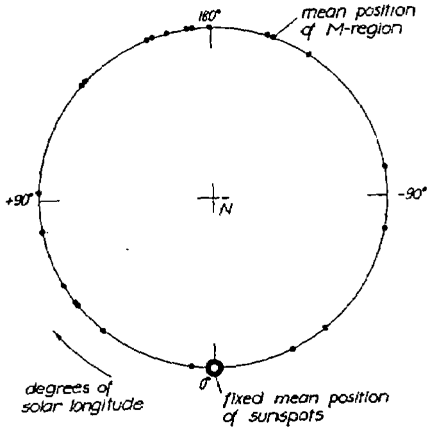
180°
mean position of M-region
+90°
-90°
N
0°
degrees of solar longitude
fixed mean position of sunspots

Fig. 2. Longitudinal mean displacement between sunspots and M-regions

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Dependence of Heat Capacity on Thermal History

IN a recent communication, Morfee and Staveley[1] have reported a "phenomenon for which, as far as we are aware, there is no precedent", namely, that the specific heat of potassium stannichloride appears to be dependent on its previous thermal history. We would like to point out that such a phenomenon has been observed in the metal cerium, where the pronounced peak in the atomic heat[2,3] at 13° K. increases after repeated coolings and eventually reaches a reproducible value about 70 per cent greater than the original. The low-temperature magnetic susceptibility[4] increases by a correspondingly large amount, while both properties show large thermal hysteresis effects between 40° K. and 200° K., which are also dependent on the previous history of the sample. These results can be explained in terms of an incomplete electronic transition $4f \rightleftarrows 5d$. Such behaviour is probably characteristic of systems which are not in true thermodynamic equilibrium.

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Mean Free Path of Phonons in a Lead Crystal

THE high flux of 'cold' neutrons now obtainable using the liquid hydrogen source[1], in the Harwell pile BEPO, has been used to investigate the mean free path of phonons in a lead crystal from observation of the spectrum of inelastically scattered neutrons.

In order to evaluate the relations between the incident and scattered wave-numbers set by the conditions of conservation of momentum and energy, a model of the crystal was assumed in which the velocity of propagation of transverse and longitudinal waves is independent of direction. If effects arising from the elastic anisotropy are not important this model is satisfactory for phonon wave vectors small compared with the maximum in the crystal. The experiment was arranged so that this latter condition was fulfilled. The calculations made for the case of the incident wave vector parallel to the reciprocal lattice vector of the (111) plane of lead, and assuming a long mean free path for the phonons, are shown in Figs. 1 and 2. The only process considered is that in which neutrons lose energy in exciting a single phonon. For the crystal orientation chosen and a range of incident neutron wave numbers from 0·9 to 1·4 A.$^{-1}$ the outgoing neutrons have wave-numbers of about 0·4 A.$^{-1}$ for transverse waves, and 0·2 A.$^{-1}$ for longitudinal waves in the crystal, if the scattering angle is about 140°. In addition, it is found that the cross-section for scattering at 140° by transverse waves is much greater than for longitudinal waves. Thus we should see a sharp peak in the spectrum of scattered neutrons at about 0·4 A.$^{-1}$ if the phonon mean free path is long, or a broad peak if it is short.

A beam of cold neutrons having wave-numbers between 0·8 and 1·5 A.$^{-1}$ was modulated by a chopper device and allowed to fall on a single crystal of lead oriented in the way described above. The time-of-flight of neutrons scattered through an angle of 140° was measured over a 70-cm. flight path. The background of the detector was regularly determined by raising the crystal above the neutron beam. The spectrum of scattered neutrons obtained with the crystal at a temperature of 80° K. is shown in Fig. 3. $N(E)$ represents the scattered neutron intensity per unit energy interval; probable errors are indicated.

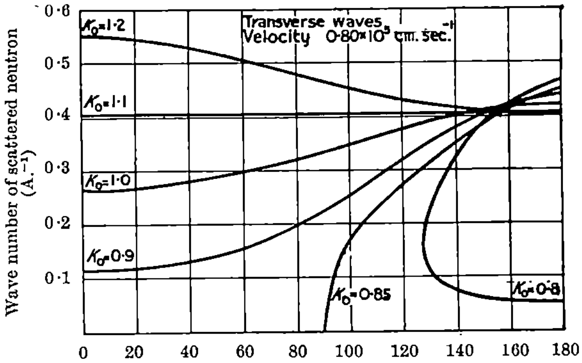

Fig. 1. Calculated values of the wave-numbers of neutrons scattered through given angles after excitation of a single transverse phonon. The orientation of the incident wave-number K_0 (expressed in units of A.$^{-1}$) is described in the text

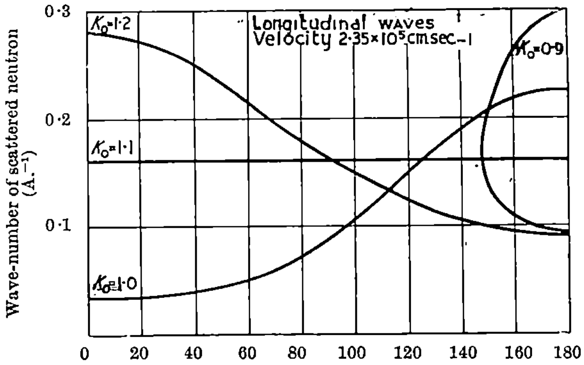

Fig. 2. Calculated values of the wave-numbers of neutrons scattered through given angles after excitation of a single longitudinal phonon

As expected, there is a group of neutrons of wave-number 0·4 A.$^{-1}$ (corresponding to 0·2 mV.); these are neutrons which have lost energy in exciting transverse phonons. The high-energy peak is due to neutrons which have been elastically scattered or have gained energy by phonon absorption. The width of the group of neutrons which have lost energy is of the order of the resolution width of the apparatus, which is about 0·06 mV. This implies that anisotropic effects have not substantially broadened the cross-over region shown in Fig. 1, and so from this value of the width the phonon mean free path at 80° K. is calculated to be greater than 180 A. The average energy of the phonon de-excited in the interaction is approximately 1·5 mV.

The results obtained with the crystal at a temperature of 300° K. are shown in Fig. 4. The ordinate scales in Figs. 3 and 4 are in the same ratio as the inelastic cross-sections (calculated for mean energy gain) at the two temperatures. The number of neutrons which gained energy was found to have increased by this ratio, which is readily calculated[2], while the number in the energy-loss group increased by only one-third the expected amount. This discrepancy cannot be explained by, for example, the increase of multiphonon processes at the higher temperature, and therefore implies that the energy loss group has a greater width at room temperature than at low temperature. The estimated width of about 0·1 mV. at 300° K. corresponds to a mean free path for transverse phonons of 110 A. R. J. Elliott has

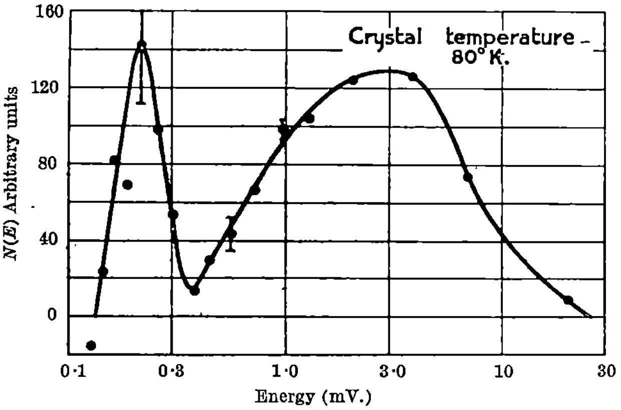

Fig. 3. Observed spectrum of neutrons scattered through an angle of 140° ; crystal temperature, 80° K.

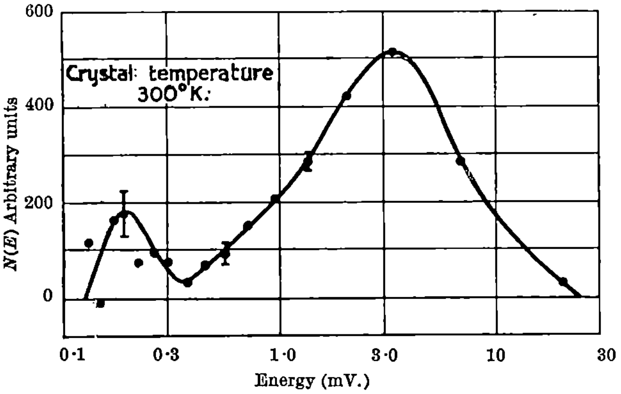

Fig. 4. Observed spectrum of neutrons scattered through an angle of 140° ; crystal temperature, 300° K.

estimated (private communication) that a mean free path of this magnitude is expected from phonon–phonon interactions in lead at room temperatures. It is hoped that ultimately measurements of the mean free path for phonons will be correlated with the thermal conductivity of the crystal.

A useful result is obtained indirectly from the variation with temperature of the scattering cross-section. This allows one to estimate the incoherent elastic scattering cross-section of lead. The value obtained is 0·05 ± 0·03 barns, which is better than previous measurements[3].

This work was performed while one of us (G. J. M.) was seconded to the Atomic Energy Research Establishment, Harwell, from the New Zealand Department of Scientific and Industrial Research. We wish to thank T. L. Schofield, L. V. Lewis and B. E. Hasler for assistance in operating the equipment during the course of the experiment. Miss B. Wilkinson and Miss M. McQuhae assisted in computation and R. O. Ridley and D. Brown kindly provided the lead crystal.

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Magnetic Susceptibility of the Alloy Pt_3Fe between 20 and 900 Degrees Absolute

According to the phase diagram published by Kussmann and von Rittberg[1], iron dissolves in solid solution in platinum up to at least 35 atomic per cent of iron. The structure is face-centred cubic, but at compositions around 25 atomic per cent of iron (Pt_3Fe) a superlattice develops which is stable up to temperatures probably in the range 650–800° C.

The magnetic susceptibility of an annealed 25 per cent alloy has been measured between 20° and 900° K. The results are given in Fig. 1. X-ray examination confirmed the presence of the superlattice in a powder taken from this specimen and given the same annealing treatment.

At high temperatures the Curie–Weiss law is obeyed, extrapolating towards a paramagnetic Curie temperature of about −90° K. On cooling below room temperature, deviations from the Curie–Weiss law begin at about 200° K. The susceptibility rises to a distinct maximum at 105° K. and then falls at lower temperatures until about 50° K. where another increase begins.

Susceptibilities were measured in an applied field of 8,200 oersteds. At 290°, 200°, 80° and 20° K. measurements were also made in a range of field strengths between 2,500 and 10,800 oersteds, and no significant variation of the susceptibility with field was detected.

The behaviour observed suggests the existence of antiferromagnetism in the ordered alloy at low temperatures, and further work is in progress to confirm this.

At compositions on either side of 25 per cent of iron, the annealed alloys were found to be ferromagnetic, as was reported by Kussmann and von Rittberg[2]. With decreasing iron-content, the magnetic moment increases, the moment (extrapolated to 0° K.) of the 15 per cent iron alloy being about

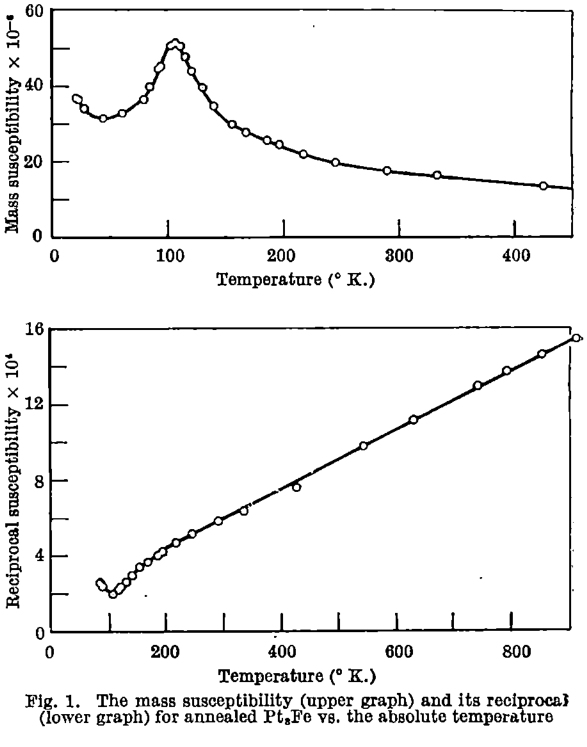

Fig. 1. The mass susceptibility (upper graph) and its reciprocal (lower graph) for annealed Pt_3Fe vs. the absolute temperature

0·6 Bohr magneton per atom. On the other side, the ferromagnetic moment rises more slowly with composition. In the 25 per cent alloy, cold work renders the material quite strongly ferromagnetic. X-ray examination showed that the structure of the cold-worked 25 per cent alloy was still face-centred cubic. The lattice parameter was apparently the same as for the undeformed material, but no superlattice reflexions were observed. It is suggested that the primary effect of the cold work was to destroy the superlattice, and that the disordered state is ferromagnetic. Further work is also in progress on these ferromagnetic platinum-rich alloys.

I wish to thank Prof. W. Sucksmith for his advice and interest, and also the Mond Nickel Company for the loan of the pure platinum on which the alloys are based.

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Correlation between Ionizing and Attachment Coefficients and Breakdown Characteristics for Carbon Tetrafluoride

The growth of pre-breakdown currents with distance has been investigated in carbon tetrafluoride for various constant values of E/p (E is the field, p the gas pressure). The purpose of this communication is to give results for ionization and attachment derived from this investigation and to show that they are consistent with previously published[1] breakdown-voltage characteristics for this material in uniform and non-uniform fields. Carbon tetrafluoride is no longer available commercially in Britain and this limited the number of pre-breakdown current measurements.

In electronegative gases the growth of current with distance is given by

$$I = I_0 . \frac{\{\alpha/(\alpha-\eta)\exp(\alpha-\eta)d - \eta/(\alpha-\eta)\}}{1-(\omega/\alpha).(\alpha/\alpha-\eta).\{\exp(\alpha-\eta)d-1\}}$$

where I_0 is the initial current, α the primary ionization coefficient, η the mean number of attachments per centimetre drift in the field direction, (ω/α) a generalized secondary ionization coefficient, and d gap distance. If the Townsend criterion is valid for breakdown in electronegative gases, the threshold for self-maintaining current is obtained when a denominator is zero. On the assumption that secondary processes are small the denominator with increasing values of d, in the range $\eta > \alpha$, approaches zero as $(\eta - \alpha) \rightarrow 0$. In the limit this is a condition which depends upon E only and sets a value for E below which no breakdown should be possible whatever the value of d. Plots of $\log(I/I_0)$ against d for carbon tetrafluoride are not linear and by curve fitting it is possible to determine α and η. Although values of $(\alpha - \eta)$ could be determined to within 1 or 2 per cent, the resolving power of the method was not good enough to permit precise determinations of α and η for the limited number of experiments that could be made.

Fig. 1 gives $(\alpha - \eta)/p$ for various values of E/p, and from the curve the value of $(E/p)_{\alpha=\eta}$ is 47·6 volts/cm./mm. pressure; this value is in close agreement with the experimentally determined limiting value of E/p obtained by plotting E against d for a uniform field at atmosphere pressure.

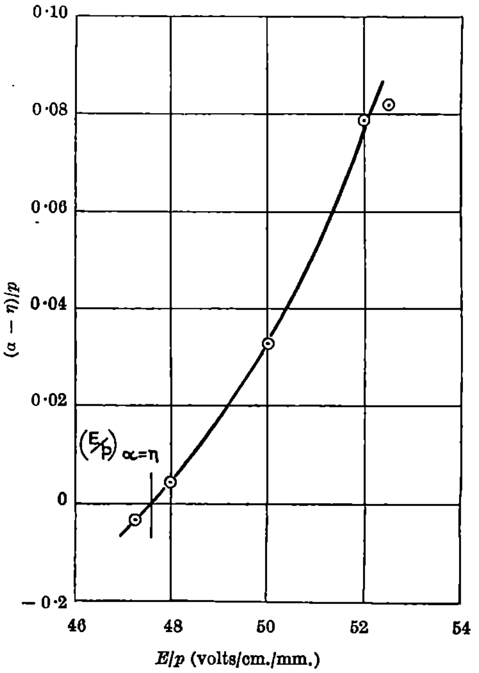

Fig. 1. $(\alpha - \eta)/p$ against E/p in carbon tetrafluoride at a pressure of 230 mm. mercury

For non-uniform fields where the high-stress region is at the positive electrode, the breakdown voltage/pressure curve for electronegative gases rises to a peak value as the pressure increases and then falls until it

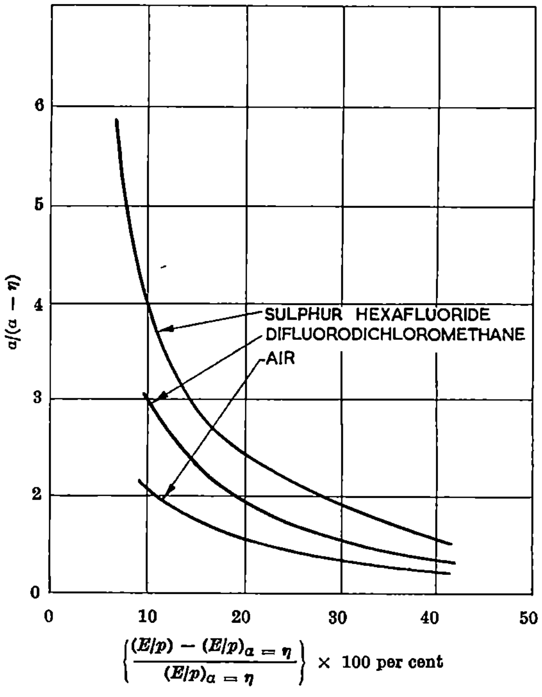

Fig. 2. $\alpha/(\alpha - \eta)$ against field strength expressed as a percentage above $(E/p)_{\alpha=\eta}$

coincides with the voltage for the onset of corona at a critical pressure. Generally, the positive static breakdown voltage is higher than the impulse value below this critical pressure so that field modification involving time is an important factor. It has been argued[2] that with impulses only electrons contribute to the lowering of the field at the highly stressed electrode while with static voltages there is an additional contribution by negative ions. This leads to the conclusion that for any gas at a particular percentage of E/p above $(E/p)_{\alpha=\eta}$ the difference between the impulse and the static values is related to the magnitude of $\alpha/(\alpha-\eta)$. Fig. 2 gives plots of $\alpha/(\alpha-\eta)$ for sulphur hexafluoride, difluorodichloromethane and air against the percentage increase of E/p above $(E/p)_{\alpha=\eta}$; the values for carbon tetrafluoride lie in the region of the curve for air. Experimental data indicate that the difference between the static and impulse breakdown voltage is greater for sulphur hexafluoride than for difluorodichloromethane; for air and carbon tetrafluoride the impulse breakdown voltages exceed by a small amount the static values, possibly due to the effect of time-lags influencing the impulse breakdown.

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Periodicity in Sea Roughness and Origin of Microseisms

Various workers have tried measuring the roughness of the sea by observing wave heights at a particular position as well as by compiling wave profiles along large distances by air observations. Glitter photographs of the sea surface have also been statistically analysed for finding the relation between development of wavelets and wind velocity. It has been recognized that description of sea roughness is very difficult by any of the above means. On the other hand, it is well known that radar clutter increases in amplitude with sea roughness, and estimation of sea roughness should be possible by observations of radar clutter. Recently, one aspect of analysis of sea roughness became imperative in view of the hypothesis that microseisms may be caused by means of interaction of wind and sea roughness. According to such ideas, the periods observed in microseisms should correspond to any autocorrelative periods in sea roughness.

A shore-based naval 10-cm. radar was used for the study of radar clutter. The echoes were observed from about 200 ft.^{2} area of sea surface at a certain distance by giving attention only to 1-mm. width at 2,000 yd. range of '*A*' type scan, the angular width of the radar beam being 2½°. The rest of the '*A*' type scan was blocked by black paper. The vertical amplitudes in the narrow width of 1 mm. on the screen gives a record of the intensity of the clutter. These amplitudes were photographed by means of a continuously moving film using a speed of 7·4 in. per min. In the absence of an automatic autocorrelation meter, the amplitudes were read manually at 0·38-sec. intervals and an autocorrelogram was computed. The autocorrelogram showed strong periods of 0·8 sec. and 4·6 sec. There was an indication of a weak period also at 1·2 sec. According to the senior author's hypothesis, periods in sea roughness produce corresponding periods in eddy viscosity at the sea-surface. This causes periodic changes in wind-stress over the sea provided the winds are cyclonic or suitably oriented near a coast line. Such changes cause pulsations in pressure over wide areas at the sea-bottom. On the other hand, according to Longuet-Higgins's theory[2], standing waves, which might be regarded as corresponding to double the period brought out by any sea roughness analysis, cause direct second-order pressure effects of double frequency on the sea bottom. The standing waves of this theory are not likely to be seen always by the usual methods of observation of sea surface. According to the standing-wave theory, simultaneous existence of suitably oriented wind at the originating area in question is not essential.

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[2] Longuet-Higgins, M. S., *Phil. Trans. Roy. Soc.*, **243**, 1 (1950).

Refraction of Microseisms

It is well established now that microseisms, the small tremors of varying intensity (in the range of 2–10 sec. period and of the order of a few microns in amplitude) recorded as more or less a permanent background by seismographs, are caused by sea waves associated with cyclonic depressions. The possibility of using these waves for location and tracking of storms has been investigated by many workers, and various techniques for estimating the direction of arrival have been put forward. But as the accuracy of estimation of direction of arrival is improved, corrections have to be applied to allow for the refraction of the waves due to variations in the velocity of propagation along the path from the generating area to the recording station. Microseisms are surface waves of the Rayleigh and Love type, and hence can be affected by variations in the geological structure of the Earth's crust and the changes in ocean depth along the path. While it is very difficult to estimate corrections for the geological configuration of the Earth's crust, the effect due to ocean depth can be calculated.

The effect of coupling between the ocean and the sea bottom on Rayleigh waves has been studied by Stoneley[1], and many workers have calculated the velocity of the modified Rayleigh waves in a uniform elastic sea bed, the ocean being regarded as a homogeneous compressible medium. As the present techniques for the direction of arrival of microseisms consist of using only the Rayleigh wave component, the refraction due to the Stoneley effect can be estimated.

Darbyshire[2,3] used this idea first and constructed refraction diagrams for Bermuda and the British Isles for microseisms arriving from various directions. The wave-fronts were assumed straight and parallel far out in the sea, and successive fronts were drawn at convenient intervals using velocities appropriate to the particular ocean depth. A method of geo-

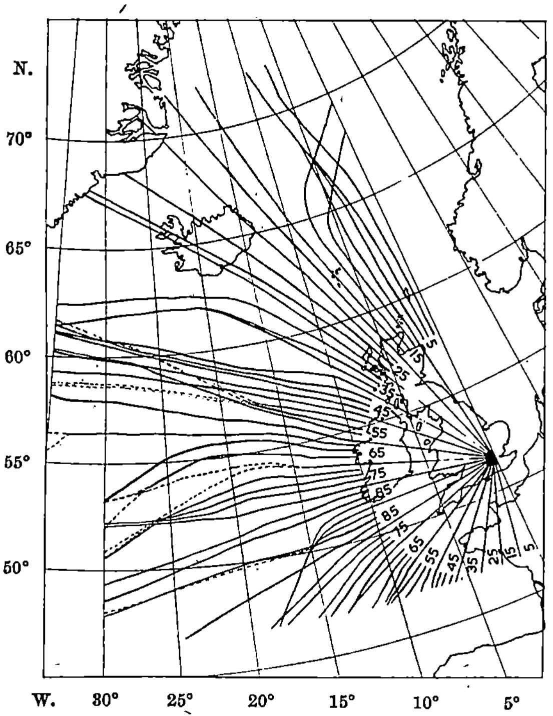

Fig. 1. Refraction diagram for microseisms of 6-sec. period

metrical construction was employed on a bathymetric chart of the area under consideration.

However, for microseisms generated by storms in the deep ocean, the amount of refraction depends on the actual position of the storm with respect to the recording station, and the parallel wave-front theory cannot be applied. Hence new refraction diagrams (Figs. 1 and 2) have been constructed using the reciprocity principle. Rayleigh waves are supposed to originate from the recording station—in this case Kew—and travel outwards. The wave-fronts are circular to start with, but become distorted as the wave progresses through the Atlantic Ocean bed. From these wave-fronts rays are drawn at $2\frac{1}{2}$°-intervals. The diagrams are constructed for 6-sec. and 9-sec. microseisms. The velocity of Stoneley waves for different depths of the oceans was calculated in exactly the same way as Darbyshire did in his paper[2].

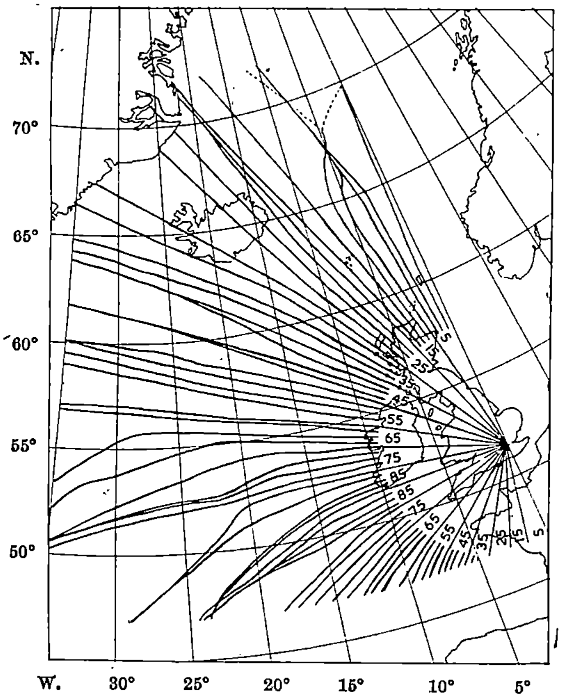

Fig. 2. Refraction diagram for microseisms of 9-sec. period

It is very easy to use these refraction diagrams. Instead of drawing a straight line from the recording station in the computed direction of arrival of microseisms and looking for the source along that line, the ray is followed along the refracted path.

The following are some of the points of interest:

(1) 9-sec. microseisms are refracted less than those of 6-sec. period.

(2) The various focusing and diverging effects are interesting. An example of the former was noticed during the hurricane of September 1957 ("Carrie"). When the storm was in the diverging area south of lat. 50° N. and west of long. 20° W., the intensity of microseisms recorded at Kew was not appreciable. But as soon as it came to the focusing point at lat. 50° N., long. 15° W., there was a sharp rise in intensity which decreased later as the storm crossed over the Irish coast.

(3) The rays represented by the dotted lines in the diagram are due to intersecting wave-fronts and are similar to the double refraction effect in optics.

Many of the anomalies observed by workers in various parts of the world in the measured intensity and direction of arrival of microseisms can, in all probability, be explained by constructing such refraction diagrams. The aid of the 'microseismic barrier' postulated from time to time to explain these anomalies can be reserved for a better use.

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Dec. 20.

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Total Sulphydryl Content of Embryos of Arsenic-resistant and -sensitive Strains of the Blue Tick, *Boophilus decoloratus*

The existence of arsenic resistance in the blue tick, *Boophilus decoloratus*, in certain regions of South Africa has been known for 16 years[1]. In a study of this phenomenon, the concentrations of sulphydryl-containing compounds in embryos of the sensitive and resistant strains of this tick have been determined.

The method used for determining —SH containing compounds is an adaptation of Mason's[2,3] method, which is based upon the reduction of ferricyanide ions by thiols to ferrocyanide ions which are then determined colorimetrically as ferric ferrocyanide. Deproteinized extracts of tick eggs at a stage midway between oviposition and hatching were used. Interference by other reducing compounds was eliminated by using a blank in which colour development due to —SH containing compounds was suppressed by addition of formaldehyde prior to addition of ferricyanide.

Fifteen pairs of determinations were carried out using embryos of sensitive and resistant strains of approximately equal age. The sulphydryl content, expressed as per cent —SH radical, of the sensitive strain varied from 120×10^{-5} to $1{,}050 \times 10^{-5}$ per cent (mean $482 \cdot 6 \times 10^{-5}$ per cent) while that of the resistant strain varied from 750×10^{-5} to $1{,}550 \times 10^{-5}$ per cent (mean $983 \cdot 3 \times 10^{-5}$ per cent). The mean difference between the resistant and sensitive members of the pairs was 500·7 in units of 10^{-5} per cent with a standard error of 68·5.

The resistant strain therefore contains slightly more than twice as much —SH radical as the sensitive strain.

Our thanks are due to Mr. D. C. Goch for statistical examination of the results and also to African Explosives and Chemical Industries, Ltd., for permission to publish this communication.

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Occurrence of Strains of the Nuclear Polyhedral Virus of the Wattle Bagworm

During the past three years, experiments have been in progress[1] to determine whether the wattle bagworm, *Kotochalia junodi* (Heyl.), could be controlled by artificially increasing the concentration of virus in plantations of black wattle, *Acacia mollissima* Willd., and whether epizootics could be initiated by introducing the virus. In all cases, a high rate of mortality due to polyhedrosis resulted. It was noted, however, that equal concentrations of virus from different localities did not give the same kill; virus suspensions prepared from material collected in plantations remote from those treated consistently gave a higher mortality than those prepared from bagworms from the area in which they were used (Table 1).

Table 1. Effect of Polyhedrosis using: (1) 'Introduced' Virus; (2) 'Local' Virus

(*a*) Mortality per cent five months after treatment

	Treated		Untreated	
	Mean	Range	Mean	Range
(1)	71·9	61·4–79·9	14·6	2·6–18·1
(2)	55·1	46·1–60·5	15·2	9·1–19·9

(*b*) No. of survivors seven months after treatment; only live specimens collected

	Mean No. of bagworms per sample tree	Range	Mean No. of bagworms per sample tree	Range
(1)	0·3	0–2 (18·8)*	27	7–45 (2·7)*
(2)	5·4	1–12 (10·0)*	7	6–9 (3·4)*

(*c*) No. of survivors eleven months after treatment; only mature specimens collected

(1)	0	0	11	3–23†
(2)	4	2–7†	6	5–8†

* Percentage of virus-infected specimens.

† The percentage of virus-infected imagines could not be determined, since mature males emerge approximately four weeks before the females become sexually mature. At the time of collection, only empty pupal cases indicated that mature males had emerged.

These results not only point to a degree of resistance of the bagworm to local virus, but also strongly suggest that there are different strains within the nuclear type of virus found in *K. junodi*.

Dr. K. M. Smith of the Molteno Institute, University of Cambridge, has commented (*in lit.*) upon the development of resistance to virus disease in *Pieris brassicae* L., but this appears to be somewhat different in origin.

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A Shorter Microbiological Assay Method for Oxytetracycline and Chlortetracycline

Some organic compounds having a known effect on the growth of bacteria were used for stimulating spore germination and growth intensity of *Bacillus subtilis FDA* 6633, with the view of shortening the length of incubation time when assaying oxytetracycline and chlortetracycline by the cup–plate technique.

The basal medium was made up as follows: agar–agar 45 gm., peptone 7·5 gm., broth 1,500 ml.; *p*H before sterilization 7·0–7·1.

After incubation for a week in a Blake flask the *B. subtilis* spores were washed with sterile, distilled water, heated for 30 min. at 65° C. and centrifuged three times, washing between each centrifugation. To determine the necessary amount (per cent) of spore suspension, its light absorption was measured. The suspension is suitable if its percentage absorption is 80–90 per cent using an orange glass parallel-sided filter with distilled water (Lange, Lichtelelektrisches Kolorimeter, Model IV). 2 ml. of this spore suspension is then diluted with a solution of selected growth factor (in this case, 98 ml. of 0·02 per cent solution of folic acid (pteroylglutamic acid)). 5·5 ml. of the diluted spore suspension is added to 100 ml. melted agar medium and thoroughly but gently stirred with a sterile glass rod. By this method only one layer, 3 mm. thick, was poured out.

The prepared plates were stored in a refrigerator at about + 4° C. for two days. If stored longer, the effect of the growth factor is lost. The working standards and the samples were diluted with phosphate buffer: *p*H 5·0 for oxytetracycline, and *p*H 4·5 for chlortetracycline (*p*H 5·0 buffer: 90·78 gm. potassium dihydrogen phosphate; *p*H 4·5 buffer: 27·20 gm. sodium dihydrogen phosphate, both diluted to 2,000 ml. with sterile distilled water).

After having dispensed the antibiotic in or on the plates, the latter are incubated at 43° C. for 3–4 hr. This incubation time is enough to produce firm bacterial growth, which is easily visible. Inhibition zones are clear, and zone edges are defined. A further advantage is that this microbiological method does not require a special assay procedure or a standard curve.

Of the compounds examined in various concentrations, DL-aspartic acid (0·0014–0·0002 per cent), folic acid (0·0020–0·00002 per cent), indoleacetic acid (0·0014–0·00002 per cent) and lactose (0·02 per cent) promoted spore germination and stimulated growth without disturbing the effect of the antibiotics on bacteria. The growth-stimulating effect of DL-aspartic acid in absence of caramelized glucose seems to be inconsistent with Hachisuka's report[1]. It is possible in this case that the caramelized sucrose components of agar–agar serve as substitute for glucose.

The possibility of employing growth factors to reduce the incubation time opens the way for similar short microbiological assay methods for antibiotics.

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[1] Hachisuka, Yoetsu, *et al.*, *J. Bact.*, **71**, 250 (1956).

Dissemination of *Verticillium albo-atrum* through the Atmosphere

IT is usually considered that spread of disease due to *Verticillium albo-atrum* is either by growth of the pathogen from diseased to healthy susceptible plants by root contact or by the dissemination of infected plant material such as leaves, root stocks, etc. However, the possibility, in some cases, of the disease being spread by airblown spores became apparent when Isaac[1] trapped colonies of *V. albo-atrum* on Petri-dish plates of Dox's agar exposed approximately 2 ft. above a stand of lucerne infected with this pathogen, and also when Davies (unpublished results) isolated *V. albo-atrum* from house dust from Edinburgh and from the atmosphere in a garden in urban London. It should be pointed out that in diseased lucerne plants, even when they are still alive and green, the fungus grows from the vascular tract in the lower basal regions of the stems out into the cortical tissue and from there superficial hyphæ bearing conidia develop ; and it has been shown by Isaac that these conidia will cause infection when placed upon recently cut surfaces of mown, healthy lucerne.

Since this disease is becoming of considerable economic importance, an investigation has been initiated to make quantitative estimates of the number of spores of *V. albo-atrum* in the air, within and above, both diseased and healthy lucerne crops and above meadow land at various sites, namely, Norfolk, Cambridge, Berkshire and Swansea. Efforts were also made to isolate the pathogen from the air near lorries unloading lucerne from an infected crop. The apparatus used to obtain these volumetric determinations was the slit sampler, described by Davies[2], the suction being provided by a hand-operated pump unit similar to that of Gregory[3] except that the pump was driven through gears. For each sample either 50 or 25 l. of air were impacted on to each of a series of plates of Dox's agar in 9-cm. Petri dishes, the intake orifice of the apparatus being 25–26 cm. above ground-level. The results are summarized in Table 1.

Table 1. NUMBER OF COLONIES OF *Verticillium albo-atrum* ISOLATED FROM THE AIR AT EACH SITE

Area	Sampling site	No. of colonies of *V. albo-atrum*	Total vol. (litres) of air sampled
Berkshire	In diseased lucerne crop	6	150
	In healthy lucerne crop	0	150
Cambridge	In mildly infected lucerne crop	1	150
	In healthy lucerne crop	0	150
	Near diseased lucerne straw being turned over	4	150
Norfolk	In diseased lucerne crop	12	150
	In open field 150 yd. down wind from disease crop being mown	12	200
	In "Green shed" of lucerne drying factory	3	50
	In "Green shed" as lorry tipped load of infected lucerne	30–40*	50
Swansea	In diseased lucerne crop	6	180
	In meadow	0	180

* Plate overcrowded with bacteria and yeasts

V. albo-atrum was never isolated alone but developed on plates in competition with the more ubiquitous constituents of the airborne fungal flora such as *Cladosporium*, *Pullularia*, *Penicillium*, *Phoma*, *Mycelia sterilia*, *Sporobolomyces*, yeasts, etc.

The results in Table 1 indicate that the number of spores of *V. albo-atrum* in and above infected stands of lucerne is sufficiently high to suggest that the spread of the disease in this crop may occur by means of wind-blown spores. Further investigations are proceeding along these lines.

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The Giant Rat of East Africa

SIX specimens of the giant rat, *Cricetomys gambianus* Waterhouse, one male and five females, were trapped at Amani, a forested area at about 3,000 ft. in the Usambara Mountains of Tanganyika. The rats were trapped in cage-type traps which had been baited with maize. They were killed with chloroform, after which their parasites were removed ; then the rodents were weighed and measured.

Measurements

	Male	Female
Body-weight	1,250 gm.	1,000–1,400 gm.
Head/body	350 mm.	335–380 mm.
Tail	400 ,,	340–400 ,,
Ear	40 ,,	40–45 ,,
Hind foot	75 ,,	70–75 ,,

Mammary formula : 2 – 2 = 8

The only ecto-parasite found on the six specimens of the giant rat was the dermapterous parasite

Hemimerus vosseleri Rehn and Rehn. No fleas, ticks or lice were found. The infestation with *H. vosseleri* varied from 4 to 13 per rat, and included nymphal and adult specimens. In all, 46 specimens of this strange earwig were obtained.

My thanks are due to the Director of Medical Services, Tanganyika, for permission to publish this communication, and to Dr. W. Hincks, of the Commonwealth Institute of Entomology, for his identification of the earwigs.

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Seed-coat Structure of Yellow Chinese Rape

Samples have been obtained of seed described as Chinese rape, imported into Europe for oil extraction. The seeds in these commercial samples are either yellow or vinaceous in colour, and the different coloured seeds are to be found in varying proportions. Plants grown from both types of seed corresponded with descriptions of *Brassica campestris chinoleifera* Viehoever[1]. It has not been possible to locate type specimens of the plant in Great Britain.

Comparatively few yellow kinds of cruciferous oil seeds are used commercially[2], and therefore a knowledge of the testa structure of this Chinese seed might well be useful in the analysis of seed samples and oil-cakes.

Fig. 1 is a drawing of a cross-section of the testa. The structure corresponds to that of the rapes rather than the mustards[2]. Consequently, the only other yellow cruciferous oil seed with which one might confuse the Chinese seed is *Brassica campestris* L. var. *Sarson* Prain.

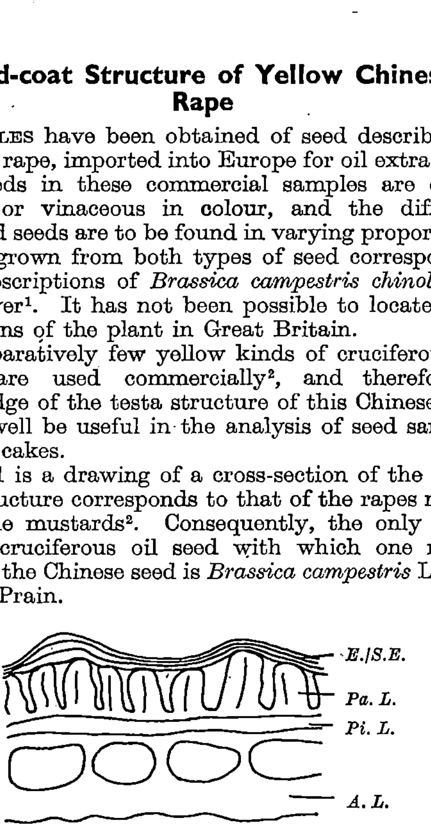

Fig. 1. Drawing of cross-section of testa of yellow Chinese rape (× 400). *E./S.E.*, disorganized epidermis and subepidermis; *Pa. L.*, palisade layer; *Pi. L.*, pigment layer; and *A. L.*, aleurone layer

The testa structure of both species has been compared; but it is extremely difficult to distinguish between the two species on this anatomical feature, although slight inequalities in height of the palisade cells of the Chinese seed present a faint reticulation in surface view. Reticulations are not normally shown by *Brassica campestris* L. var. *Sarson* Prain.

This difficulty of distinguishing between the two species need not present any great problem during the analysis of oil-cakes, because, compared with the mustards, both seeds are usually regarded as fairly mild for feeding purposes.

It is intended to publish the details of this investigation elsewhere. I am indebted to the Incorporated Oil Seed Association and Salamon and Seaber (consulting analytical chemists) for the supply of material and also the Central Research Fund of the University of London for the loan of certain apparatus used in this work.

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[1] Viehoever, A., Clavenger, F., and Ewing, C. O., *J. Agric. Res.*, **20**, 117 (1920).

[2] Winton, A. L., "The Microscopy of Vegetable Foods" (New York, 1916).

Nomenclature of Cell Strains

At the International Tissue Culture meeting, held in Glasgow during August 26–27, the subject of the nomenclature of cell-strains used in tissue culture was considered. After general discussion, a committee was appointed and recommendations were made. It was suggested that authors should give the following information when first mentioning a cell strain in the course of a publication. (1) Whether the tissue of origin was normal or neoplastic, and, if neoplastic, whether benign or malignant. (2) Whether the tissue was adult or embryonic. (3) Animal species of origin. (4) Organ of origin. (5) The cell-type (if known). (6) The designation of the strain. (7) Whether the strain has been cloned, and, if so, the clone number. (8) The reference to the original article in which the strain was described.

It was further suggested that the designation of the strain should consist of a series of not more than four letters indicating the laboratory of origin, followed by a series of numbers indicating the strain, for example, *NCL* 123. Thus, a strain might be described: normal adult rat heart fibroblast, strain *XYZ* 111, clone 29 (Lobachevsky, Z. (1922), *J. Metaphys. Cytol.*, **99**, 77). Afterwards, in the same communication it would suffice to refer to the strain by its strain designation.

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Histological and Chemical Changes in the Rat Pituitary Neural Lobe following Treatment with Neurohypophysial Substances

No agreement exists as to the effect of administration of exogenous posterior pituitary principles on neurohypophysial structures. Some authors[1] describe no changes in neurosecretory phenomena, others[2] think the dosage important, whereas increase in neurosecretion has been reported by me[3]. One of the difficulties in evaluating and comparing alterations in material stained with chrome-alum hæmatoxylin is the lack of adequate histological assaying methods. When the amount of chrome-alum hæmatoxylin-positive material has not increased considerably following hormone treatment, it is difficult to be reasonably certain of the effect. In addition, not all such material necessarily represents posterior pituitary hormone or 'true' neurosecretory material[3,4].

For these reasons, in the present series of experiments an attempt was made to correlate the histological alterations of the neurohypophysis with changes in chemical composition of the infundibular process, assuming the latter to be a storage place for posterior pituitary principles.

Adult rats of both sexes, body-weight 150–200 gm., were given daily intraperitoneal injections in nine groups of five animals for each experiment, for six consecutive days, using 'Pituitrin' (0·5 U.; 2·0 U.; 2·5 U.), 'Pitocin' (0·5 U.; 1·0 U.; 2·5 U.) or 'Pitressin' (0·5 U.; 2·0 U.; 2·5 U.). The animals were killed on the sixth day 2 hr. after the last injection, and the brain and pituitary gland examined histologically in the usual manner[3]. Sections of control and experimental animals were processed together. It was found that a slight but definite increase in chrome-alum hæmatoxylin-positive material had occurred in the hypothalamic magno-cellular nuclei of all treated groups, independent of the dosage. The infundibular process stained very darkly in all groups, probably more than in normals.

In another series, paper chromatograms (hydrolysis in 25 per cent hydrochloric acid at 110° C. for 18 hr., Schleicher and Schüll paper 2043*b*, butanol/acetic acid, ninhydrin) were made of homogenates of the infundibular process of rats treated similarly ('Pituitrin' 2·5 U.; 'Pitocin' 2·5 U.; 'Pitressin' 2·5 U.). These were compared with chromatograms of neurohypophysis of normal and dehydrated (5 days thirst) animals, brain tissue, and the pituitary principles injected. By standardizing the procedures and running aliquots in doubles in different batches, quantitative as well as qualitative changes could be roughly ascertained. In all groups treated with posterior pituitary principles a marked increase in amino-acid content could be shown, cystine being especially prominent. In the group treated with 'Pitressin' a definite increase in lysine and phenylalanine was observed. From the size and colour intensity of the spots the following quantitative estimates were made: normal, 100; 'Pituitrin'-treated, 145; 'Pitressin'-treated, 185; 'Pitocin'-treated, 160; dehydrated, 75.

It would appear, then, from these results that following treatment with various dosages of neurohypophysial principles there is a definite increase in chrome-alum hæmatoxylin-positive material and amount of posterior pituitary hormones in the rat neurohypophysis. It is not clear whether this increase is due to increased production or decreased release of endogenous neurohypophysial substances, or storage of exogenous material.

J. DE GROOT

Anatomical Department,
State University, Utrecht.
Aug. 18.

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[1] Green, J. D., and Van Breemen, V. L., *Amer. J. Anat.*, 197, 177 (1955).

[2] Legait, H., *C.R. Soc. Biol., Paris*, 149, 1016 (1955).

[3] Groot, J. de, *Anat. Rec.*, 127, 201 (1957).

[4] Adams, C. W. M., and Sloper, J. C., *J. Endocrinol.*, 13, 221 (1956).

Cryptocotyle lingua in British Mink

THE development of the intermediate stages of heterophyid trematodes of the genus *Cryptocotyle* commences in sea snails and continues in various species of coastal fish. The definitive hosts are birds and mammals which eat infected fish. These flukes have been recorded from various hosts in Britain. Thus Lewis[1] found *C. lingua* in the herring gull, *Larus argentatus*, and *C. concava* in the black-necked grebe, *Podiceps nigricollis*, both in the Aberystwyth area, while Mahfouz A. M. Fahmy, whose unpublished observation is quoted by Lapage[2], found *C. lingua* in an otter, *Lutra lutra*, in the suburbs of Edinburgh in 1953. *Cryptocotyle* spp., chiefly *C. lingua*, have been recorded in mink, *Lutreola vison*, by various authors on the continent of Europe[3] and in North America[4].

Since British farm mink are largely fed on raw sea-fish, a particular search was made during routine post-mortem examinations for alimentary parasites in general and fish-borne trematodes in particular.

Of 37 mink so far examined, one was found to have four specimens of *C. lingua* in the small intestine. Characteristic eggs were found in the rectal fæces.

Small numbers of eggs 50µ × 23µ and 30µ × 18µ were found in the intestinal contents of another mink. These were attributed to *C. lingua* and *C. concava* respectively; but no recognizable parasites were found in the intestine, possibly due to post-mortem disintegration. So far as can be ascertained, this is the first report of *C. lingua* in mink in Britain.

I am indebted to my colleague Mr. K. W. Head, of the Department of Pathology, for the opportunity to carry out these examinations.

H. SCOTT McTAGGART

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Edinburgh 9.
Dec. 5.

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[1] Lewis, E. A., *J. Helminth.*, 4, 7 (1926).

[2] Lapage, G., "Veterinary Parasitology", 256 (Oliver and Boyd, Edinburgh, 1956).

[3] Sprehn, C., *Dtsch. tierärztl. Wschr.*, 63, 342 (1956).

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Multiple-Mutation Theory of Carcinogenesis

NEW life was given to the somatic mutation theory of carcinogenesis when it was recognized that not just one, but several mutations were probably required. Fisher and Hollomon[1] thought that a number of similar mutations in adjacent cells might initiate cancer, and deduced a law of the form (age)$^{p-1}$ for the rate of appearance of cancers in a population, with p being the number of cells in the critical size group. They arrived at a value of p near 7 from the mortality data. Muller[2] and Nordling[3] thought that a number of successive mutations in the same cell might initiate cancer, and deduced a law of the same form, (age)$^{p-1}$, for the rate of appearance of cancers, with $p \approx 7$ now being the number of mutations required in a single cell.

Nordling[4] recognized that mutation would, in general, tend to render cells less able or more able to survive than their normal neighbours, and that for once-mutated cells to be preserved for subsequent mutations they must be more, rather than less, able to survive. Platt[5] made this point clearer by emphasizing that each somatic mutation that survives must lead to a clone of mutated cells growing at the expense of their normal neighbours. Armitage and Doll[6] recognized that the growth of the clone generated by the first mutation was important in increasing the number of cells in which the second could occur, and showed that the mortality data could fit fairly well with a two-mutation theory if an exponential rate of clone growth was assumed.

Based upon these multiple-mutation ideas, the most realistic theory now would seem to require the following sequence of events: (1) mutation; (2) clone growth from the mutated cell; (3) another mutation somewhere in the clone; (4) growth of a new clone from the cell with the second mutation; (5) a third mutation in the second clone and so on until a cancer clone is the result. The first three steps of the above sequence are essentially the two-stage theory of Armitage and Doll[6], if it is assumed that the growth-rate of the first clone is exponential. However, I believe there is a more reasonable growth-rate than the exponential, which leads to an improved agreement between theory and experience.

Free cells, such as bacteria, are observed to grow exponentially in number, as long as the conditions for growth are maintained. They do so because they divide again and again at a constant rate, each generation doubling the number of cells present. The cells in the germinal layer of adult mammalian epithelium, on the other hand, stay essentially constant in number in spite of a finite mitotic rate. After mitosis, half the daughter cells leave the germinal layer and move outward, maturing and finally dying. The maturing cells no longer divide, so that a constant number of reproducing cells is maintained in the germinal layer whatever the mitotic rate. Consider now a clone of mutated cells in epithelial tissue. If the clone be non-malignant, the advantage of the mutated cells over their normal neighbours is likely to be small, and the germinal layer of the clone should expand laterally at some slow rate. Since the environment at the perimeter of the clone is in an essentially steady state—a sheet of mutated cells in edgewise contact with a sheet of normal cells—the rate of spreading of the clone should remain approximately constant. (Only when the clone consists of half a dozen cells or fewer should the lateral growth-rate differ from its final constant value, for only then is the perimeter of the clone appreciably curved on the scale of cellular dimensions.) The mitotic rate in the interior of a clone should not affect its rate of spreading at all, for the reasons already discussed for normal epithelium.

If the radius of a clone increases at a steady rate, say $r = \alpha(t - \tau)$, where r is the clone radius, t is the time, τ is the time at which the clone started growing, and α is a constant, then the area of the clone will be $a = \pi r^2 = \pi\alpha^2(t - \tau)^2$. The number of cells in the clone will be proportional to its area, hence

$$\text{number of cells} = \beta(t - \tau)^2 \qquad (1)$$

where β is a constant, t is time, and τ is the time of clone initiation. A law of this sort for the growth of non-malignant mutant epithelial clones seems more reasonable than the exponential, which should correspond more nearly to malignancy.

The consequences of a power law of the form $\beta(t - \tau)^2$ for the number of cells in a clone are very interesting and suggestive. Assume first the simplest possibility, namely, that all mutation-rates and clone growth-rates are constant. Then the rate of appearance of cancers in a population should be proportional to a power of the time,

$$\text{Cancer-rate} \sim (\text{age})^{3(n-1)} \qquad (2)$$

where n is the number of mutations required. Consider $n = 1, 2, 3$ successively in detail. For $n = 1$, equation (2) indicates that the rate is a constant, as it should be if the first mutation were to produce cancer. Cancers of this type, appearing at an early age in many members of the population, would be strongly selected against genetically, and should largely have been eliminated through the evolutionary process. However, carcinogenic materials that were not often found in the environment of our ancestors might be able to produce single-mutation cancers.

For $n = 2$, the number of clones produced by the first mutation is proportional to (age) and the average number of cells in each to $(\text{age})^2$. The aggregate number of cells where the second mutation can occur is then proportional to $(\text{age})^3$. If the second mutation leads to cancer, the cancer initiation-rate will be proportional to $(\text{age})^3$ as the formula $(\text{age})^{3(n-1)}$ indicates. That this expression is correct can be seen by direct computation of the number of cells in the various clones at time t. Let R be the mutation-rate per individual, so that his number of mutant clones is Rt. Then in the time interval τ to $\tau + d\tau$ the number of clones formed is $R\,d\tau$. Each of them at subsequent time t contains $\beta(t - \tau)^2$ cells. Adding, the total number of cells is

$$n = \int_{\tau=0}^{t} \beta(t - \tau)^2 R\,d\tau = R\beta t^3/3$$

For $n = 3$, another factor of $(\text{age})^3$ is introduced, giving finally $(\text{age})^{3(n-1)} = (\text{age})^6$ for the rate of appearance of a three-mutation cancer.

The large number of human epithelial cancers with incidence-rates observed to be proportional to $(\text{age})^6$ suggests strongly that three mutations are required for the initiation of most human carcinoma.

Suppose now that the question of chemical or radiation carcinogenesis is raised. Again assume the simplest conditions: uniform exposure to a carcinogenic agent that produces all the required mutations, and uniform growth-rate of clones. Then the rate of appearance of cancer is proportional to a power of the dose-rate as well as to a power of the time,

$$\text{Cancer-rate} \sim (\text{dose-rate})^n(\text{age})^{3(n-1)} \qquad (3)$$

The dose-rate appears only to the power n because it affects only the n required mutations and not the $(n - 1)$ clone growth-rates. If the carcinogen were to cause only m of the mutations, with $m < n$, then the cancer initiation-rate would be

$$\text{Cancer-rate} \sim (\text{dose-rate})^m(\text{age})^{3(n-1)} \qquad (4)$$

and would be directly proportional to the concentration of carcinogen should $m = 1$.

When the dose of carcinogen varies with time, it is easy to see that many different time-dependences can be obtained for the rate of incidence of cancer. Similarly, if the growth-rates of clones were to depend upon the hormone balance of the organism and to change with time, as suggested by Armitage and Doll[6], still other time-dependences could be obtained.

Multiple-mutation theories of carcinogenesis will have to stand or fall through the degree of their agreement with observations of the progress of the disease in afflicted organisms, and with the increases in the cancer-rate produced by age, carcinogenic materials, and radiation. Semi-quantitatively, at least, the model here proposed appears to be in agreement with such observations.

J. C. Fisher

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Nov. 1.

[1] Fisher, J. C., and Hollomon, J. H., *Cancer*, 4, 916 (1951).
[2] Muller, H. J., *Sci. in Prog.* 7, 130 (1951).
[3] Nordling, C. O., *Nord. Med.*, 47, 817 (1952).
[4] Nordling, C. O., *Brit. J. Cancer*, 7, 68 (1953).
[5] Platt, R., *Lancet*, i, 867 (1955).
[6] Armitage, P., and Doll, R., *Brit. J. Cancer*, 11, 161 (1957).

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, March 3

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 4.30 p.m.—Annual General Meeting. 5.30 p.m.—Mr. F. Greenaway: "The Phlogiston Theory and Collingwood's Philosophy of History".

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. C. E. Tharratt: "The Saunders-Roe Pulse Jet Engine".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. J. A. Wheeler (Princeton University): "Physics as Geometry—the Present Status of Einstein's Programme".* (Further lectures on March 5 and 10.)

UNIVERSITY OF LONDON (at the Westminster Hospital Medical School, Horseferry Road, London, S.W.1), at 5.30 p.m.—Dr. Otto Westphal (University of Freiburg): "Bacterial Endotoxins (Lipopolysaccharides)—Chemical and Immunological Aspects".*

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. T. R. Puzey: "The Application of Nuclear Energy to Power Production".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at Battersea Grammar School, Abbotswood Road, Streatham, London, S.W.16), at 6.30 p.m.—Dr. H. J. Barber, Dr. I. L. Jones, Dr. J. H. Pryor, Dr. J. A. Read, Dr. C. W. Herd and Dr. K. G. A. Pankhurst: "Careers in Chemistry".

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Sir Frederic Bartlett, F.R.S.: "Applications of Psychology".

AMBASSADE DE FRANCE, BUREAU SCIENTIFIQUE (at the French Institute, 15 Queensberry Place, London, S.W.7), at 8.30 p.m.—Monsieur l'Inspecteur Général G. Laclavère: "Contribution Française à l'Année Géophysique Internationale".

Tuesday, March 4

INSTITUTION OF CHEMICAL ENGINEERS (at the Hoare Memorial Hall, Church House, Westminster, London, S.W.1), at 9.30 a.m.—Spring Meeting.

AMBASSADE DE FRANCE, BUREAU SCIENTIFIQUE (in the Chemistry Theatre, Royal College of Science, London, S.W.7), at 1.30 p.m.—Monsieur l'Inspecteur Général G. Laclavère: "Oil in the Sahara".

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 5 p.m.—Mr. E. L. Bubb and Mr. K. R. Wilderspin: "The Use of Rectangular Loop Magnetic Material in Electronic Switching Circuits".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. E. Bünning (University of Tübingen): "Endogenous Diurnal Periodicity in Plants and Animals".* (Further lectures on March 5 and 7.)

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, London, W.C.2), at 6 p.m.—Discussion on "Some Impressions of Technical and Industrial Training in the United States", opened by Dr. K. R. Sturley.

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "Mathematics in Mechanical Engineering".

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "The Future of the Railways". Chairman: Major-General G. N. Russell. Speakers: Monsieur l'Ingénieur Principal P. Weil and Mr. H. P. Barker.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE (in the College Conference Hall, Keele, Staffordshire), at 8.30 p.m.—Prof. M. Polanyi, F.R.S.: "Understanding Ourselves". (First of three Lindsay Memorial Lectures on "The Sciences of Man". Further lectures on March 6 and 10.)

Wednesday, March 5

ASLIB (at the Connaught Rooms, Great Queen Street, London, W.C.2), at 10 a.m.—Conference on "Scientific and Technical Translation".

NATIONAL INSTITUTE OF OCEANOGRAPHY (at Wormley, Godalming, Surrey), at 2.30 p.m.—Dr. G. Laclavère: "The French Contribution to the International Geophysical Year".

PHYSICAL SOCIETY COLOUR GROUP (at the Institute of Ophthalmology. Judd Street, London, W.C.1), at 3.30 p.m.—Cdr. Dean Farnsworth (U.S. Naval Research): "How the World Looks to a Color Blind".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. D. A. Robson: "The Geological Structure of the Wadi el Dirba Area of Sinai"; Dr. Frances E. S. Alexander: "Observations on Tropical Weathering—a Study of the Movement of Iron, Aluminium and Silicon in Weathering Rocks at Singapore".

INSTITUTE OF PHYSICS, EDUCATION GROUP (at 47 Belgrave Square, London, S.W.1). at 5.15 p.m.—Annual General Meeting. 6 p.m.—Dr. Martin Johnson: "The Spinning Galaxy—a History in Co-operation between Sciences".

AMBASSADE DE FRANCE, BUREAU SCIENTIFIQUE (at the Institute of Transport, 80 Portland Place, London, W.1), at 5.30 p.m.—Monsieur l'Ingénieur Principal P. Weil: "The Latest Developments and Future Prospects of the S.N.C.F.".

UNIVERSITY OF LONDON (at the Westminster Hospital Medical School, Horseferry Road, London, S.W.1), at 5.30 p.m.—Dr. Otto Westphal (University of Freiburg): "Bacterial Endotoxins—Biological Activities and Investigations on their Mode of Action".*

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (at 14 Belgrave Square. London, S.W.1), at 6.15 p.m.—Dr. D. Dickinson: "Relationship of Chemical Composition to Quality in Fruit and Vegetables for Canning"; Mr. L. P. Burroughs: "The Free Amino Acids of Certain Fruits".

Thursday, March 6

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. J. H. Callomon: "Electronic Emission Spectra of the Carbon Disulphide Ion, CS_2^+"; Mr. N. K. Bridge and Mr. G. Porter: "Primary Photoprocesses in Quinones and Dyes".

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. F. Busemann and Mr. W. Casson: "Results of Full-Scale Stability Tests on the British 132 kV. Grid System"; Dr. F. H. Last, Mr. E. Mills and Mr. N. D. Norris: "The Organization for Large-Scale Grid System Tests".

INSTITUTE OF REFRIGERATION (at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, Westminster, London, S.W.1), at 5.30 p.m.—Monsieur P. Vidal: "Modern Trends in Cold Store Design and Operation in France".

INSTITUTION OF MECHANICAL ENGINEERS, EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "How Should Liberal Studies be dealt with in Technical Colleges?"

INSTITUTE OF METALS, LONDON LOCAL SECTION (at 17 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. B. E. Hopkins: "High Purity Iron".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. W. R. Hawthorne, F.R.S.: "Aero-Thermodynamics".

Thursday, March 6—Friday, March 7

NATIONAL ASSOCIATION FOR MENTAL HEALTH (at the Assembly Hall, Church House, Westminster, London, S.W.1), at 10 a.m. daily—Annual Conference—"The Report of the Royal Commission on the Law Relating to Mental Illness and Mental Deficiency: Implications for Local Authorities and the General Public".

Friday, March 7

ASSOCIATION OF APPLIED BIOLOGISTS (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, London, S.W.7), at 10.50 a.m.—Symposium on "Frit Fly".

SOCIETY OF DYERS AND COLOURISTS, LONDON SECTION (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Dr. R. Wittwer: "Recent Developments in the Dyeing of Manmade Fibres".

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Mining Institute, Newcastle-upon-Tyne), at 6.15 p.m.—Mr. A. M. Laird, Prof. A. W. Scott and Prof. A. S. T. Thomson: "Experimental Investigations on Natural Circulation in Water-tube-boilers".

Saturday, March 8

BRITISH MYCOLOGICAL SOCIETY (in the Lecture Theatre, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 11 a.m.—Meeting on "Some Mechanisms of Variation in Fungi".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PHYSICIST, Senior grade (with an honours degree in physics, preferably in the field of radiotherapy), for duties in the Radiotherapy Department—The Personnel Officer, St. Thomas's Hospital, London, S.E.1 (March 8).

LECTURER (preferably with an interest in marine zoology) IN ZOOLOGY at the University College of Ghana—The Secretary Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 13).

PHYSICAL CHEMISTS (with an honours degree, or equivalent, and experience in corrosion or a related field) at the Research Laboratories, Leatherhead, Surrey, for work on corrosion problems arising in nuclear and conventional power stations—The Personnel Officer, Central Electricity Generating Board, 24/30 Holborn, London, W.C.1, quoting Ref. N/53 (March 14).

LECTURER in PHYSICS—The Secretary, St. Mary's Hospital Medical School (University of London), Paddington, London, W.2 (March 15).

RESEARCH ASSISTANT IN PHYSIOLOGICAL ELECTRONICS—The Secretary of University Court, The University, Glasgow (March 15).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN CHEMISTRY OR PHYSICS—The Secretary, The University, Exeter (March 24).

LECTURER or ASSISTANT LECTURER IN PLANT PHYSIOLOGY (with special reference to metabolism and plant biochemistry)—The Secretary and Registrar, The University, Southampton (March 24).

LECTURER or ASSISTANT LECTURER (preferably with qualifications in mathematical analysis) IN MATHEMATICS at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 28).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN CHEMISTRY, ENGINEERING and PHYSICS—The Secretary and Registrar, The University, Southampton (March 29).

Imperial Chemical Industries Research Fellows in Chemistry, Physiological Chemistry, Agricultural Chemistry, Agricultural Botany, Microbiology, Geology and Physics or related subjects—The Registrar (Room 22, O.R.B.), The University, Reading (March 31).

Lecturer (Engineer, Physicist or Applied Mathematician) in Civil or Mechanical Engineering—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (March 31).

Lecturer or Assistant Lecturer in Inorganic and Structural Chemistry—The Registrar, The University, Leeds 2 (March 31).

Lecturer (preferably with an interest in the mechanism of organic reactions) in Chemistry (Organic)—The Secretary, The University, Aberdeen (March 31).

Research Fellow (Zoologist, with interests in marine biology)—The Registrar, University College, Singleton Park, Swansea (March 31).

Reader in Soil Science—The Secretary, The University, Aberdeen (April 7).

Research Fellow in Natural Sciences or Engineering—The Secretary, Fellowships Committee, Trinity Hall, Cambridge (April 12).

University Students and Fellows, for experimental or theoretical research in nuclear and elementary particle physics—The Professor of Natural Philosophy, The University, Glasgow (April 12).

Chair of Geography—The Registrar, The University, Birmingham 15 (April 18).

Esso Student in Chemical Engineering—The Registrar, Imperial College, London, S.W.7 (April 25).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Chemotherapy, Engineering, Metallurgy, Pharmacology and Physics—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

Lecturer (with an honours degree in mathematics and experience in numerical methods and programming high-speed digital computers) in Computing in the Department of Mathematics—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks (April 30).

Senior Lecturer in Bacteriology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

Turner and Newall Research Fellow in Engineering, Inorganic Chemistry or Physics—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

Lecturer in Fuel Technology and Chemical Engineering—The Registrar, The University, Sheffield (May 1).

Esso Student in Chemical Engineering—The Registrar, University College, Gower Street, London, W.C.1 (May 16).

Assistant Professor in the Department of Physics—University of New Brunswick, Fredericton, N.B., Canada.

Director (preferably physicist, with experience of research in fibre technology at a textile research institute in the U.K.) of Jute Research (Technology) at the Jute Research Institute, near Dacca, East Pakistan—The Ministry of Labour and National Service (E.9), Almack House, King Street, London, S.W.1, quoting A.12/PAK/163/TCS.

Lecturer or Assistant Professor in Chemistry—Department of Chemistry, United College, Winnipeg, Manitoba, Canada.

Mathematicians and Physicists (honours graduates in mathematics or physics) at the A.E.R.E. Harwell and the A.E.E. Winfrith (Dorset), for work in theoretical reactor physics, neutron transport theory and numerical analysis—Group Recruitment Officer (1029Y/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Metallurgist (British of British parents, an honours degree in metallurgy or A.I.Met. or equivalent, and industrial experience in ferrous and non-ferrous metallurgy) at the Ministry of Supply Royal Ordnance Factory, Birtley, for research and development work in connexion with new ammunition manufacturing processes involving hot- and cold-drawing and extrusion of ferrous and non-ferrous materials—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. F.138/8A (March 21).

Professor/Assistant Professor in Physical Chemistry; a Professor/Assistant Professor in Inorganic and General Chemistry; and an Assistant Professor/Lecturer in Biochemistry—The Dean, College of Arts and Sciences, The University, Baghdad, Iraq.

Senior Lecturer in Animal Husbandry, Lecturer in Agriculture (Pedology and Soil Science), Lecturer in Agriculture (Animal Nutrition), Lecturer in Agricultural Chemistry, and a Lecturer in Animal Husbandry at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Senior Technician (preferably with experience of histology and other biological techniques) in the Anatomy Department, for research and classwork—The Secretary, University College, Gower Street, London, W.C.1, quoting 'Anatomy/7'.

Technician (preferably with some experience in electronics) in the Nuclear Engineering Laboratory, to assist in work on an electronic reactor simulator and other similar projects—The Registrar (NPT), Queen Mary College (University of London), Mile End Road, London, E.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Planning, Vol. 23, No. 417 (16 December, 1957): The Growth of Government. Pp. 229+252. (London: Political and Economic Planning, 1957.) 2*s.* 6*d.* [1612

Gas for Scotland. Pp. 24. (Edinburgh: The Scottish Gas Board, 1957.) [1612

Manchester Public Libraries. The 105th Annual Report of the Libraries Committee, 1956–1957. Pp. 27. (Manchester: Manchester Public Libraries, 1957.) [1612

Personnel Management in the Small Firms. By J. M. Collingridge and M. Ritchie. Pp. 55. (London: Institute of Personnel Management, 1957.) 4*s.* 6*d.* [1612

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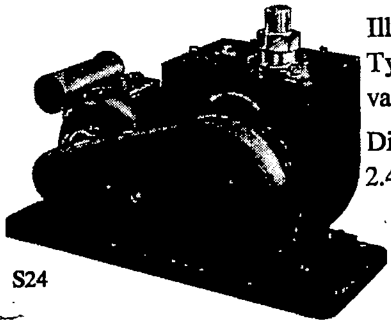
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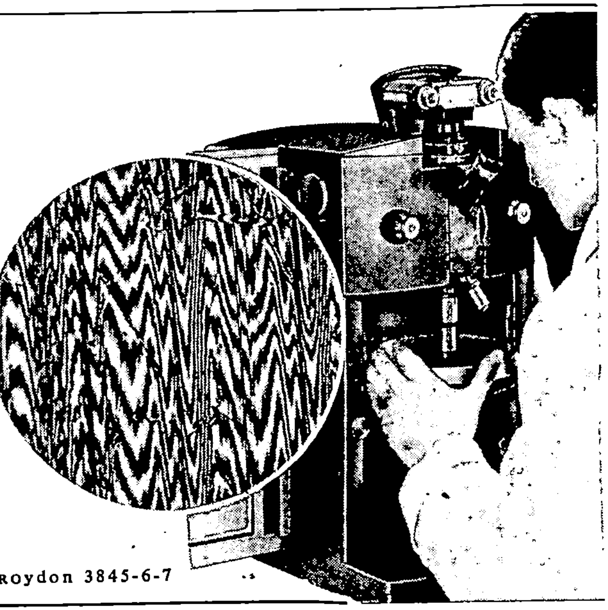

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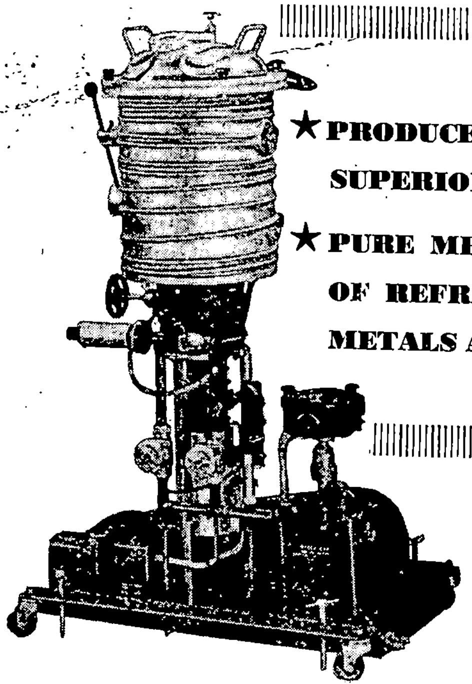

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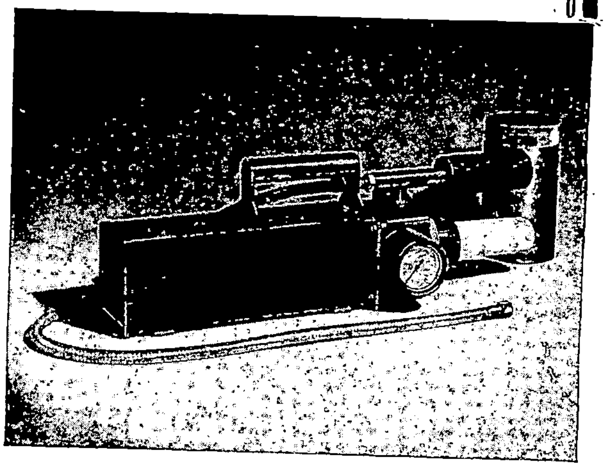

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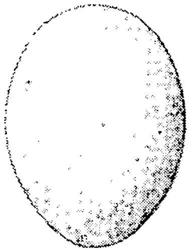

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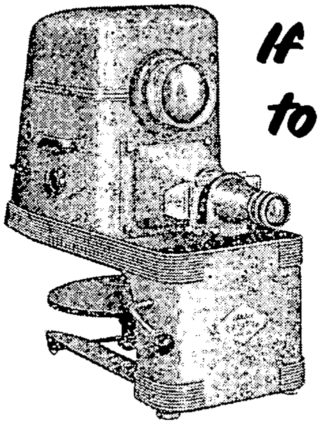

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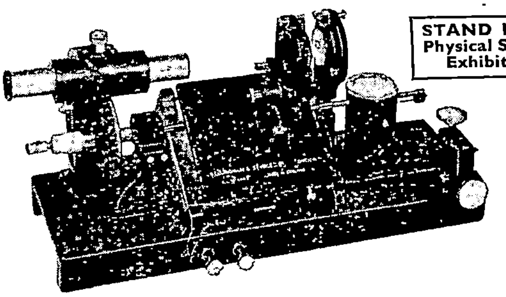

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CO-OPERATION IN RESEARCH AND DEVELOPMENT

THE impracticability of national self-sufficiency in defence had been increasingly recognized in Anglo-American relations, even before the Declaration of last autumn gave full expression to the common agreement that Britain and the United States can no longer afford to waste resources in skill and money but must make joint efforts fully co-operative. That much was recognized by the Howitt Committee, reporting in 1956, as a decisive reason for its reluctant recommendation that the Government should have permanent but limited powers to acquire the use of technical information in contracts for the supply of material for defence purposes. The resources of materials and of man-power in Britain are quite inadequate for us to hope to carry out in Government departments all the research that is desirable for defence purposes, and the real question behind the discussion on the Defence Contracts Bill is how far it will promote or hinder the free circulation of technical and scientific information.

That is only one aspect of defence research, on which some 10 per cent of the defence vote is spent. An even more vital one for Britain is raised in the Fifth Special Report from the Select Committee on Estimates for the Session 1956–57*. The greater part of this document consists of the observations of the Admiralty upon the seventh report of the Select Committee on Estimates for the session 1955–56 on naval research and development ; but it also contains some comments from the Minister of Supply and the Minister of Defence on other recommendations of the Committee, in its second report of the session 1955–56, which are no less pertinent to the whole question of the scale and organization of defence research.

In its seventh report for the session 1955–56, the Committee recommended an immediate examination of the possibility of merging naval and research development establishments with those working for other Government departments, including the Council for Scientific and Industrial Research, wherever this merger is practicable. The final decision on which establishments are to be merged should rest, the Committee suggests, with the Ministry of Defence. The Admiralty has during the past ten years or more been under fairly strong criticism for its reluctance to co-operate fully in research, and it now explains that it is already planning the merger of several of its own research and development establishments. A large measure of integration of the Services' research and development programmes, and of co-ordination between those activities and those of non-Service research and development establishments already exists, and in particular, where appropriate, one Department assumes responsibility for the conduct of all research in certain fields.

The present report of the Select Committee announces that in the light of the Committee's earlier recommendation and of changes in the defence programme, the Ministry of Defence has agreed to undertake a review of all research and development facilities. This may prove to be a step forward, though it may carry us no further than the review of expenditure on research and development generally, which was made ten years ago by the Select Committee on Estimates. What is needed is a review not of research facilities and plants but of defence research as a whole, and its balance with the national research effort as a whole. Only, for example, in such a context is it possible to judge how far our effort in nuclear research is adequate and justifiable in relation to the rest of the research effort demanded of the strictly limited resources—in man-power, institutions and materials—that are available in Britain ; and whether it is reasonable to employ some 20,000 qualified scientists and engineers in the Government services.

In this connexion, it is important to remember that, as Sir John Cockcroft recently remarked in Amsterdam, research equipment is now becoming so expensive that some must be considered not national but even international ventures if national economy is not to be distorted and a really efficient return secured on the investment. Under such conditions, it may become essential to consider the abandonment of whole projects, possibly in agreement with other countries. The fatal way could well be that beloved of the politician, of paring 10 per cent here and there in the hope of achieving a useful economy in the aggregate.

Before considering the further implications of this proposal to review defence research and development facilities, it is as well to note the comments on other recommendations of the Select Committee. The Admiralty has agreed to amend the heading in the Navy Estimates, "Research work by other Government Departments on Admiralty behalf", to read, in the 1957–58 Estimates, "Stores and equipment supplied to, and research done for, Admiralty research departments by other Government departments, etc.", and a note is to be added to make it clear that the Subhead 0 does not include all naval expenditure on research and development. The recommendation that for proposals for new works, services and equipment, research and development establishments should be treated as a single headquarters service, and also the recommendations for extending to research and development the policy of amalgamating establishments with powers to make their proposals direct to the Admiralty, has been accepted ; but the Admiralty does not regard it as desirable or practicable to allow each of thirty research establishments a separate fund with discretion to spend up to £300 on individual items, though it has been decided to set aside each year a small central reserve fund to be administered by the Director of Research Programmes and Planning on which superintendents of research establishments can indent.

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* Fifth Special Report from the Select Committee on Estimates, Session 1956–57. Pp. 25. (House of Commons Paper No. 307.) (London: H.M. Stationery Office, 1957.) 1s. 3d. net.

The Admiralty questions whether the recommendation that research and development establishments should be made responsible to a single organization in the Admiralty for purposes of their programme of research, staffing and progress gives sufficient weight to the position of the Deputy Controller (Research and Development), who as scientific adviser to the Board of Admiralty and as deputy to the Controller is responsible for supervizing and co-ordinating the research and development programmes. Accordingly, the Admiralty suggests that no great advantage is likely to result from placing such establishments under the direction of the heads of the purely scientific departments in the same way as the basic research establishments already do. It is pointed out that the Committee's proposals would separate the responsibility for research and development from that for the final design and production, and that the Admiralty would prefer to reserve final judgment pending the report of the Admiralty Committee, under the chairmanship of Sir Barclay Nihill, which is at present reviewing Admiralty organization in the material field.

In the discussion of this recommendation, there is no reference to the Defence Research Policy Committee or the position of the Deputy Controller in relation to that Committee, of which he is a member. This omission also bears on two other recommendations which the Admiralty has, in principle, accepted: that if it is decided in future to open a new research and development establishment, particular care should be taken to site it in an area where it will not recruit in competition with existing research and development establishments, and that an early choice should be made between finding more suitable premises for the Royal Naval Physiological Laboratory and arranging for such work as is necessary to be done elsewhere. Indeed, it already appears that if the most effective use is to be made of existing research institutions and available scientific and technical man-power, a good deal of close co-operation between the Defence Research Policy Committee and the Advisory Council for Scientific Policy is necessary.

Three other recommendations of the Select Committee are rejected by the Admiralty. The Admiralty considers that the present system affords full opportunities for advancement consistent with the maintenance of proper standards, and accordingly does not propose to evolve a system of promotion from the 'assistant (scientific)' grade to the 'experimental officer' grade and from the latter to the 'scientific officer' grade, which already draws 8 per cent of its officers from the experimental officer grade while the latter draws 17 per cent from the scientific assistants. The Admiralty also maintains that its present procedure does obtain the most favourable possible research and development contracts with industry, nor does it accept the recommendation that the views of the Director of Navy Contracts should be sought at an earlier stage in the formulation of the research and development programme. His essential contribution is to ensure that the work is carried out with maximum value to the Admiralty; to consult him in the planning stage and in the decision which projects should be put out to industry and which should be carried out by the Admiralty research and development establishments, it is suggested, would not in general be of assistance.

The Select Committee on Estimates in its second report, 1955–56, recommended review of the system of control to ensure that research projects (on military aircraft) are not continued after they have outlived their usefulness. The Minister of Supply and Minister of Defence now claim that the Director-General of Scientific Research (Air) and the Finance Branch keep all research projects under continuous review, while the Research and Development Board of the Ministry of Supply considers the list of projects periodically, and the Aircraft Research and Development Programmes Committee, of which the Controller of Aircraft is chairman and which includes representatives of the Naval and Air Staffs, does so annually. These arrangements, it is believed, should ensure that no project is continued after it ceases to be worth while, and it is pointed out that while the primary purpose of a research aircraft is usually to explore new fields of aerodynamics, when this has been done, the use of such aircraft for the flight testing of engines and equipment required for later operational aircraft of comparable characteristics usually offers economy in both time and money.

A review of the effectiveness of the control by the Minister of Defence of projects was also recommended by the Committee. This control of the research and development programme is exercised in the main through the Defence Research Policy Committee, which has a strong scientific element in its composition, including the Secretary of the Department of Scientific and Industrial Research. The Committee is served by a small full-time scientific and military staff which conducts a preparatory examination of all projects, dealing with minor projects on behalf of the Committee. Moreover, the Committee does not confine itself to military considerations, but also takes account of the call that a given project would make on resources of money, man-power and capacity in relation to the military and scientific advantage that the project would secure.

To some extent the Defence Research Policy Committee does contribute to that informal and flexible exchange of views which Sir Owen Wansbrough-Jones described in his William Jackson Pope Memorial Lecture five years ago as an invaluable characteristic of the place which Britain now gives the scientist in the Services. Nevertheless, the circulation which the Defence Research Policy Committee's reports receive is inevitably restricted, and it would seem desirable to seek some further means of bringing outside informed criticism to bear on problems in which so large a scientific and technological element now enters, quite apart from the appraisal of the total defence research effort in relation to other demands on scientific and technical resources. The problem is essentially one of striking a balance between the free flow of information and the minimum amount of secrecy which defence considerations rightly demand; and it is important that due regard should be paid not simply to the dangers which may attend the disclosure of information, but also to the price which has inevitably to be paid in waste of man-power and materials and in the loss of constructive criticism and creative ideas for any secrecy or impediment to the flow of information in the proper professional channels.

Neither risk is to be lightly disregarded; at the present time, if Anglo-American co-operation in research and development is not to be hindered, the former must be a calculated risk. The right approach to both problems, however, is from the angle of securing the conditions in which scientific and technological work is most fruitfully pursued, of which the maximum freedom of interchange of information is one of the first. That is a factor also if any searching review is to be made of defence research as a whole, and of its balance with the national research effort generally. Much depends here on the formal and informal organization of that effort at the highest level, and on the relations between the Ministers of Defence and Supply and the Lord President of the Council, for example. If they are adequately served and advised, it does not appear inherently impossible that the existing structure should provide what is needed, though in recent years doubts have been freely expressed as to the adequacy of the Lord President of the Council's office in surveying civil research. Nor can the whole problem be divorced from that of the supply of trained man-power and the measures now being taken to maintain and increase that supply.

The effective disposition of scientific and technological man-power between defence and the several civil and industrial spheres, and the provision of adequate facilities, are really one problem. There must be no waste of trained man-power, either on work that could be carried out by less highly trained staff, through the absence of adequate equipment and facilities, by duplication of work being carried out elsewhere, or by failure to provide sufficiently for the communication of knowledge on which the stimulation of creative ideas largely depends. The task of co-ordination and balance is too immense to be entrusted to any one individual. It can best be carried out by ensuring that at all levels, from Ministers downwards, those concerned are fully alive to all the issues involved and capable of appreciating for themselves the scientific and technical aspects with the financial and military and other factors.

Nor is this simply a matter of Government organization alone. As was shown in the discussion which followed addresses to the Parliamentary and Scientific Committee on November 26, 1957, on problems of aircraft research and development in Great Britain, demonstration of an adequate policy to exploit our strength in aeronautical research—and in other fields—depends on the closest collaboration with industry. Without such co-operation and full understanding, we cannot hope to use to the full the powerful resources for research and development which exist in Britain, resources which in quality are often as good as exist anywhere. Moreover, as Sir William Farren pointed out, apart from the question of shortage of trained man-power, it is a matter of retaining the ablest young scientists and technologists at their most creative period. No increase in the total output of scientists and technologists is likely to add appreciably to those of the highest ability; and to provide the conditions which attract and retain the services of men of that class is a major responsibility not only of the aircraft industry but also of other industries, including the nationalized industries and public corporations.

The aircraft industry is not a typical example of relations between industry and the Government, especially the Services, though differences in relations are rather in degree than in kind. Two points at least which emerged in this discussion have wide validity: the selection of projects and the problem of continuity. They are indeed related and have a vital bearing on the problem of Anglo-American co-operation.

Referring to the assertion that research is too closely related to projects, Sir William Farren remarked that when well led, research will generate its own projects, and he emphasized the dependence of all technological advance on fundamental research and new knowledge. Once again the vital importance of the unimpeded dissemination of new knowledge is apparent, and it would be fatal if any arrangements with the United States were allowed to place unjustifiable restrictions on the circulation of such ideas. Apart from the disastrous results of such measures on the stimulation of new ideas, every effort should be made to bring home both here and, as tactfully as possible to our allies, the force of Sir Ralph Glyn's remark: "There has been more extravagance in expenditure due to documents being labelled 'Secret' than from any other single cause. . . . The word secret is very often applied in order to cover up extravagance".

In considering these relations between Government departments and industrial establishments in the matter of research, due weight should be given to factors which Sir George Thomson stressed in his Fawley Foundation Lecture, "The Strategy of Research", last autumn. His reasons for believing that the serious difficulties of Government research establishments outweigh their advantages bear closely on the question of the distribution of our research effort both in defence and in the civil field. Further, its distribution has implications in regard to the second point, that of continuity, which is particularly liable to be jettisoned in Government establishments.

The most important factor making for economy in research is the wise choice of targets or projects, and while it is true that one of the most difficult decisions which a director of research has to take is when to abandon a programme, it should be stressed that

that is not primarily or mainly a financial decision. Once a project has been selected, it should be carried through to completion, unless scientific and technical factors emerging in the course of the project point to its abandonment; it should not be liable to interruption to secure small 5 or 10 per cent savings in a research budget. On no other basis is the planning of research and development possible, and the need of the aircraft industry for this kind of security was emphasized before the Parliamentary and Scientific Committee.

This commitment in advance to expenditure bears closely on the practicability of achieving effective economy in co-operative research between Great Britain and the United States. It implies that each country must surrender its right to abandon support of a joint research or development project on which it has once agreed without the consent of the other parties to the agreement. Without this, waste rather than economy may result from such co-operative ventures. This implication is not likely to be accepted readily by the British Government, and it is essential that its importance and the reasons for such continuity should be clearly understood in advance. To that end scientists and technologists generally should ensure that their professional associations consider carefully and fully all that is involved in this question of the most effective deployment of resources in research and development, both in defence and in the civil field, and in the co-operation with the United States now being examined. Even more than critical examination of points of detail is the clear and creative thinking out of which sound constructive proposals will emerge.

PHYSICS AND METAPHYSICS

Causality and Chance in Modern Physics

By Prof. David Bohm. Pp. xi+170. (London: Routledge and Kegan Paul, Ltd., 1957.) 21*s*. net.

THIS is the most paradoxical book I have seen for many years. Its author is not only a distinguished physicist but also a thinker with progressive views on most things; yet he is blind to one of the greatest of the advances in rational thinking which the development of physics has initiated. He purports to discuss fundamental aspects of modern science, but, scorning the scientific method established since Newton's time, he revives the metaphysical attitude of system-makers like Descartes, whose self-assurance he wonderfully imitates. He holds out the expectation that his ideas will eventually elucidate the strange properties of matter in its states of highest energy, but there is not a word in the book about the possible relation of these properties to the themes treated at great length in it. The elementary style of exposition could easily mislead the unwary student into the belief that he is here presented with a straightforward account of the problem stated in the title; but what the specialist sees in these dreary pages is a picture distorted beyond recognition by misinterpretation and misrepresentation.

The author's original endeavour was to vindicate the traditional conception of deterministic causality in atomic physics. Having notoriously failed in this, he now tries to argue that one ought to consider more general types of causality, partaking of both determinism and chance: the element of chance appearing at any 'level' of description would have to be underpinned by the determinism of some hidden processes going on at a 'deeper' level. This novel conception, however, is not 'synthetic', as he thinks, but just confused; at any rate, it does not correspond to the actual situation with which we are confronted in atomic physics. In fact, the infinite sequence of deeper and deeper levels of reality, which Prof. Bohm imagines, appears to serve no other purpose than to provide him with a perpetual line of escape from embarrassing difficulties.

The true character of the causal relations of atomic physics was fully elucidated by Bohr and Heisenberg thirty years ago, and all that we have learned since about atoms and nuclei and other fundamental agencies of Nature has only strengthened the conclusions then reached and extended their scope. In particular, one of the most firmly established facts about the newly discovered mesons and hyperons is that the laws of their behaviour and interactions, whatever surprises they may hold in store for us in other respects, follow the general pattern of quantum theory, with its essentially statistical character. Thus, the great discovery of the non-conservation of parity in weak interactions refers to a typically non-classical feature, which can only be defined in statistical terms.

Altogether, it is impossible to discern in this new domain of experience the slightest foundation for the surmise that a return to some deterministic mode of description could throw light upon the phenomena. If some physicists nevertheless entertain such expectations, it is because, in contradiction with the exigencies of sound scientific method, they give to some metaphysical prejudice, like determinism, greater weight than to the immediate lessons of experience. That such irrational dogmatists should hurl the very accusation of irrationality and dogmatism at the defenders of the common sense, uncommitted attitude of other scientists is the crowning paradox which gives a touch of comedy to a controversy so distressingly pointless and untimely.

L. Rosenfeld

GEOLOGICAL INTERPRETATION OF MARINE SEDIMENTS

Géologie Sédimentaire

Les Séries Marines. Par Prof. Augustin Lombard. Pp. 725+13 planches. (Paris: Masson et Cie.; Liège: H. Vaillant-Carmanne, S.A., 1956.) 11,000 French francs.

PROF. A. LOMBARD of Brussels, previously a lecturer at Geneva, starts with a somewhat muddled warning against unreserved acceptance of the doctrine of uniformitarianism—a dreadful word replaced in French by actualism—which, for our purpose, may be interpreted as present-day-ism. Lombard quotes, with approval, a recent remark by Debyser that the present is only the key to the past, not its replica; but this of course is exactly what Hutton, Playfair and Lyell tried to teach us from the beginning.

Lombard's criticism of actualism is clearly based on confusion, since, by way of illustration, he blames the principle for six "hypothetical and mistaken interpretations", in regard to all of which it is perfectly innocent. For example, he complains that ripple-marks have long been thought to be restricted to shallow-water formations, whereas they have recently been photographed on the sea bottom at a depth of 2,000 m. The obvious answer is that the mistake was made through ignorance, not knowledge, of the present.

Lombard's main quarrel with the idea of interpreting the past in the light of the present is due to his fear that an observer of the present may be distracted by some short-term process; and so he may fail to realize an accompanying long-term process, which, though it produces no appreciable result within his experience, may be of great importance in the course of geological time. The typical example of this, in his opinion, is afforded by some geologists having attributed the graded bedding of many deep-sea sandstones to turbidity currents. He himself thinks that in most cases it is due to sea-bottom creep, analogous to solifluxion (soil-flow) commonly found on land. A graded bed, it may be explained, is one in which a relatively coarse base grades upwards into a relatively fine top. The connexion between turbidity currents and graded bedding seems to have been first advanced by myself in 1938; but its experimental confirmation and much more besides we owe to Kuenen. It is very doubtful whether many geologists will follow Lombard in the modification he has proposed.

While not agreeing with Lombard on quite a number of points I have found his book, especially Part I, pp. 11–208, full of stimulating discussion of such phenomena as island arcs, the mid-Atlantic ridge, continental shelves and slopes, atolls, submarine canyons, guyots (submerged truncated peaks), rhythmic sequences, etc. He gives brief, readable summaries of the views of many fellow-workers; and these are supported by a bibliography with 1,200 entries (50 per cent in French, 30 English, 20 German), along with a good index and contents. The whole should help future research quite considerably.

Like others in the same inquiry, Lombard finds it very useful to draw graphic sections of successions which he is investigating, whether in the field or in boreholes. Of late, such sections, where based on boring, have often been supplemented by curves recording electric resistance, radioactivity, etc. These latter-day curves supply additional information that cannot be derived from the graphic sections, although comparison, once all have been drawn, allows of valuable correlation. Now Lombard suggests supplementing each graphic section by a curve directly based upon it, using a succession of co-ordinates corresponding with sandstone, shale, limestone (and as many intermediate terms as may seem desirable). I confess I have found these curves less informative than the graphic sections from which they have been derived. It is, however, quite possible that students will enjoy publishing them, just as for many years they have enjoyed publishing 'norms' corresponding with analyses of igneous rocks.

I have mentioned the sequence, sandstone, shale, limestone, as a standard with which Lombard compares actual sequences. I have also indicated that he is prepared to admit intermediates, such as shaly sandstone, sandy shale, etc., in his scale. A problem is presented when the local sequence includes an item, say, coal, which cannot lithologically be placed in the standard succession. This particular difficulty is faced by Lombard in a section on "Séquences rhythmiques détritiques-colloïdales-calcaires à charbon", pp. 473–498, in which he takes most of his data from Moore's account of the Carboniferous in Texas and Robertson's of the same formation in Britain. In its simplest form the vertical sequence of rock types runs from older to younger as follows: sandstone, shale (more or less converted to root-bed), coal, shale, limestone, shale; sandstone again, with a similar repeat of the other terms. Lombard has not realized that the coal is an aerial formation, which places it outside his standard scale, intended for marine formations only. Accordingly, he inserts it between non-calcareous and calcareous shale, remarking that it has originated from fine plant debris.

Before leaving this subject I may add that I do not agree with Robertson's idea that the rhythm depends upon the intermittent rupture of a bar that normally excluded the sea from a low-level, subsiding, afforested marsh. It would require a pump. Peach's 1885 explanation involving recurrent speeding up of subsidence is much more acceptable.

E. B. Bailey

OUTLINE OF STEROID CHEMISTRY

The Chemistry of Steroids

By Dr. W. Klyne. (Methuen's Monographs on Biochemical Subjects.) Pp. 216. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1957.) 18*s.* net.

In the quarter of a century which has elapsed since the elucidation of the final features of the structures of the sterols and bile acids and the almost coincident recognition that an identical ring system occurred in the first of the sex hormones to be isolated, the chemistry of the steroids has undergone extensive development. Numerous new members of the group, many with the properties of hormones, have been isolated from animal sources, while a few types of important plant products, such as the cardiac glycosides, have been shown to contain the same characteristic ring system. Steroid chemistry has thus become a wide and specialized field.

Treatises on the subject, or on parts of it, are of course available, but these are mainly for the specialist. A brief survey of the whole field, such as is contained in the above volume, is therefore to be welcomed. That this work, dealing as it does with the purely chemical side of the subject, should appear in a well-known series of monographs on biochemical subjects might, at first sight, seem strange. But this anomaly finds its explanation in the author's statement that a companion volume, by another writer dealing with the biochemistry, is in course of preparation.

One aim of the book, namely, the provision of "an outline of the chemistry of the steroids for the non-chemical reader", has, in my view, not been achieved, and I doubt if such an end could be attained. Consequently, the few very elementary passages found interspersed in the text might well have been omitted. The subject-matter is not arranged for easy reading nor, as the author recognizes, is the treatment comprehensive. In my view, the work must be regarded as a masterly summarization and tabulation of the principal facts relating to the chemistry of the steroids. Thus, to take a random example from one of the less common steroids, if one wished to gain some information about stigmasterol one would find in Table 6A its systematic name, molecular formula and two physical constants. From the systematic name, and with the aid of the formula for cholesterol on p. 111, of the system of numbering for the nucleus given in the introduction and of the structure of the side chain reproduced on p. 112, one could write the complete structural formula for stigmasterol. Table 6A also gives the soya bean as its source, from which one could deduce that stigmasterol is probably a phytosterol. As a work of this nature, the book will be found to be a handy volume for the expert or semi-expert to have at his elbow when he wishes to refresh his memory about the accepted structure, configuration or conformation of a particular steroid.

The text is remarkably free from misprints, although the misspelling of the word stereochemistry in one place on the first page of the preface produces initially a bad impression. E. STEDMAN

RECENT RADIOBIOLOGY

Advances in Radiobiology

Proceedings of the Fifth International Conference on Radiobiology held in Stockholm on 15th–19th August, 1956. Edited by George Carl de Hevesy, Arne Gunnar Forssberg, and John D. Abbatt. Pp. xvi+503. (Edinburgh and London: Oliver and Boyd, Ltd., 1957.) 77*s.* 6*d.* net.

RADIOBIOLOGY is now a subject in its own right and the principle of holding an annual international conference is well established. The present volume contains the sixty-nine papers contributed to the 1956 conference in Stockholm, together with the resulting discussions. As is inevitable in an annual conference, many of the papers are rather scrappy accounts of incompleted work. Nevertheless, every radiobiologist will find at least some topics discussed which impinge directly or indirectly on his own interests. But whether the book will appeal to a wider audience is more doubtful. Not all branches of radiobiology are represented and the main themes in this conference were radiation chemistry, biochemical effects on enzymes and cell components, irradiation of single cells and parts of cells, effects on the hæmopoietic system, protection by chemical and cellular agents, and genetics.

Perhaps the most important new discovery is that if a suspension of spleen or bone-marrow cells is injected intravenously into a heavily irradiated mouse, some of the injected cells colonize and eventually entirely repopulate the radiation-depleted hæmopoietic tissues of the mouse, giving rise to what has come to be called a 'radiation chimera'. It had been known for some time that animals could be 'protected' from otherwise fatal doses of radiation by the post-irradiation injection of spleen or bone marrow and it was generally guessed that this was due to some chemical or humoral factor in the injected material. It has now been shown, however, by four different groups of workers, that the effective agent in the injected material is cellular rather than humoral, and that the injected living cells reach and eventually recolonize the bone marrow, spleen, lymph nodes and thymus of the irradiated animal. It has been found that even rat cells will repopulate the organs of the mouse, at any rate for a time. The most elegant and convincing of these demonstrations is that of Ford, Hamerton, Barnes and Loutit, which is fully reported in this volume. They were able to identify the transfused foreign donor cells by virtue of their chromosomal characters and to determine the proportion of these cells in the various hæmopoietic organs of the irradiated recipient. Important as this new discovery is for radiobiology, it also has some far-reaching implications and applications in the general field of biology. The whole subject of radioprotection by both chemical and cellular agents is admirably dealt with by Cohen, Vos and van Bekkum in a paper which deserves special mention.

Another new line of thought which emerges, particularly in the discussions, is the suggestion of Bacq and Alexander that the primary biochemical lesion produced by radiation may be a breaking of the hydrogen bonds which hold the individual enzymes together and in place in the cell. The enzymes are thus released from their normal sites in mitochondria or microsomes and escape into the general cytoplasm, where they proceed to attack various structures including the nucleus. More specifically, it has been shown that after irradiation deoxyribonuclease is liberated from the mitochondria and microsomes into the cytoplasm, and this could perhaps account for the nuclear changes which are the first visible signs of radiation damage.

Most of the biological effects of irradiation are assumed to result from an indirect action of radiation, in the sense that the primary ionizing action of the radiation is on the water, not on the cell proteins, etc. The free radicals produced by the ionization of water may then react with oxygen to produce even more toxic substances such as hydrogen peroxide. The chief evidence in support of this view has been the fact that the great majority of radiobiological effects are both oxygen- and temperature-dependent. Alexander has now shown, however, that when various polymers and also certain proteins are irradiated in the dry state the radiochemical changes produced are also oxygen- and temperature-dependent. As a result of this and other work more attention is now being paid to possible direct effects of radiation on the macromolecules of protein or deoxyribonucleic acid.

Little progress has been made in the search for radioprotective chemical substances. The sulphur compounds—cysteine, cysteamine, cystamine and certain thiuronium compounds—have not yet been bettered, but the mechanism by which they act is still hotly debated. The simple explanation that they all act by lowering the intracellular oxygen concentration seems no longer tenable. There is evidently still much to be learnt in this field and the outlook is not so discouraging as at one time appeared.

Irradiation of localized areas in single cells by a microbeam of α-particles has not so far given the clear-cut answers which were hoped for.

In the more medical field, Curtis and Healey find that animals receiving a dose of radiation as young adults undergo premature ageing quite apart from the increased incidence of tumours. Furthermore, in old age these animals are much less able to withstand a 'toxic stress' as, for example, the administration of typhoid vaccine or nitrogen mustard. Faber presents figures from the Danish health service which show an association between the incidence of chronic myeloid leukæmia and previous diagnostic radiography.

This volume is somewhat smaller than its predecessor but costs 23 per cent more. O. A. TROWELL

Handbook of Chemistry and Physics

A Ready-Reference Book of Chemical and Physical Data. Edited by Prof. Charles D. Hodgman, in association with Prof. Robert C. Weast and Dr. Samuel M. Selby. Thirty-ninth edition. Pp. xxii+3213. (Cleveland, Ohio: Chemical Rubber Publishing Company, 1957.) n.p.

LIKE the world's population, the size of reference books increases alarmingly from year to year. The "Handbook of Chemistry and Physics" is no exception. There are nearly two hundred contributors (living, emeritus and deceased) to the thirty-ninth edition, which runs to more than three thousand, two hundred pages, though some of these are reserved for future expansion. The book is, however, kept down to a manageable size by the use of India paper. Unfortunately, a solution along these lines is not possible where human populations are concerned.

The "Handbook" has appeared almost every year since 1914; this is in itself some indication of its success and usefulness. In each edition new information is added until now the amount it contains is really stupendous. Opening the index at random one finds such esoteric topics as Babo's law; concentration, freezing points and densities of calcium chloride brines; haversines, table; label protection; stain, acid proof, for wood; ultra-violet sensitization of photographic plates. There is something for everyone.

New tables in this edition include nuclear spin and moments; relative sensitivities (which relate the nuclear magnetic resonance of certain nuclides to that of the proton); superconductivities of metals, alloys and compounds; energy, mass and velocity relations to the electron; magnetic properties of transformer steels and high permeability materials; dielectric constants of pure liquids; dielectric constants and dipole moments of substances in the gaseous state. The information on isotopes has also been extended and revised and now goes up to element 101. There are four new tables on the sugars.

There is no doubt that having the "Handbook" to hand will save many a wearisome hunt in the library. It may also save something else: if you are quick enough after sucking a bit too hard while filling your pipette with 10*N* cyanide, just turn to p. xix and find out what to do.

The Study of Plant Communities

An Introduction to Plant Ecology. By Prof. Henry J. Oosting. Second edition. Pp. viii+440. (San Francisco, Calif.: W. H. Freeman and Company; London: Bailey Bros. and Swinfen, Ltd., 1956.) 6 dollars; 51*s*.

IN this second edition of Prof. Oosting's book the general plan remains unaltered, but the text has been brought up to date and many sections are entirely rewritten. Intended as an introduction to plant ecology for university students, the aim is admirably achieved, and the book contains much that is available otherwise only in more advanced texts. In this it well merits a place in the school library where botany is taught to scholarship-level. The discussion loses little for the British reader from being based on American plant communities, for the scope is wide, and good illustrations make up for the unfamiliarity of the plants referred to.

The opening section deals with the nature of plant communities and the techniques for sampling and describing them. A chapter on the objectives and methods of the European phytosociological school is welcome, for, with the divergence of aim in the trend that British ecology has followed, we have tended to lose contact with those aspects of Continental work which can be of help to us. The ensuing five chapters deal generally with environmental factors controlling the community, and the standard techniques for their measurement. In the section on community dynamics the chapter on plant succession has been rewritten to give a clear summary of the monoclimax and polyclimax interpretations of vegetation. Climax regions of North America are then described, and the final chapter deals with the applications of ecology to practical problems of forestry, pasture management, erosion control and land utilization.

A list of books for wider reading is given with each chapter, and there is a good bibliography of original references, including a fair sprinkling of European papers. MAURICE ASHBY

Automatic Control

(A *Scientific American* Book.) Pp. x+148. (London: G. Bell and Sons, Ltd., 1957.) 10*s*. 6*d*. net.

THIS book was first published in the United States in 1955 and the format immediately strikes one as American, particularly the rather crude illustrations. On looking a little closer, one finds that it is a series of popular articles covering all the essential aspects of automatic control, by authors of international repute. This led to the expectation of nothing more than a hotch-potch of disconnected 'potboilers'. However, on reading it, this proved to be quite unjust to both publishers and authors, for as might be expected of such authors as Gordon Brown, Arnold Tustin, Grey Walter and Warren Weaver, the chapters are all written with great care to give the general reader a clear and accurate picture of some of the most recent developments.

Although there is no apparent connexion between the chapters, together they cover all the important aspects of this wide and difficult field. The theory of control; mechanical, hydraulic and other control systems; chemical plant, machine tools and the automatic office; information theory and the physiological comparisons between man and machines are all covered. Even the economic impact of automation has been included in a short but informative article by Wassily Leontief.

As a book, it has the great merit of being short. Covering such a wide field in less than 150 pages, it cannot go very deep; but it goes deep enough for the average reader, whether scientific or non-technical. The illustrations, which are ugly to look at because crudely drawn, have the great merit of clarity. It is a pity that such excellent letterpress has not been set in a more pleasing type.

J. F. COALES

Selected Papers in Statistics and Probability

By Abraham Wald. Second printing. Pp. ix+702. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1957.) 80*s*. net.

THIS volume contains 51 papers on probability and statistics by Abraham Wald, who met an untimely and much lamented death in an air-crash in 1950. The first printing, edited for the Institute of Mathematical Statistics by a number of distinguished statisticians, was published by McGraw-Hill in 1955. It was rapidly exhausted and this second printing, issued by the Stanford University Press, will be very welcome.

A THREE-DIMENSIONAL MODEL OF THE MYOGLOBIN MOLECULE OBTAINED BY X-RAY ANALYSIS

By DRS. J. C. KENDREW, G. BODO, H. M. DINTZIS, R. G. PARRISH and H. WYCKOFF
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AND
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Davy Faraday Laboratory, The Royal Institution, London

MYOGLOBIN is a typical globular protein, and is found in many animal cells. Like hæmoglobin, it combines reversibly with molecular oxygen; but whereas the role of hæmoglobin is to transport oxygen in the blood stream, that of myoglobin is to store it temporarily within the cells (a function particularly important in diving animals such as whales, seals and penguins, the dark red tissues of which contain large amounts of myoglobin, and which have been our principal sources of the protein). Both molecules include a non-protein moiety, consisting of an iron–porphyrin complex known as the hæm group, and it is this group which actually combines with oxygen; hæmoglobin, with a molecular weight of 67,000, contains four hæm groups, whereas myoglobin has only one. This, together with about 152 amino-acid residues, makes up a molecular weight of 17,000, so that myoglobin is one of the smaller proteins. Its small size was one of the main reasons for our choice of myoglobin as a subject for X-ray analysis.

In describing a protein it is now common to distinguish the primary, secondary and tertiary structures. The *primary structure* is simply the order, or sequence, of the amino-acid residues along the polypeptide chains. This was first determined by Sanger using chemical techniques for the protein insulin[1], and has since been elucidated for a number of peptides and, in part, for one or two other small proteins. The *secondary structure* is the type of folding, coiling or puckering adopted by the polypeptide chain: the α-helix and the pleated sheet are examples. Secondary structure has been assigned in broad outline to a number of fibrous proteins such as silk, keratin and collagen; but we are ignorant of the nature of the secondary structure of any globular protein. True, there is suggestive evidence, though as yet no proof, that α-helices occur in globular proteins, to an extent which is difficult to gauge quantitatively in any particular case. The *tertiary structure* is the way in which the folded or coiled polypeptide chains are disposed to form the protein molecule as a three-dimensional object, in space. The chemical and physical properties of a protein cannot be fully interpreted until all three levels of structure are understood, for these properties depend on the spatial relationships between the amino-acids, and these in turn depend on the tertiary and secondary structures as much as on the primary.

Only X-ray diffraction methods seem capable, even in principle, of unravelling the tertiary and secondary structures. But the great efforts which have been devoted to the study of proteins by X-rays, while achieving successes in clarifying the secondary (though not yet the tertiary) structures of fibrous proteins, have hitherto paid small dividends among the metabolically more important globular, or crystalline, proteins. Progress here has been slow because globular proteins are much more complicated then the organic molecules which are the normal objects of X-ray analysis (not counting hydrogens, myoglobin contains 1,200 atoms, whereas the most complicated molecule the structure of which has been completely determined by X-rays, vitamin B_{12}, contains 93). Until five years ago, no one knew how, in practice, the complete structure of a crystalline protein might be found by X-rays, and it was realized that the methods then in vogue among protein crystallographers could at best give the most sketchy indications about the structure of the molecule. This situation was transformed by the discovery, made by Perutz and his colleagues[2], that heavy atoms could be attached to protein molecules in specific sites and that the resulting complexes gave diffraction patterns sufficiently different from normal to enable a classical method of structure analysis, the so-called 'method of isomorphous replacement', to be used to determine the relative phases of the reflexions. This method can most easily be applied in two dimensions, giving a projection of the contents of the unit cell along one of its axes. Perutz attached a *p*-chloromercuri-benzoate molecule to each of two free sulphydryl groups in hæmoglobin and used the resulting changes in certain of the reflexions to prepare a projection along the *y*-axis of the unit cell[3]. Disappointingly, the projection was largely uninterpretable. This was because the thickness of the molecule along the axis of projection was 63 A. (corresponding to some 40 atomic diameters), so that the various features of the molecule were superposed in inextricable confusion, and even at the increased resolution of 2·7 A. it has proved impossible to disentangle them[4]. It was clear that further progress could only be made if the analysis were extended to three dimensions. As we shall see, this involves the collection of many more observations and the production of three or four different isomorphous replacements of the same unit cell, a requirement which presents great technical difficulties in most proteins.

The present article describes the application, at low resolution, of the isomorphous replacement method in three dimensions to type *A* crystals of sperm whale myoglobin[5]. The result is a three-dimensional Fourier, or electron-density, map of the unit cell, which for the first time reveals the general nature of the tertiary structure of a protein molecule.

Isomorphous Replacement in Myoglobin

No type of myoglobin has yet been found to contain free sulphydryl groups, so that the method of attaching heavy atoms used by Perutz for hæmoglobin could not be employed. Eventually, we were able to attach several heavy atoms to the myoglobin molecule at different specific sites by crystallizing it with a variety of heavy ions chosen because they might be expected, on general chemical grounds, to possess affinity for protein side-chains. X-ray, rather than chemical, methods were used to determine whether combination had taken place, and, if so, whether the ligand was situated predominantly at a single site on the surface of the molecule. Among others, the following ligands were found to combine in a way suitable for the present purpose: (i) potassium mercuri-iodide and auri-iodide; (ii) silver nitrate, potassium auri-chloride; (iii) *p*-chloromercuri-benzene sulphonate; (iv) mercury diammine ($Hg(NH_3)^{2+}$, prepared by dissolving mercuric oxide in hot strong ammonium sulphate), *p*-chloro-aniline; (v) *p*-iodo-phenylhydroxylamine. Each group of ligands combined specifically at a particular site, five distinct sites being found in all. The substituted phenylhydroxylamine is a specific reagent for the iron atom of the hæm group[6], and may be assumed to combine with that group; in none of the other ligands have we any certain knowledge of the mechanism of attachment or of the chemical nature of the site involved.

Methods of X-ray Analysis

Type *A* crystals of myoglobin are monoclinic (space group $P2_1$) and contain two protein molecules per unit cell. Only the $h0l$ reflexions are 'real', that is, can be regarded as having relative phase angles limited to 0 or π, or positive or negative signs, rather than general phases; when introduced into a Fourier synthesis, these reflexions give a projection of the contents of the cell along its y-axis. In two dimensions the analysis followed lines[7] similar to that of hæmoglobin. First, the heavy atom was located by carrying out a so-called difference-Patterson synthesis; if all the heavy atoms are located at the same site on every molecule in the crystal, this synthesis will contain only one peak, from the position of which the x- and z-co-ordinates of the heavy atom can be deduced, and the signs of the $h0l$ reflexions determined. These signs were cross-checked by repeating the analysis for each separate isomorphous replacement in turn; we are sure of almost all of them to a resolution of 4 A., and of most to 1·9 A. Using the signs, together with the measured amplitudes, we may, finally, compute an electron-density projection of the contents of the unit cell along y; but, as in hæmoglobin and for the same reasons, the projection is in most respects uninterpretable (even though here the axis of projection is only 31 A.). On the other hand, knowledge of the signs of the $h0l$ reflexions to high resolution enabled us to determine the x- and z-co-ordinates of all the heavy atoms with some precision. This was the starting point for the three-dimensional analysis now to be described.

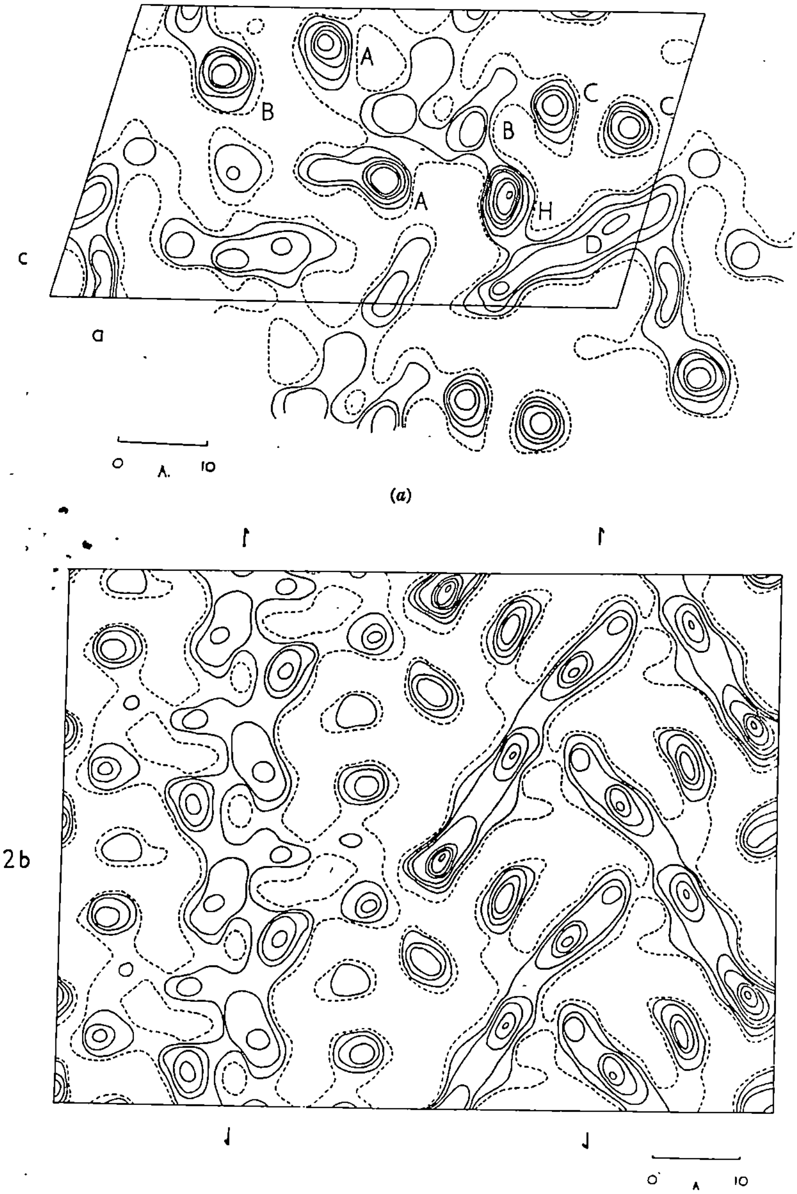
In three dimensions the procedure is much more lengthy because all the general reflexions hkl must be included in the synthesis, and more complicated because these reflexions may have any relative phase angles, not only 0 or π. Furthermore, we need to know all three co-ordinates of the heavy atoms; the two-dimensional analysis gives x and z, but to find y is more difficult, and details of the methods used will be published elsewhere, including among others two proposed by Perutz[8] and one proposed by Bragg[9]. Finally, a formal ambiguity enters into the deduction of general phase angles if only one isomorphous replacement is available; this can be resolved by using several replacements[10], such as are available in the present case. Once the phases of the general reflexions have been determined, one can carry out a three-dimensional Fourier synthesis which will be a representation of the electron density at every point in the unit cell.

Before such a programme is embarked upon, however, the resolution to be aimed at must be decided. The number of reflexions needed, and hence the amount of labour, is proportional to the cube of the resolution. To resolve individual atoms it would be necessary to include at least all terms of the series with spacings greater than 1·5 A.—some 20,000 in all; and it is to be remembered that the intensities of all the reflexions would have to be measured for *each* isomorphous derivative. Besides this, introduction of a heavy group may cause slight distortion of the crystal lattice; as the resolution is increased, this distortion has an increasingly serious effect on the accuracy of phase determination. In the present stage of the analysis the most urgent objective was an electron-density map detailed enough to show the general layout of the molecule—in other words, its tertiary structure. If the α-helix, or something like it, forms the basis of the structure, we need only work to a resolution sufficient to show up a helical chain as a rod of high electron density. For this purpose we require only reflexions with spacings greater than about 6 A.; in all there are some 400 of these, of which about 100 are $h0l$'s already investigated in the two-dimensional study. The Fourier synthesis described here is computed from these 400 reflexions only, and is in consequence blurred; besides this, it is distorted by an unknown amount of experimental error, believed to be small but at the moment difficult to estimate. Thus while the general features of the synthesis are undoubtedly correct, there may be some spurious detail which will require correction at a later stage.

The Three-dimensional Fourier Synthesis

The synthesis was computed in 70 min. on the EDSAC Mark I electronic computer at Cambridge (as a check, parts of the computation were repeated on DEUCE at the National Physical Laboratory). It is in the form of sixteen sections perpendicular to y and spaced nearly 2 A. apart; these must be piled on top of one another to represent the electron density throughout the cell, containing two myoglobin molecules together with associated mother liquor (which amounts to nearly half the whole). Unfortunately, the synthesis cannot be so represented within the two-dimensional pages of a journal; furthermore, if the sections are displayed side by side, they give no useful idea of the structure they represent. The examples reproduced in Fig. 1 illustrate some of the more striking features.

A first glance at the synthesis shows that it contains a number of prominent rods of high electron density; these usually run fairly straight for distances of 20, 30 or 40 A., though there are some curved ones as well. Their cross-section is generally nearly circular, their diameter about 5 A., and they tend to lie at distances from their neighbours of 8–10 A. (axis to axis). In some instances two segments of rod are joined by fairly sharp corners. Fig. 1*a*



(a)

(b)

Fig. 1. (a) Section of three-dimensional Fourier synthesis of type *A* myoglobin at $y = -1/8\ b$. *A–D*, polypeptide chains; *H*, hæm group. (b) Section parallel to [20$\bar{1}$] at $x = 0$, showing polypeptide chain *A* (on the right)

shows several rods—three of them (*A*, *B* and *C*) cross the plane of the section almost at right angles, while one (*D*) lies nearly in that plane. *D* is part of a nearly straight segment of chain about 40 A. long, of which some 20 A. is visible in this section. It seems virtually certain that these rods of high density are the polypeptide chains themselves—indeed, it is hard to think of any other features of the structure which they could possibly be. Their circular cross-section is what would be expected if the configuration were helical, and the electron density along their axes is of the right order for a helical arrangement such as the α-helix. The various rods in the structure are intertwined in a very complex manner, the nature of which we shall describe later.

Another prominent feature is a single disk-shaped region of high electron density which reaches a peak value greater than at any other point in the cell. A section through this disk is shown at *H* in Fig. 1*a*. We identify this feature as the hæm group itself, for the following reasons: (i) the hæm group is a flat disk of about the same size; (ii) its centre is occupied by an iron atom and therefore has a higher electron density than any other point in the whole molecule; (iii) a difference-Fourier projection of the *p*-iodophenylhydroxylamine derivative shows that, at least in *y*-projection, the position of the iodine atom is near that of our group; this is what we should expect, since this reagent specifically combines with the hæm group; (iv) the orientation of the disk corresponds, as closely as the limited resolution of the map allows one to determine it, with the orientation of the hæm group deduced from measurements of electron spin resonance[6,11].

We cannot understand the structure of the molecules in the crystal unless we can decide where one ends and its neighbours begin. In a protein crystal the interstices are occupied by mother liquor, in this case strong ammonium sulphate, the electron density of which is nearly equal to the average for the whole cell. Hence it is to be expected that in the intermolecular regions the electron density will be near average (the density of coiled polypeptide chains is much above average, and that of side-chains well below). It should also be fairly uniform; these regions should not be crossed by major features such as polypeptide chains. Using these criteria, it is possible to outline the whole molecule with minor uncertainties. It was gratifying to find that the result agreed very well, in projection, with a salt-water difference-Fourier projection made as part of the two-dimensional programme (for the principles involved, see ref. 12). Moreover, the dimensions of the molecule agreed closely with those deduced from packing considerations in various types of unit cell.

The Myoglobin Molecule

We are now in a position to study the tertiary structure of a single myoglobin molecule separated from its neighbours. Fig. 2 illustrates various views of a three-dimensional model constructed to show the regions of high electron density in the isolated molecule. Several points must be noticed. First, the model shows only the general distribution of dense regions. The core of a helical polypeptide chain would be such a region; but if the chain were pulled out, into a β-configuration, for example, its mean density would drop to near the average for the cell and the chain would fade out at this resolution.

Similarly, side-chains should, in general, scarcely show up, so that the polypeptide rods in the model must be imagined as clothed in an invisible integument of side-chains, so thick that neighbouring chains in reality touch. Third, features other than polypeptide chains may be responsible for some of the regions of high density; patches of adsorbed salt, for example. Fourth, the surface chosen to demarcate a molecule cannot be traced everywhere with certainty, so it is possible that the molecule shown contains parts of its neighbours, and correspondingly lacks part of its own substance.

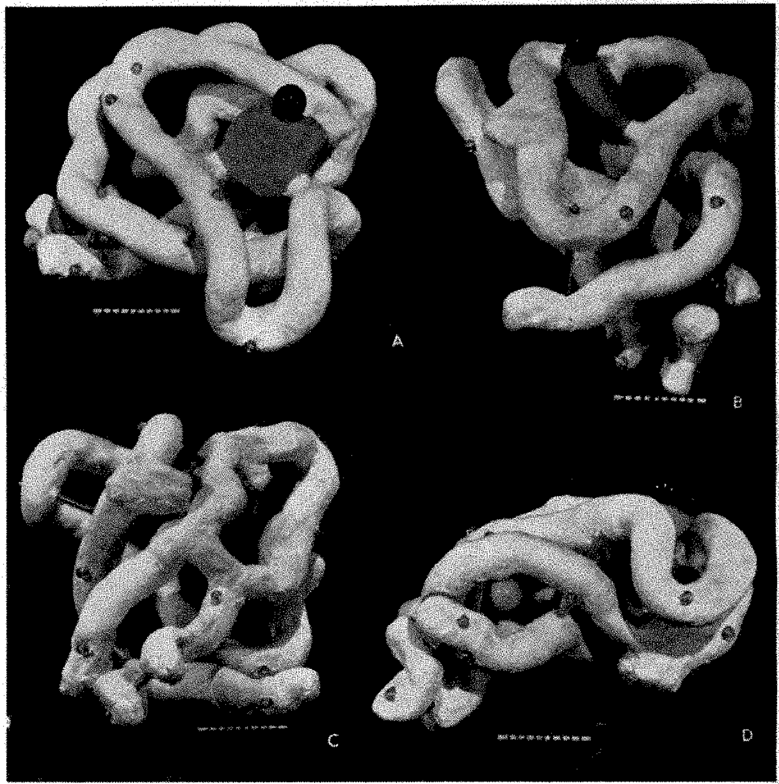


Fig. 2. Photographs of a model of the myoglobin molecule. Polypeptide chains are white; the grey disk is the hæm group. The three spheres show positions at which heavy atoms were attached to the molecule (black: Hg of *p*-chloro-mercuri-benzene-sulphonate; dark grey: Hg of mercury diammine; light grey: Au of auri-chloride). The marks on the scale are 1 A. apart

Making due allowance for these difficulties, we may note the main features. It is known[13] that myoglobin has only one terminal amino-group: it is simplest to suppose that it consists of a single polypeptide chain. This chain is folded to form a flat disk of dimensions about 43 A. × 35 A. × 23 A. Within the disk chains pursue a complicated course, turning through large angles and generally behaving so irregularly that it is difficult to describe the arrangement in simple terms; but we note the strong tendency for neighbouring chains to lie 8–10 A. apart in spite of the irregularity. One might loosely say that the molecule consists of two layers of chains, the predominant directions of which are nearly at right angles in the two layers. If we attempt to trace a single continuous chain throughout the model, we soon run into difficulties and ambiguities, because we must follow it around corners, and it is precisely at corners that the chain must lose the tightly packed configuration which alone makes it visible at this resolution (an α-helix, for example, cannot turn corners without its helical configuration being disrupted). Also, there are several apparent bridges between neighbouring chains, perhaps due to the apposition of bulky side-chains. The model is certainly compatible with a single continuous chain, but there are at least two alternative ways of tracing it through the molecule, and it will not be possible to ascertain which (if either) is correct until the resolution has been improved. Of the secondary structure we can see virtually nothing directly at this stage. Owing to the corners, the chain cannot be in helical configuration throughout; in fact, the total length of chain in the model is 300 A., whereas an α-helix of 152 residues would be only 228 A. long. The 300 A. might correspond, for example, to 70 per cent α-helix and 30 per cent fully extended chain, but of course intermediate configurations are probably present, too. The hæm group is held in the structure by links to at least four neighbouring chains; nevertheless, one side of it is readily accessible from the environment to oxygen and to larger reagents such as *p*-iodo-phenylhydroxylamine (in the difference-Fourier projection of this complex, referred to above, the position of the iodine atom indicates that the ligand is attached to the outside of the group). Clearly, however, the model cannot at present be correlated in detail with what we know of the chemistry of myoglobin; this must await further refinement.

Perhaps the most remarkable features of the molecule are its complexity and its lack of symmetry. The arrangement seems to be almost totally lacking in the kind of regularities which one instinctively anticipates, and it is more complicated than has been predicated by any theory of protein structure. Though the detailed principles of construction do not yet emerge, we may hope that they will do so at a later stage of the analysis. We are at present engaged in extending the resolution to 3 A., which should show us something of the secondary structure; we anticipate that still further extensions will later be possible—eventually, perhaps, to the point of revealing even the primary structure.

Full details of this work will be published elsewhere. We wish to record our debt to Miss Mary Pinkerton for assistance of all kinds; to the Mathematical Laboratory, University of Cambridge, for computing facilities on the EDSAC; to Dr. J. S. Rollett and the National Physical Laboratory for similar facilities on the DEUCE; to Mrs. Joan Blows and Miss Ann Mansfield for assistance in computing; for fellowships to the U.S. Public Health Service (H. W.), the Merck Fellowship Board (R. G. P.), the U.S. National Science Foundation (R. G. P. and H. M. D.), and the Rockefeller Foundation (H. M. D.); and to Sir Lawrence Bragg for his interest and encouragement. Finally, we wish to

express our profound gratitude to the Rockefeller Foundation, which has actively supported this research from its earliest beginnings.

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RECENT CLIMATIC CHANGES

By DR. E. B. KRAUS

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CLIMATE is nowhere invariant. The existence of a never-ending change is most apparent along the shifting boundaries of the various climatic provinces. During the past few hundred years the boundaries of the Alpine and Sub-Arctic regions have experienced some striking changes in glaciation and considerable variations in the extent and the seasonal duration of sea ice. It has now been established from the analysis of rainfall and stream-flow records that fluctuations of corresponding or even larger amplitude occurred in the sub-tropics at the boundary of the arid zone. During the same time the climates of the Antarctic ice cap, the central Sahara or the Amazon rain forest may not have altered a great deal.

Changes in a time series can be illustrated to advantage by graphs of cumulative percentual deviations from a mean. Graphs of this type accentuate changes in a time series, while running averages or orthodox statistical analyses tend to smooth them out. They demonstrate, at a glance, the existence of a trend and the time when it changes.

In the following diagrams (Figs. 1–6), the ordinate:

$$y(n) = 100 \sum_{l=1881}^{n} \left(\frac{r_l}{\bar{r} - 1}\right)$$

where n represents the running calendar year, r_l the rainfall or stream discharge for the year l, and $\bar{r}$ the mean for the years 1881–1940. It is easily seen that y must be zero at the beginning of 1881 and the end of 1940. The graph of y rises for $r_l > \bar{r}$ and vice versa. It will be concave upwards during periods when r is increasing with time and convex when it is decreasing. The percentual deviation from $\bar{r}$ of the mean for any other period, say the years n to $(n + m)$, is given simply by $[y\ (n + m) - y(m)]/m$.

The accompanying six diagrams have been brought together to demonstrate how fluctuations of the same type occur at about the same time all around the globe. Fig. 1 illustrates the changes which occurred in the rainfall regime of semi-arid, north-western New South Wales (Australian rainfall district No. 48). It can be deduced from the curve that the mean rainfall for the years 1879–97 was 26 per cent above the 1881–1940 average. It was 11 per cent below that average during the period 1898–1946. In absolute terms, the mean annual rainfall from the beginning of records to 1897 was 16·90 in.; during the following forty-nine years it was 12·02 in. During the past ten years conditions were again more similar to those of the nineteenth century.

Fig. 2 deals with the east coast of Queensland (Australian rainfall district No. 40). The rainfall there is more seasonal but also more than three times as heavy as in north-western New South Wales. The onset of the dry period occurred two years later. It was interrupted by wetter conditions after about 1923, though a second severe drought occurred in the late '30's and early 1940's.

Conditions on the east coast of North America are illustrated by Fig. 3, which gives the mean rainfall for Charleston and Cape Hatteras. In an earlier paper[4] it had been shown that fluctuations there were paralleled by the records of other stations along the American east coast, and that the records suggest the persistence of relatively wet conditions all through the nineteenth and the later eighteenth centuries.

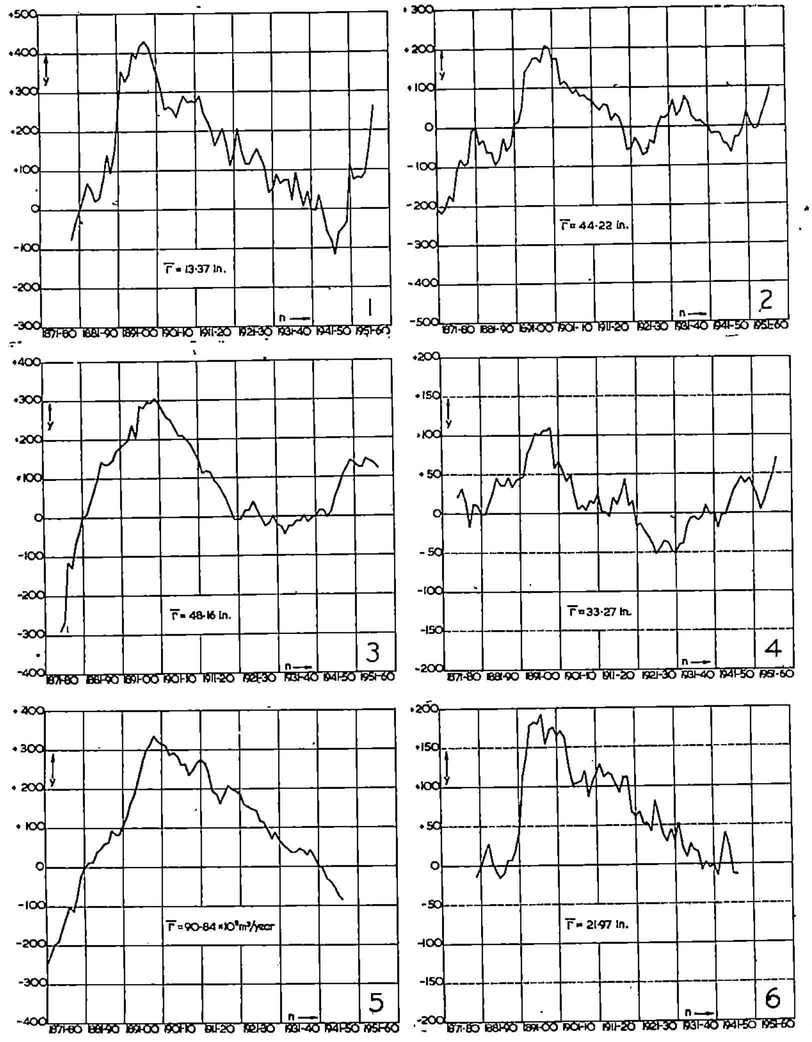
Fig. 4 shows the changes which occurred in the space-average of a large number of rainfall stations used by the Indian Meteorological Service to evaluate and forecast monsoon rainfall over the Indian peninsula. The change in the rainfall regime there was comparatively small and the vertical scale of the diagram has therefore been doubled. The same pattern of change with somewhat larger amplitude occurred in the more arid districts of north-west India and West Pakistan. All over this region the dry period which began at the end of the past century was ameliorated or terminated by about 1910.

Fig. 5 treats the discharge of the Nile at Aswan in a similar way. The difference in the mean discharge before and after 1898 amounts, in this case, to more than 30 per cent or 27 × 10^9 m.^{3}/year.

The changes which occurred in parts of South Africa are illustrated by Fig. 6, which represents the South African rainfall district No. 16*A* in the Central Cape Province. Unfortunately, data after 1946 were not available in Australia for the two African cases.

Arakawa[1] and I have shown that changes similar to those demonstrated here have occurred in maritime parts of East Asia and in the West Indies, Hawaii and other tropical stations. They can also be found in Rhodesian rainfall records. Together, this material would seem to prove the existence of parallel and rather abrupt climatic fluctuations over a large part of the Earth.

The amplitude of the change in rainfall regime was largest at the fringes of the arid zone. In the extreme case of Aden, the rainfall record shows a difference of 84 per cent between the means for the thirty years after 1894 and the preceding thirteen years of avail-



Figs. 1–6. Cumulative percentual deviations from the 1881–1940 annual mean. (1) N.W. New South Wales (Australian rainfall district No. 48); (2) Queensland Coast (Australian rainfall district No. 40); (3) Carolina Coast (mean of Charleston and Cape Hatteras); (4) India (peninsula); (5) Nile discharge at Aswan; (6) Central Cape Province (South Africa Rainfall District No. 16A)

able records. The change is also well marked along the sub-tropical east coasts of North America and Australia. In the humid tropics it appears to have been restricted to the beginning or end of the rainy seasons. Similarly, in the sub-tropical transition regions, where rain may fall both summer and winter, the same pattern of change may be restricted to the intermediate seasons of autumn and spring. The curves of cumulative deviations from the mean for these seasons for some parts of Australia and South Africa are parallel to those shown for annual rainfall and stream-flow in the present article. In some cases they show extremely large amplitudes, though the changes in annual rainfall were comparatively insignificant.

A more detailed analysis indicates that the onset of dry conditions at the end of the past century was associated with a widening of the arid zone, mainly at the expense of the equatorial summer-rainfall belt. This produced a wider separation in space and time of summer- and winter-rainfall regimes. As rain in many sub-tropical regions is associated with the seasonal migration of the equatorial rainfall belt, the narrowing of this belt caused rainy seasons to become shorter.

The observable sequence of events began in 1894 with a failure of spring rains in the 'transition' regions of South Africa and Australia. A prolonged drought commenced in 1895 on the equatorial fringes of the arid zones. From 1899 onwards dry conditions affected both the east coast of the continents and wet tropical regions with pronounced seasonal rainfall regimes. In 1902 a sudden onset of warmer conditions can be observed in the temperature records of many stations in temperate regions, demonstrated for Edinburgh, for example, by Veryard[7]. An accelerated recession of glaciers has also been reported to have started at the beginning of the century. By 1910 the seasonal pressure fluctuations associated with the Asiatic monsoon began to increase in amplitude, resulting in a return to somewhat moister conditions in India[5].

To interpret the sequence it should be considered that in spite of the marked change of rainfall in low latitudes, no corresponding change can be discerned in higher latitudes. The decrease of rainfall in low latitudes must therefore have been associated with reduced evaporation. There is no evidence of a change in solar radiation at sea-level; in fact, the decrease in rainfall may well have been associated with a decrease in cloudiness. As a result of reduced evaporation, the sea surface should have become warmer. Transport of warmer water to higher latitudes may have contributed to the temperature increases and accelerated glacier recessions there, at the beginning of the century. By 1910 the heating of the Arctic may have progressed sufficiently to cause a weakening of the zonal atmospheric circulation which would permit a stronger development of the monsoon.

Evaporation from the sea depends on the wind strength. The trade-wind circulation is largely driven by a heat source associated with the liberation of latent heat in precipitation, and by a cold source associated with radiational cooling in the free atmosphere. The intensity and the difference in the level of these two sources determine the efficiency of the conversion of thermal into kinetic energy, and hence the strength of the trade circulation.

Both the height and the intensity of radiational cooling from the troposphere are affected to some small extent by ozone. Plass[8] calculated that comparatively minor changes in the ozone distribution could change the equilibrium temperature at the ground and at the top of cloud banks by more than 2 deg. C. In the free troposphere the heating and cooling rates due to ozone amount only to a few tenths of a degree per day, but even that may be sufficient to affect the trade circulation, which is a rather finely balanced process. The ozone layer in high latitudes is so thick that its upper strata shield it effectively against most solar influences. Changes in the ozone distribution there are mainly associated with vertical motion in the troposphere below. Near the equator the ozone is more likely to be affected directly by possible changes in ultra-violet solar radiation. Increases in short-wave radiation would tend to cause some heating and possible lowering of the tropical ozonosphere. This in turn would reduce radiational cooling in the troposphere and so decrease the efficiency of the trade circulation. It may be shown that if this effect exists, sudden changes in the tropical radiation balance would tend to cause disturbances in the atmospheric circulation pattern some two or three weeks later. This is supported by some observational evidence.

Menzel[6] and Bell[6] have discussed another possible mechanism of solar – weather relationships. They quote Craig, who found a statistically significant association of magnetic perturbations with pressure rises at 60–70° N. and pressure falls at about 40° N. It is assumed that such a pressure change would tend to oppose the accumulation of cold surface air in the Arctic. Magnetic disturbances are caused by corpuscular streams. Menzel indicates that the incoming stream may at times carry an energy density which over a limited area can be equivalent to that of solar radiation itself, and that this should cause intense heating of the surrounding atmospheric regions. Bell suggests that this causes the reported statistical changes in surface pressure. It is difficult to conceive a physical mechanism which would link high-level heating in the auroral zone with mass movements in the troposphere. If the mechanism stipulated by Miss Bell does in fact exist, it would act parallel to the one outlined above for the tropics. The increased solar activity would then tend to favour penetration of warm air into high latitudes on one hand; on the other, it would be associated with a less efficient trade circulation, decreased evaporation and a narrowed tropical rainbelt.

The tropospheric radiation balance is also affected by dust. Variations in dust content may affect in addition the available number of freezing nuclei. However, the decrease in rainfall at the end of the past century cannot be readily associated with the date of any major volcanic eruption or known change in meteoric activity; nor can this be done for the recent widespread increase in precipitation. Furthermore, these rainfall changes affected only a limited part of the globe. This seems to exclude explanations of climatic change primarily in terms of a changing number of atmospheric freezing nuclei.

To summarize: precipitation in the sub-tropics was generally above the 1881–1940 mean during the recorded part of the nineteenth century. A dry period associated with a widening of the arid belts set in abruptly at the end of the century. This lasted with only short interruption until a return of consistently wetter conditions in recent years. In several stations at the fringes of the arid zone the changes of long-term means amounted to more than 30 per cent. In climatically corresponding locations the change occurred simultaneously north and south of the equator. Tentative explanations in terms of variable solar activity are possible, but they cannot be substantiated without continuing quantitative measurements of the Sun and the upper air.

The large simultaneous change which occurred at the end of the past century at the fringes of the arid zone passed comparatively unnoticed. With the present more intensive development of marginal resources the economic effects of a similar change would be more apparent. In the case of Japan, this has been demonstrated rather strikingly by Arakawa[2]. Records of rainfall, stream flow, flood incidence, etc., which cover a limited period only, must not be used uncritically as a basis for planning costly developments of marginal water resources. The study of climatic fluctuations has therefore concrete practical implications, besides bearing upon knowledge of the past and upon interpretation of our present physical environment.

District rainfall values were made specially available by the Directors of the Australian and Indian Meteorological Services; this is gratefully acknowledged.

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[3] Kraus, E. B., *Quart. J. Roy. Met. Soc.*, **81**, 198 (1955).
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OBITUARY

Dr. A. V. Few

By the death of Dr. A. V. Few on December 24 from poliomyelitis, after a very short illness, research work on the surface chemistry of biological systems has lost one of its foremost younger workers.

Alan Victor Few was born on December 28, 1926, and was educated at Alleyn's School, Dulwich (1937–43), and then at Battersea Polytechnic, London, where in 1946 he graduated in chemistry, obtaining the B.Sc. (Special) degree with first-class honours. After a short spell in industry, he returned to Battersea in 1947 and worked with Dr. J. W. Smith. In 1949 he obtained the Ph.D. degree at the University of London for his work on the "Molecular Polarization of Amines in Solution".

However, his future interest in research was determined in 1949, when he moved to the Wright-Fleming Institute of Microbiology. Here he commenced to work on the physical chemistry of bacterial cells with Drs. P. D. Cooper and D. Rowley, work which led to the investigation of the mode of action of penicillin with the cell wall of *Staphylococcus aureus*, and emphasized the importance of studying the surface chemical properties of penicillin salts. In 1951 he moved to the Department of Colloid Science, Cambridge, with a grant from the Medical Research Council, where in the group under the direction of Dr. J. H. Schulman he commenced to study in detail the interaction of antibiotics with bacterial surfaces using surface-chemical techniques. As well as penicillin, the action of polymyxins was studied, and by the use of a low-pressure surface balance, with salt solutions as substrate, the molecular weights of polymyxins *A*, *B*, *D* and *E* were determined. In 1953 he was awarded the Ph.D. degree of the University of Cambridge for a thesis entitled "The Surface Chemistry of Certain Antibiotics".

This work had merely acted as an *apéritif*, and on his appointment to the external staff of the Medical Research Council, he proceeded with great enthusiasm to study the interaction of many other compounds with bacterial surfaces, and with cell extracts. His most recent work included investigations on the behaviour of the cyclic polypeptides, tyrocidine and gramicidin *S* at the air–water interface, the binding of surface-active agents by proteins, and an extensive study with Dr. A. R. Gilby of the interaction of surface-active agents with bacterial surfaces.

A modest man of charming disposition, he was an enthusiastic and determined research worker, always willing to discuss problems with junior workers and to give advice when consulted. He will be remembered with great affection by his colleagues and collaborators. His untimely death at an early age has robbed surface chemistry of a very active and promising worker.

His marriage to Gwendolen Mary Crookenden in 1949 was a very happy one, and there can be no doubt that his happy home-life contributed greatly to his research. He is survived by his wife and two young daughters.

R. H. OTTEWILL

University College of Science
Physics Dept.

NEWS and VIEWS

Commonwealth Trans-Antarctic Expedition

THE Commonwealth Trans-Antarctic Expedition led by Dr. Vivian Fuchs arrived at Scott Base on the Ross Sea at 1.47 p.m. on March 1, having completed the "last great journey in the world". The expedition has crossed the Antarctic Continent from Shackleton Base on the Weddell Sea, a distance of 2,150 miles, in ninety-nine days. The purpose of the journey has been to conduct a programme of scientific observations including seismic soundings, gravimetric readings, and meteorological observations in connexion with the International Geophysical Year. The survey party was accompanied by Sir Edmund Hillary, who met Dr. Fuchs at Depot 700, the last of the chain of five depots of food and fuel, established earlier between Scott Base and the South Pole. The other members of the expedition are: Warrant-Officer Roy Homard, engineer (Brixton); Ralph Lenton, wireless operator and carpenter (Coulsdon, Surrey); George Lowe, photographer (Hastings, New Zealand); David Pratt, engineer and transport officer (Bournemouth); Allan Rogers, medical officer (University of Bristol); David Stratton, surveyor and second in command of the team (London); Johannes la Grange, meteorologist (Keighley); and Geoffrey Pratt, physicist (Richmond, Surrey). They were met by vehicles and sledges manned by the New Zealand party which set out from Scott Base to accompany the expedition for the last mile or so. Dr. Fuchs was greeted at Scott Base by congratulatory messages from scientific and geographic institutions throughout the world, and from the prime ministers of the United Kingdom, New Zealand and South Africa.

A message from H.M. The Queen, who has announced her intention of conferring a knighthood upon Dr. Fuchs, said: "On the completion of your hard and adventurous journey across Antarctica my husband and I send our warmest congratulations to you and all members of the Commonwealth Trans-antarctic Expedition. You have made a notable contribution to scientific knowledge and have succeeded in a great enterprise. Well done. Elizabeth R."

Woods Hole Oceanographic Institution:

Dr. C. O'D. Iselin

DR. C. O'D. ISELIN, director of the Woods Hole Oceanographic Institution and its mainstay since it was founded in 1930, is retiring. He started his oceanographic career by exploring the Labrador current in his own schooner *Chance* in the summer of 1926. He had much to do with the building of *Atlantis*, which still serves the Institution, and took command on her first voyage in 1931. He was appointed director of the Institution in 1940, but after serving for ten years asked to be relieved of this responsibility (as Dr. Bigelow had done after the first ten years) to gain time for research. He is best known for his contributions to our knowledge of the Gulf Stream and the circulation of the western North Atlantic Ocean, but since 1940 he has devoted much of his time to the commendable task of guiding the many new developments created by the growing demands of science, defence and industry, for better understanding of the oceans. Although it has been a period of great expansion of interest in marine physics, he has maintained the traditional interest of the Woods Hole Institution in biological problems, and has done much for the local fisheries. For his work on the application of science to undersea warfare he was awarded the Legion of Merit in 1948, and he received the Agassiz Medal of the U.S. National Academy of Sciences in 1951. He had to return to the directorship of the Institution as a temporary measure in 1956 on the retirement of Admiral E. H. Smith, and will continue to be associated with the laboratory as the first holder of the chair of Henry Byant Bigelow Oceanographer recently founded by the Board of Trustees.

Dr. P. M. Fye

DR. PAUL M. FYE, the future director, is a chemist with long experience of government service and research administration. In 1942, at the age of thirty, he went to the Underwater Explosives Laboratory at the Woods Hole Institution, and became research director of the project in 1945. After the Second World War he returned to teaching for a year in the University of Tennessee, and then went to work at the Naval Ordnance Laboratory, where he was appointed associate director for research in 1956. His research interests have been in the fields of gas kinetics, photochemistry, purification of gases, high explosives damage, underwater photography, gas equilibria, liquid state and explosion of products. His work at Woods Hole and in the Naval Ordnance Laboratory has interested him in oceanographic problems, and he is well known to marine scientists in the United States.

Mathematics at Bedford College :

Prof. W. N. Bailey

The retirement of Prof. W. N. Bailey from the chair of mathematics at Bedford College, in the University of London, has been announced. Previous to his appointment to this chair in 1944, Prof. Bailey had been for many years senior lecturer in mathematics in the University of Manchester. He is best known for his work on generalized hypergeometric series, being the author of a number of papers on the subject, and of a Cambridge Tract (published in 1935) which is the standard work of reference. He is a D.Sc. of the University of Manchester and an Sc.D. of the University of Cambridge. He has held several offices in the London Mathematical Society, having been librarian during 1944–46, editor of the *Proceedings* during 1946–49, secretary 1954–55 and vice-president during 1955–57.

Dr. H. G. Eggleston

Dr. H. G. Eggleston has been appointed to the chair of mathematics at Bedford College in the University of London, in succession to Prof. W. N. Bailey. Dr. Eggleston has been lecturer in mathematics in the University of Cambridge since 1953, having previously held an appointment at University College, Swansea. He is one of the younger generation of analysts who have established their reputation since the Second World War : he graduated at Cambridge in 1943, took the Ph.D. degree in 1948 and was awarded an Sc.D. in 1954. His work has been mainly in real variable theory, particularly the theory of measure and the properties of convex sets. His distinguished contributions to these fields have been recognized by the award to him, last year, of the Adams Prize in the University of Cambridge. He is at present a member of the editorial committee of the Cambridge Philosophical Society, and a member of the Council of the London Mathematical Society.

Physiological Chemistry in the University of Reading

The Department of Agricultural Chemistry in the Faculty of Agriculture and Horticulture of the University of Reading is concerned with animal nutrition, soil science, dairy chemistry and pesticide chemistry. Modern developments in these subjects have been particularly concerned with physiology and biochemistry, which have accordingly in the past few years figured prominently in the Department's teaching and research programme. These developments, and the fact that there is no separate department in the Faculty of Science concerned with physiology or biochemistry, have resulted in the establishment of the Department of Physiological Chemistry. It will be formed in October 1958, and will have responsibilities to both Faculties. In the Faculty of Agriculture and Horticulture, teaching of, and research in, the various branches of agricultural chemistry will continue as before. This teaching consists of the provision of the honours degree course in agricultural chemistry and of what may be called 'service courses' for students reading for degrees in agriculture, horticulture, dairying and agricultural botany. In the Faculty of Science there will ultimately be courses in physiological chemistry to general and special degree levels, but these developments will depend upon the provision of more laboratory space and the recruitment of new staff. Prof. C. Tyler, who has been professor of agricultural chemistry since 1947, will become professor of physiological chemistry on September 30, and the staff of the Department of Agricultural Chemistry will form the nucleus of the staff for the new department.

European Organization for Nuclear Research

Replying to a question on February 25 regarding the laboratories of the European Organization for Nuclear Research at Geneva, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, said that the smaller nuclear particle accelerator has undergone running trials and is now available for full-scale research. The larger accelerator should come into service in 1960, and good progress is also being made with the laboratory buildings. The third annual report of the Organization will be issued shortly. The United Kingdom has provided about 40 of the total staff of 170 and is responsible for about a quarter of the total cost of the project of £15 million.

Preservation of Hadrian's Wall

The methods used in preserving Hadrian's Wall were discussed in the House of Commons on February 25. The Minister of Works, Mr. H. Molson, said in reply to a question that the methods of maintenance used by the Ministry have been approved by the Ancient Monuments Board for England. The archæological policy in carrying out the repair work is directed by the Ministry's Inspector of Ancient Monuments, who has visited the work periodically and has had the co-operation of local archæologists who are specialists on Hadrian's Wall. The day-to-day work is supervised by staff with long experience of archæological restoration. Original Roman work is exposed, retained and consolidated in the state in which it is found. Fallen stones are replaced if their original position is known, and stones on the point of falling are removed from the Wall and re-bedded. Apart from this re-bedding, there has been no dismantling of the Wall at Birdeswald or elsewhere. Roman mortar is kept wherever possible, and on exposed surfaces lime mortar is used when necessary. Mr. Molson said that he has had letters from Prof. E. Birley and Mr. J. P. Gillam, professor and reader, respectively, of Romano-British history and archæology in the University of Durham, approving of what had been done.

Ordnance Survey

In replying for the Government in an adjournment debate on February 20 on redundancies in the Ordnance Survey Department, Mr. J. B. Godber said that the Ordnance Survey had for some years been endeavouring to recruit cartographic draughtsmen and surveyors through the Civil Service Commission, but had not succeeded in filling its authorized non-industrial complement. Last summer there was a marked improvement in recruitment and more than 200 out of nearly 300 candidates were accepted. Continuance of recruitment at this rate for two or three months would have filled the authorized complement, and sufficient established recruits would have been available to replace the temporary staff during 1958. Meanwhile, the Civil Service Arbitration Tribunal awarded an increase of about 15 per cent in the rates of pay for cartographic draughtsmen, and in consequence of the Government's policy that increased wages costs falling on the Exchequer should be met by corresponding savings elsewhere, it was decided to restrict the Ordnance Survey

Department's non-industrial strength to 3,827. In consequence, the Department had 200 fewer posts and more than 200 additional draughtsmen, 50 of whom had been asked to report for duty. After considering the three alternative possibilities, the Minister decided, in view of the adverse effect on recruitment of the alternatives, the importance of a proper age distribution and of the maximum proportion of permanent staff, to advance the anticipated discharge of temporary staff during 1958, most of whom were eligible for consideration for a gratuity, and discharge some temporary staff immediately and the remainder over a period of nearly a year, not more than twenty-five in any three months. Mr. Godber emphasized that most of them had had an opportunity to become established at some time.

Agricultural Research

Mr. J. B. Godber, Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, in a written answer for the Lord President of the Council in the House of Commons on February 17, gave the total estimated expenditure on agricultural research co-ordinated by the Agricultural Research Council for the present financial year as £4,657,000, of which £2,033,000 is for animal research, £2,084,000 on plants and soils research and £350,000 on research on agricultural machinery. Research under the Ministry of Agriculture, Fisheries and Food was estimated to amount to another £166,000 on animal research and £2,000 on plant research.

University Apartheid

As a result of suggestions made by participants at the meeting on university apartheid held in London in November (see *Nature*, **180**, 1163; 1957), the International Committee on Science and Freedom, in co-operation with the World University Service, has launched an appeal for funds to help non-white South African students to obtain university education at one of the two 'open' universities, at Cape Town and Witwatersrand, before the Separate University Education Bill, reserving these universities for whites only, becomes effective in South Africa. This legislation will probably not become effective before January 1959; students who are attending a university at that time will be allowed to finish their course. If and when the Separate University Education Bill becomes effective, then the funds collected in aid of non-white students will be used to help them to attend universities outside South Africa. The World University Service will distribute the money, in the first instance, among the organizations that have been formed in South Africa, under university auspices, to assist non-white students to obtain university education. These organizations will be responsible for selecting the students who are to benefit from financial aid, and watching over their progress. Contributions to this fund can be sent to the Secretary, World University Service, 59 Gloucester Place, London, W.1, from whom further information can be obtained.

Importation into Britain of Liquid Natural Gas

A development of singular interest has recently been reported, namely, the importation into Britain of liquefied natural gas, to be used in the gas industry. There are many parts of the world in which natural gas is found, but in which there is no local demand for fuel. If the importation of such gas from such sources can supplement the fuel supplies of industrial areas on an economical basis, then the development constitutes an addition to the utilizable fuel supplies of the world. Trial shipments of natural gas, liquefied by the use of an already existing liquefaction plant constructed on a barge, are to be taken from the Gulf Coast oilfields to a depot on Canvey Island. The technical problem which appears to have been overcome is the construction of insulated tanks, and the ballasting of the ship to carry the exceptionally light cargo. It is well known that normal materials for the construction of such tanks are liable to lose the required properties at the very low temperatures involved, in this case − 260° F., for liquefaction at atmospheric pressure. A new transmission line is being laid from Canvey Island to connect with a high-pressure main already in existence between Shellhaven and Romford Works, and the gaseous methane will mix with refinery gases from the Shellhaven refinery. The vessel which is being converted for a trial load is a double-bottom cargo ship about 340 ft. in length which, after conversion, will carry about 2,000 tons of liquid methane. The methane, of which natural gas mainly consists, and a rich gas of a calorific value of 1,000 B.T.U. per cu. ft., will be transformed into gas of the normal towns' gas value of 500 B.T.U. per cu. ft. for use in consumers' appliances. The results of this venture will doubtless be watched with great interest.

Aerodynamics

A symposium on "Real Gas Effects in High Speed Flow" held at the Armament Research and Development Establishment, Fort Halstead, on February 11, was attended by representatives of the Government research establishments, the universities and interested firms. Four papers were presented, the first by K. N. C. Bray (University of Southampton) discussing "Relaxation Phenomena in a Hypersonic Nozzle". Using Prof. Lighthill's model of an ideal dissociating gas and Dr. Freeman's equation for the rate of dissociation, Bray showed that for a typical hypersonic nozzle it is unlikely that the flow would reach thermodynamic equilibrium and that the nozzle exit, that is, test conditions, would be unrepresentative of free flight. These very interesting conclusions are in direct contrast to other previous work. In "The Effect of Relaxation on Gas Properties", D. H. G. Frood (University of Liverpool) examined the flow chemistry behind a strong shock and suggested that dissociation need not occur from the ground-state only, as postulated by previous workers. This would explain the short dissociation relaxation times found experimentally. B. G. Woods (Royal Aircraft Establishment, Farnborough) presented the results of some shock-tube performance calculations in his paper "Real Gas Effects in the Hypersonic Shock Tube". He directed attention to the difficulty of avoiding slip-flow test conditions when expanding to flow temperatures representative of the atmosphere. Real gas effects reduce to less than half the testing period at shock strengths greater than 10. The final paper, on "Energy Transfer through a Dissociated Gas in Couette Flow", was read by J. F. Clarke (College of Aeronautics, Cranfield). The chemical composition of the flow was presented, together with the velocity and temperature profiles for both chemically frozen flow and flow in thermodynamic equilibrium. The heat-transfer and skin-friction relations were also described. The meeting ended with a brief tour of the hypersonic test facilities at Fort Halstead. Fuller reports of the papers presented and the discussion are to be published by the Establishment.

British Group for Engineering Applications of Automation

The British Conference on Automation and Computation is being organized in three sections, as follows: (*A*) the British Group for the Engineering Applications of Automation; (*B*) the British Group for Computation and Automatic Control; and (*C*) the British Group for the Sociological and Economic Aspects of Automation Techniques (*Nature*, 179, 948; 1957). The British Group for Computation and Automatic Control, Group *B*, was formally constituted on December 20 (*Nature*, 181, 237; 1958). At a meeting held on February 20, Group *A*, the British Group for the Engineering Applications of Automation, was formally constituted, comprising as its members twenty-one professional and learned institutes and societies with interests in this field. The objects of the Group are: to foster the development of the engineering applications of automation; to afford a common meeting ground for the adhering organizations; to maintain liaison with other Groups of the British Conference on Automation and Computation and with corresponding national committees of other countries; and to encourage and to coordinate the presentation at international conferences of British papers on subjects falling within the purview of the Group. Dr. D. F. Galloway, a member of the Council of the Institution of Mechanical Engineers, was elected chairman of the Group, with Mr. J. S. Brough and Sir Walter Puckey (past-president of the Institution of Production Engineers) as vice-chairmen. Mr. Brian G. Robbins (secretary of the Institution of Mechanical Engineers) was elected honorary secretary, and the offer of the Institution of Mechanical Engineers to provide secretarial services for the Group was accepted. Dr. Galloway, Mr. Brough and Sir Walter Puckey will represent Group *A* on the general committee of the British Conference on Automation and Computation, which is made up of three representatives of each Group. The constitution of the Group provides for the election of additional member societies: those interested should write to the honorary secretary of the Group, at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1.

Foundation of an Association of Radiobiologists

The formation of an Association of Radiobiologists has been under consideration for some time (*Nature*, 180, 411; 1957). At a recent meeting of the Radiation Research Visiting Club, a steering committee was set up to propose the constitution of some form of association which would not jeopardize the future of the Club as it is at the moment. The Radiation Research Visiting Club has been invited to visit the Experimental Radiopathology Research Unit, at Hammersmith Hospital, on May 9 and 10, and an open meeting is to be held on May 9 at 5 p.m., at which the steering committee will formally propose the formation of an Association. The question as to whether an Association should be formed and, if so, the general nature of its constitution, will be debated. If it accords with the wishes of the meeting, an Association will come into being at this meeting and a body of persons will be elected to draw up rules and to attend to any other business of the Association which the meeting shall direct. Any interested person who wishes to attend this meeting, and who has not previously been in contact with the Radiation Research Visiting Club, should communicate with the Director, Experimental Radiopathology Research Unit, Hammersmith Hospital, Ducane Road, London, W.12.

Trace Metals and Nitrogen Metabolism

In an investigation of the function of trace metals in the nitrogen metabolism of plants, D. J. D. Nicholas (*Annals of Bot.*, N.S., 21, 587; 1957) has pointed out that trace metals have been found to be associated with flavoproteins, a number of which are key enzymes in the nitrogen metabolism of plants. Thus, molybdenum is a constituent of nitrate reductase which catalyses the reduction of nitrate to nitrite in some bacteria, fungi and higher plants. During the enzymic reduction of nitrate a one-electron change is involved, $Mo^{6+} \rightleftharpoons Mo^{5+}$. Nitrite and hyponitrite reductases both require iron and copper and flavin for maximum activity and are inhibited by uncoupling reagents so that a phosphorylation takes place at these two reductive steps. Hydroxylamine reductase is a flavoprotein dependent on manganese, but, as with nitrate reductase, it is unaffected by uncoupling reagents. An aromatic route may also exist in plants for the reduction of organo-nitro compounds, but it is more likely that the aliphatic route is the primary reductive pathway.

Molybdenum, vanadium, tungsten and iron may all be involved in the process of nitrogen fixation in free-living micro-organisms and in the root-nodule bacteria. The suggestion that the enzyme hydrogenase is coupled to nitrogen fixation is not borne out by the results of valency experiments with molybdenum and vanadium, which show that an active hydrogenase does not necessarily result in a vigorous fixation process. Although molybdenum has been shown to be a constituent of hydrogenase from *Clostridium pasteurianum*, experiments in the Long Ashton Research Station laboratory show that a deficiency of iron only reduced the enzyme in this organism and in *Azotobacter*. Both molybdenum and iron, however, are essential for nitrogen fixation. In some strains of *Azotobacter*, vanadium or tungsten can partially replace molybdenum for nitrogen fixation.

The Folklore of Birds

A survey of English folklore is being made by the Department of English in University College, London, under the guidance of Prof. A. H. Smith, with the assistance of Mr. J. McN. Dogson. The object of this survey is to collect an archive of folklore materials rather than to prepare, in the early stages at least, studies and monographs on particular aspects of folklore. A large and representative body of voluntary collectors and informants from all parts of the country is needed, and those who are interested should write for information to the English Folklore Survey, University College, Gower Street, London, W.C.1. Questionnaire No. 8 of the English Folklore Survey deals with birds. It seeks information on the popular lore relating to birds, on popular beliefs about the physical appearance, habits and life-cycles of British birds, both wild and domestic, on any association of birds with good or ill luck, or with weather, etc. Informants are requested to send in information referring to various aspects of bird-life in folklore discussed under fourteen headings. British ornithologists and especially bird watchers should be interested in the work carried on by the survey.

Radiofrequency Spectroscopy Group

A discussion will be held on "High Resolution Nuclear Magnetic Resonance" in Oxford during April 21–22, organized by Dr. R. Richards. Limited accommodation will be available in college for those who wish it. Reservation forms for this should be obtained from Dr. R. Richards, Lincoln College, Oxford. It is hoped that there will be contributions on the theory of high-resolution spectra, its application to organic and inorganic chemistry, and on the design of spectrometers. It is not intended to have any introductory accounts of the subject. Another meeting will be held during September 22–23, at Newcastle, on "Magnetic Resonance in the Solid State", organized by Dr. E. E. Schneider. Further information about these meetings and the Group can be obtained from Dr. D. J. E. Ingram, Honorary Secretary, Radiofrequency Spectroscopy Group, The University, Southampton.

Physical Society Exhibition

The Physical Society's annual Exhibition of Scientific Instruments and Apparatus will be held in the Old and New Halls of the Royal Horticultural Society, Westminster, S.W.1, on the following dates: March 24, 10.30 a.m.–7 p.m. (Fellows and Press only, 10.30 a.m.–2 p.m.); March 25, 10 a.m.–9 p.m.; March 26, 10 a.m.–7 p.m.; March 27, 10 a.m.–4.30 p.m. The size of the Exhibition is expected to be similar to that of previous years, including 133 exhibitors, and a large number of universities, hospital physics departments and research organizations are again participating, thus assuring a high proportion of purely research exhibits. The following discourses, to be delivered at 5.45 p.m. on the dates indicated, are to be given: March 24, "Goethe's Colour Experiments", by Mr. M. H. Wilson (Goethean Science Foundation); March 25, "Some Uses of Physics in Archæology", by Dr. E. T. Hall (Research Laboratory for Archæology and History of Art, Oxford); March 26, "Some Recent Investigations with Aircraft on the Physics of Clouds and Rain", by Mr. R. J. Murgatroyd. As in previous years, the Society is publishing a "Handbook of Scientific Instruments and Apparatus" in connexion with the Exhibition (6*s.* net or 7*s.* 8*d.* post paid). All inquiries should be addressed to the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

University News:

University College of Rhodesia and Nyasaland

Lever Brothers (Rhodesia), Ltd., has given £10,000 to the University College of Rhodesia and Nyasaland to endow a Research Fellowship. The Lever Research Fellowship will be of the value of £650 per annum, and preference in its award will be given to male graduates who wish to pursue advanced study and research in chemistry, chemical engineering or allied subjects. There are no restrictions of race or colour for candidates, who must normally be residents or children of residents in the Federation of Rhodesia and Nyasaland.

Sheffield

The following have resigned: Prof. R. P. Jepson, on his appointment as professor of surgery in the University of Adelaide; Prof. W. Hobson, on his appointment as medical officer in training and education in the World Health Organization Regional Office, Copenhagen.

The University has received the following grants: £2,000 a year for the next five years from the Town Trustees. This will be used for strengthening the recently created Department of Psychiatry. 8,500 dollars from the Rockefeller Foundation for research in microbiology.

Announcements

The following awards have been announced by the Royal Society of Edinburgh: Keith Prize, 1955–57, to Dr. I. M. H. Etherington, for his papers on algebra published in the *Proceedings* of the Society during the period of the award and for his earlier contributions in the same field; Neill Prize, 1955–57, to Monica Taylor, for her joint paper published in the *Proceedings* of the Society during the period of the award and in recognition of her distinguished contributions to protozoology.

Dr. D. G. Evans has been appointed director of the Division of Biological Standards at the National Institute for Medical Research in succession to Dr. W. L. M. Perry, who is going to the chair of materia medica in the University of Edinburgh.

The annual open day of the Glasshouse Crops Research Institute will be held on June 11. Further information can be obtained from the Institute, Worthing Road, Rustington, Littlehampton, Sussex.

The 1958 annual conference of the Textile Institute will be held at Edinburgh during May 12–16. The subject will be "Fibre Blends and Mixtures". Further information can be obtained from the Textile Institute, 10 Blackfriars Street, Manchester 3.

A general discussion, organized by the Faraday Society, on "Configurations and Interactions of Macromolecules and Liquid Crystals" will be held in the Department of Chemistry, University of Leeds, during April 15–17. Further information can be obtained from the Secretary, Faraday Society, 6 Gray's Inn Square, Gray's Inn, London, W.C.1.

The Institution of Electrical Engineers is holding an International Convention on Microwave Valves during May 19–23. Further information can be obtained from The Secretary, Institution of Electrical Engineers, Savoy Place, London, W.C.2.

The third congress of the International Federation of Prestressing will be held in Berlin during May 5–10. Further information can be obtained from Mr. Philip Gooding, Secretary, Prestressed Concrete Development Group, Terminal House, Grosvenor Gardens, London, S.W.1.

The eighth annual meeting of the Société de Chimie Physique, which is to be held in Paris during May 27–30, will be devoted to a discussion on "Transferts d'Energie Lumineuse et Photosensibilisation". Further information can be obtained from Prof. G. Emschwiller, Ecole Supérieure de Physique et de Chimie, 10 rue Vauquelin, Paris Ve.

Erratum. In the communication entitled "*Iso*leucine and Allo-*iso*leucine" by Anna W. I. van Dam-Bakker in *Nature* of January 11, in line 8 on p. 117, the comment "erroneously called threonine by Shulgin" is incorrect; the phrase should read "an allo-configuration is also possible for hydroxyproline, hydroxylysine and threonine, which also contain 2 asymmetric carbon atoms".

INDUSTRIAL CARBON AND GRAPHITE

THE rapidly developing interest in carbon and graphite was demonstrated by the presentation of more than sixty papers, running in preprint form to more than 500 pages, to the Conference on Industrial Carbon and Graphite organized by the Society of Chemical Industry and held in London during September 24–26. In part, the enhanced importance of these materials has arisen from the employment of graphite as a moderator in nuclear-power production, but the use of industrial carbon in many other branches of industry has also increased greatly in the past two decades.

The Conference was opened by Dr. H. K. Cameron, who surveyed the traditional uses of carbon, and modern developments from them, and ventured to predict some of the problems of carbon technology which might be solved in the future.

Historically, the expanding industrial use of carbon has depended mainly upon the evolution of a technology for the conversion of the irregular piece of coke or char resulting from the carbonization of organic matter into strong, rigid, macroscopically homogeneous forms suitable for industrial application. The basic process has remained unchanged for a century. The primary coke is ground (to form the 'grist'), mixed with a suitable binder (such as tar or pitch), pressed or extruded into the desired shape and calcined. The binder decomposes to form a secondary coke which links together the particles of the primary coke to produce a rigid product. At this stage the material is called 'industrial carbon'. In recent years a further process is often added in which the carbon is heated in an inert atmosphere (such as argon) to temperatures in excess of 2,000° C. to induce graphitization. The product is 'industrial graphite'.

Materials prepared in this way find many applications. Among those dealt with specifically at the Conference were: as electrodes in both electrochemical furnaces (used, for example, in aluminium production) and in melting furnaces; as moulds, crucibles and dies in metallurgical processes; in the construction of chemical plant to withstand either high temperatures or corrosive conditions; as carbon brushes for electrical machines; as dry bearings; as electrical resistors both in the electronics industry and in heavier electrical applications; and finally as a moderator in nuclear piles.

Industrial carbon and graphite differ from natural graphite in many important respects, most of which were referred to during the Conference. These differences are structural rather than chemical in origin, and are associated with features ranging from variations in the crystal lattice of sub-microscopic regions of the material, to heterogeneity on the microscopic and occasionally on the macroscopic scale which results inevitably from the method of manufacture. The properties of the final product depend on many factors, including the nature of the basic raw material, the way in which it is carbonized, the method of grinding, the size distribution and the shape of the grist particles, the nature of the binding agent and the amount used, the method of forming the product (pressing or extrusion), the conditions of the second carbonization and finally the temperature of graphitization and the atmosphere in which it is carried out. These factors often interact with one another, so that the problem of understanding the nature and properties of a given industrial carbon or graphite in relation to its method of preparation is exceedingly complex, and in the absence of a fundamental understanding, a substantial body of empirical technique has been built up in the industry. The papers presented to the Conference show, however, that real attempts are being made to rationalize knowledge of the fundamental processes, and to relate this knowledge to the properties of the final product by the correlation of information derived from a wide range of experimental methods.

The property which reflects most directly the difference between artificial carbons and natural graphite is the bulk density: industrial materials rarely exceed a density of 1·75 gm./cm.^{3}, whereas graphite has a density of 2·26 gm./cm.^{3}. This difference arises from structural differences at all size-levels. It is generally presumed (although not definitely proved in all cases) that the basic structural unit of carbonized materials is the C_6-ring, although the presence of some side-chains with free valencies is also assumed. Evidence for the presence of free radicals comes from electron-resonance studies (Ingram). These rings are fused together to form planar aggregates which may be complete or possess 'holes' of various kinds. X-ray studies show that natural graphite consists of perfect planes of fused rings, arranged parallel to one another with a definite interlayer spacing, and with the orientation of each plane relative to its neighbour completely defined. The energies of the electronic configurations in the graphite structure are not yet calculable with high accuracy, and an attempt to obtain evidence about them by studying the reflectance of light of various wave-lengths by polished graphites was reported to the present Conference by Humphreys-Owen and Gilbert. Less-perfect structures of lower density occur when the relative orientation of the rings in adjacent planes is random, and the average distance between planes increases slightly: the structure is said to be 'turbostratic'. Amorphous carbons have also been subjected to careful study by X-ray techniques, and it is concluded that they consist of graphite-like crystallites, the size of which may range from the order of ten angstrom units to several hundred, interspersed with turbostratic and possibly even more randomly arranged carbon. In addition, nearly all carbons have a characteristic porous structure consisting of cavities the dimensions of which may range from a few angstroms to tenths of a millimetre, and the shapes of which may vary widely. Each individual carbonized material has its own characteristic structure, while the industrial carbons under discussion consist of an intimate blending of two such structures, one arising from the primary coke and the other from decomposition of the binder. Some of the more important implications of this two-component structure were brought out in Mrozowski's general introduction to the Conference, which stressed not only the complexities of the microstructure of artificial carbons, but also the analogy between them and compressed powders.

X-ray studies have formed the basis of many of the conclusions regarding the molecular structure of carbon and graphite, and a survey of diffraction methods (including neutron diffraction) was given by Bacon, while a rapid X-ray method for determining the preferred crystallographic orientation was described by Ali, Fitzer and Ragoss. Recent work on the structure of carbonized coals was reported by Diamond and Hirsch, while the carbonization products of materials of known composition have been examined by Stadler and Thomson (single crystals of flavanthrone) and by Winslow, Matreyek and Yager (vinyl polymers). Further work on the progress of graphitization at high temperatures, as revealed by X-ray studies, was reported by Maire and Mering, and by Steward and H. W. Davidson. Correlation is found by Adamson and Blayden between the size of the graphite crystals and the magnetic susceptibility, and these authors used the latter property to study the dependence of crystallite size on starting material and thermal treatment. Other properties which are closely related to the structure of carbons are the thermal and electrical conductivities. They depend mainly on the size, orientation and density of the crystallites, but in different ways in various ranges of temperature. Consequently, measurements of thermal and electrical conductivity over a wide temperature-range are important (Berman; Powell; Albert and Parisot; Mason), especially when associated with X-ray studies (Bowman, Krumhansl and Meers). The porosity of carbons is a property which in some applications is desirable and for many others undesirable. Reliable methods for assessing the total porosity and its distribution in terms of the size of cavities are therefore important. Bond and Spencer reviewed methods developed at the British Coal Utilization Research Association for studying the ultra-fine structure of coals and carbonized coals, while Academician Dubinin surveyed Russian work on the correlation of adsorptive properties with porous structure. A paper by Cadenhead and Everett was concerned with the elucidation of the porous structure of carbons by a study of the thermodynamics of adsorption processes. Gas permeability methods are widely used for assessing porosity, although the fundamental theory of the method is far from satisfactory. Papers by Wiggs and by Hutcheon, Longstaff and Warner discussed both the theory and the interpretation of experimental results on industrial graphites.

The major part of the porosity of an industrial carbon is associated with the secondary coke formed by decomposition of the binder. Consequently, it is desirable to use the minimum amount of binder. The grist aggregate must therefore have a minimum of inter-particle voids, and optimum packing is achieved by blending different particle sizes in the grist. The shape as well as the size of grist particles is also important, and this has been studied by Amstein and Watson. Furthermore, extruded carbons are anisotropic and this is in part controlled by the particle shape (Grossman). The choice of suitable binder is of great importance, and several papers (Darney; McNeil and Wood; Blakeley and Earp; Lessing) were devoted to this problem. A systematic investigation of the variation of the properties of carbons, in particular mechanical strength and electrical resistivity, with amount of binder and with the composition of the grist, was reported by Fialkov.

The manufacture of electrodes having long life is important economically, both in the production of aluminium and in electro-melting: half a ton of carbon is consumed for each ton of aluminium produced, while 15 per cent of the cost of converting scrap steel to ingots arises from electrode wear. Two problems in the production of electrodes for aluminium cells were discussed. The first is concerned with the cracking of electrodes during baking, which causes uneven current distribution. According to Pratt, this arises from shrinkage of the grist during the second carbonization, and he has studied the shrinkage of cokes at 1,000° C.; this is shown to be related to the hydrogen content of the coke. Disintegration of the electrode surface, arising from preferential oxidation of one component of the carbon, also makes an important contribution to electrode wear, and Bowitz, Böckman, Jahr and Sandberg attribute this to the greater porosity and reactivity of the coked binder. The mechanism of electrode consumption in melting furnaces is not clearly understood, and the work of Ravenscroft and Preston on the distribution of electrode wear at different points on the surface as a function of electrode current and voltage provides some basic information about the phenomenon.

Problems of electrode life, as well as many industrial applications of carbon, depend upon the reactivity of carbons towards oxidizing gases. A fundamental study by J. D. Watt and Franklin in which changes of structure arising from oxidation were studied by X-ray methods suggests that the most reactive part of a porous carbon structure consists of single, unstacked, graphite layers which can adsorb oxygen on both faces. The kinetics of reaction of carbon with various gases continues to be studied, and a number of recent researches were reported (Graham, A. R. G. Brown, Hall and W. Watt; Earp and Hill; Walker and Nichols; Day, Walker and Wright); particular emphasis is now being placed on measurements at high temperatures (1,500–2,500° C.) and at high rates of gas flow. The effect of surface oxides on the reactivity of carbon was the subject of a paper by Harker, Marsh and Wynne-Jones.

In the electrical industry great importance is attached both to the electrical conductivity of carbon, and to the contact resistance at carbon–carbon and carbon–metal interfaces. A review of developments in applications of carbon to current-collection was given by Vaughan, with particular reference to behaviour under high-altitude conditions, where, in the absence of water vapour, the friction between brush and metal commutator increases and rapid wear ensues. Experimental studies of the electrical properties of sliding contacts at low gas-pressures were described by Millet. In these applications metallized types of graphite are often employed, and details of the production of copper–graphite materials were given by Beech and Price. The contact resistance at carbon–carbon surfaces, and its dependence on load, is important both in high-duty variable carbon-plate resistances and in carbon microphones. The former application was discussed by Knowles, while measurements of the electrical characteristics of microphone carbon as a function of frequency were reported by Fairweather, Frost and Shirley. Blanchard presented results on the electrical conductivity characteristics of a wide range of compressed carbon blacks, in particular in relation to their dependence on heat treatment, while Dawson and White reported on the properties of resistors made from various carbon blacks bonded with resins.

Methods of preparing dense, unreactive carbon are of great importance. If successful, they would find application both in bulk form and as surface coatings for less dense material. Recent work (A. R. G. Brown and W. Watt) shows that dense impervious material is produced by the thermal decomposition of hydrocarbons at a hot surface (1,600–2,100° C.), and surface coatings of this kind enhance the chemical resistance of more reactive graphites. The kinetics of deposition of carbon films from benzene and toluene vapour carried by a stream of helium in a rather lower temperature range (850–950° C.) have been studied by Kinney and Murphy.

Carbons as normally prepared may contain, besides small amounts of trace elements, a substantial amount of hydrogen, oxygen, nitrogen and sulphur. These elements may have an important influence on the structure, and Riley, Baraniecki and Streeter reviewed the properties of these 'heterocarbons'. The particular case of graphitic oxide has been studied extensively in the past thirty years: the present position was reviewed by de Boer and van Doorn in the light of their more recent work.

Considerable emphasis was placed on industrial carbon as a constructional material. Reviews of its applications in various industries were contributed by Lyddon and Hurden (mechanical engineering); K. F. Anderson (chemical engineering); H. D. Anderson and Ward (chemical plant); Hilliard (heat exchangers); Haines (high-temperature furnaces); G. E. Ross and D. W. Brown (metallurgy); Lakin and Mackenzie (blast-furnace linings). The mechanical properties relevant to these applications were discussed by H. W. Davidson, Losty and A. M. Ross, and by Arragon and Berthier, while methods of non-destructive testing were outlined by T. D. Davidson.

The most important new field of application of industrial graphite is in nuclear-power plant, where to the desirable properties of high density, low reactivity and mechanical strength, must be added the over-riding requirement of high purity. Discussions of this application and of the required properties were contributed by McIntosh, Heal and Cowan; Lockett; and McIntosh, O'Driscoll and Tyzack. Special attention has to be paid to the effects of high temperatures and of neutron irradiation, and papers by Hove and by Simmons were concerned with these problems. In studying the suitability of various raw materials and manufacturing procedures for nuclear-graphite production, large-scale experimental plant is needed, and that recently constructed at Harwell was described by Price and Yeats. The problems arising in the manufacture of nuclear graphite were discussed by Cornault and Rochettes. High purity may in principle be attained either by using very pure raw materials, by the purification of ordinary graphite or by purification in the course of the final graphitization. The latter method is that actually chosen, and a study of the purification of graphite by treatment with gaseous chlorine or a chlorofluorohydrocarbon during graphitization was the subject of a paper by Odening and Bowman. The resultant purity depends on the permeability of the carbon: the high density and low porosity desirable in graphite for use as a moderator may not be compatible with gas-purification methods. Methods of estimating the purity of reactor graphite were mentioned in several papers—the usual method being to compare the effect of different graphites on the time required for the reactor to become critical; detection and estimation of rare earths by the radioactivation technique and a study of the changes of rare earth content in the course of graphite manufacture was described by Decour, Leveque, Hering and Jouquet. The alteration of properties brought about by purification was discussed by Baroin.

During the period of the Conference an exhibition of industrial carbon and graphite was held in the Department of Chemical Engineering, University College, London; and this, together with several social functions, contributed to the success of the Conference.

D. H. EVERETT

SAFETY IN MINES RESEARCH

THE scope of the Safety in Mines Research Advisory Board was widened early in 1956 when the Board was re-appointed, with Prof. R. V. Jones as chairman, and given new terms of reference which ask the Board "to keep under review and advise the Minister of Power on the general scope, organization and progress of research work on safety in mines". Until then the scope had been restricted to the Ministry's research work on the subject. It is appropriate, therefore, for the thirty-fifth annual report on safety in mines research (London: H.M. Stationery Office, 1958) to include a short account of the ninth international conference of directors of safety in mines research and to give in appendixes not only synopses of recent publications of the Safety in Mines Research Establishment, but also a list of papers presented by all the delegates to the ninth international conference.

The report, however, is essentially a report of the work of the Safety in Mines Research Establishment for the year 1956. During the year the move to new premises, in Broad Street, Sheffield, housing the engineering sections and much of the Technical Information Service Department, was begun. It is significant that the acute problem of accommodation has resulted "as much from increasing the strength of research teams to the necessary extent, as from the increasing complexity of the work". As the director of the Establishment, Mr. H. T. Ramsay, remarks in his introduction to the report, "Mining research has been in progress for a long time and the easier answers have usually been found; real advances against the remaining hazards will only be made by a penetrating study of their mechanisms and, so far from becoming easier, one may expect the Establishment's work to become more difficult".

Most of the report is concerned with the research of the Establishment into the hazards of mining. There are eight main sections, namely, explosives and blasting devices, the explosion hazard, breathing apparatus, fire hazard, engineering and metallurgical research, dust control and pneumoconiosis hazard, miscellaneous, and testing services. The wide scope of the work of the establishment is illustrated by the fact that within the eight main sections there are nearly a hundred sub-sections dealing with such widely different topics as pulsed infusion of coal, ignition of gases by sparks of various origins, fighting roadway fires with foam-plugs, atomic hydrogen welding of wrought iron, catalytic oxidation of exhaust gases of Diesel locomotives, deposition and dispersion of respirable dust, automatic assessment of miners' pneumoconiosis from chest radiographs, safety helmets and factors affecting the movement and control of rats in drift mines.

It is not easy to select from the necessarily highly condensed accounts of investigations included in the report examples which illustrate adequately the scope and quality of the work of the Establishment; accordingly, the largest sections, those devoted to the explosion hazard and to engineering and metallurgical research, are selected for mention. The report points out that, during the decade 1946–55, there was a marked decrease in the number of casualties from explosions in mines in Great Britain, due not to any great reduction in the number of gas ignitions but to reduced severity of the explosions as measured by the number of casualties. This improvement may well be due to improved mine ventilation and gas control, with consequent reduction in the size of accumulations of gas available for inflammation. It is felt by the Establishment that current research on the causes of ignition of gas in mines should be supplemented by research on the movement of firedamp in mines and on the dispersal of accumulations of gas. Coal-dust explosions in mines are generally initiated by explosions of methane, so that attention continues to be directed towards the ignition of methane, particularly by frictional sparking such as may occur when certain light alloys strike rusty steel, or from steel chock releases, or from auger mining, or from rocks during drilling.

So far as coal-dust explosions are concerned, the report includes work on binding of coal dust by dilute solutions of adhesive and by aerosols, and work in the Establishment's explosion gallery at Buxton on the propagation and prevention of propagation of a coal-dust explosion. The work in the gallery includes an investigation on the dispersion of dust by, and in, the blast from an explosion. An interesting part of that section on explosions deals with the application of gas chromatography followed by a hot-wire detector (or for some purposes an infra-red analyser) for analysis of mine atmospheres, natural gases from boreholes in coal and ironstone mines, fire products and Diesel exhausts.

The section on engineering and metallurgical research shows that light-weight roof-bars were studied during 1956 especially in respect of their stability in temporary support systems at roadheads. Attention was given to the development of convenient and rapid non-destructive methods for checking the soundness of welds in chain links, of particular importance, for example, in cage suspensions. Several failures in ropes and components of couplings and draw gear were examined, and as a result theoretical and experimental work was begun to find improvements in design or in choice of material; photo-elastic methods are being used increasingly in this work. Mining gear may be subjected to corrosion arising from, for example, moist salt spread in mines to bind dust, from acid pit-water, or from the reaction products between salt and acid pit-water. The effects of potentially corrosive materials on mining gear, including wire ropes, were examined during the year and the influence of certain inhibitors was investigated.

As mentioned above, it is not easy to deal adequately in this short notice with the wide variety of work summarized in the report. The report will be read, as the earlier reports of the Establishment have been, with real interest by those connected with the mining industry. It can be recommended, also, to those who are not connected with the mining industry, not only because of the wide range of problems receiving attention but also because several of the problems are similar to those found in other industries.

S. G. Ward

BIOLOGISTS IN THE TROPICS

On July 5 a meeting was arranged by the Institute of Biology to discuss the professional problems of biologists serving overseas. A report of the meeting has been published in the Institute's *Journal* (4, No. 4; 1957). The meeting was opened by Dr. Kenneth Mellanby, lately principal of the University College, Ibadan, Nigeria, who said that many of the economic problems of tropical territories could only be solved by biologists, for whom there are an immense number of fascinating and important problems waiting to be tackled. So far, there has been very little serious biological research in any part of the tropics. Hard-pressed government officials in a number of territories have done much fine work, but shortages of staff and the constant preoccupation with *ad hoc* measures have meant that the fundamental work on which practical measures should be based has not been tackled. At times, the need for such fundamental work has not even been realized; in Nigeria the belief was that there was no need for any work on cocoa and its pests because this was all covered by the work of the Cocoa Research Station in Ghana. There are many more entomologists in Britain studying the wheat bulb fly than there are in West Africa concerned with the pests of cocoa, the mainstay of the economy of Ghana and Western Nigeria.

Dr. E. E. Weatherly, who some years ago worked as a botanist in the Department of Agriculture, Uganda, indicated that there could be no better experience for a biologist of Ph.D. level than that of spending a few years of research in a tropical country. The major professional difficulty in working in tropical parts is that of isolation. First, there is isolation from libraries. To a scientist the library comes second only to the laboratory, but a library is more difficult and expensive to equip and maintain than a laboratory. This difficulty is inherent in spreading out research over isolated and remote stations, for even reasonably useful libraries simply cannot be maintained at such centres.

Next to the absence of books comes the absence of professional colleagues. Except for the very few, discussion of work with others in the same or related fields is a vital stimulus to progress. Few specialists in the tropics can expect such contacts.

Professional isolation has a secondary effect: it can lead only too easily to professional oblivion. The young man overseas, having no opportunity for the self-advertisement provided by conferences and meetings, remains unknown to those of his seniors who might help promote his professional interests.

The greatest problem of all who serve overseas, according to Dr. Weatherly, is education of children. It looms even larger than the purely professional problems, but it inevitably leads to a vital question which is professional in nature. This is the question of length of service. In view of professional and family difficulties, the ideal arrangements would seem to be five, ten or even fifteen years of service, with the opportunity of a return to the United Kingdom when professional or family circumstances demand.

The not-so-young biologist who wishes to resign is confronted with the problem of obtaining a post in the United Kingdom; for this the specialist is better placed than his administrative colleagues. A general agricultural officer is unfit for a return to Britain in proportion to the length of his service. His intimate knowledge of the agriculture, people and climate of an area in Africa is not likely to impress a committee of the Ministry of Agriculture in Britain, or a commercial firm wanting a farm manager.

The difficulties of the biologist research officers wishing to return to the United Kingdom are considerable. For a man who obtains a Colonial Office scholarship immediately after his first degree, the possibility of obtaining a higher degree is precluded. In any event, the type of work carried out in a government department might not be suitable for submission as a thesis. Moreover, his work, although very valuable to his employers and perhaps very valuable as experience to himself, may have led to little publication except in local reports or journals. Then there is the disadvantage of physical remoteness. The head of a department receiving applications for a post is likely to view one from overseas less favourably than others. Nor can the attitude which many senior biologists have to work overseas be precluded. In most branches of biology, tropical experience is not at a premium—it is often regarded as an improper and largely irrelevant version of experience gained in the United Kingdom.

This misconception is rendered possible by the fact that so many senior biologists themselves have never visited, or worked in, the tropics and are in no position to assess the value of tropical experience. Many biologists who have spent some years of successful research in the tropics might reasonably look forward to a biological post in one of the universities in the United Kingdom, but the pattern of university recruitment to-day makes their chances very slender. University teaching has become a profession which may be entered at the bottom, occasionally at the top, but very seldom in the middle.

Finally, there is the problem with which a university tutor is faced in advising students whether to take up tropical work. Is a young man to-day well advised to enter a field of work which seems to be contracting? Self-government in overseas territories and the increasing education of Africans and other peoples up to university-level must inevitably mean fewer posts for Europeans. This would seem to point to scientific careers in the tropics being in many cases rather short, at all events much shorter than thirty years.

Guarantees of security for young men who wish to venture overseas are essential. As biologists they are taking great professional risks and their interests should be safeguarded. Such safeguards are expressed by the Colonial Office in "Reorganization of the Colonial Service, 1954"* as follows: "They will be given adequate notice of any intention to terminate their employment in consequence of constitutional changes, and Her Majesty's Government in the United Kingdom will endeavour to find them alternative employment should they so desire". The word 'endeavour' should be replaced by 'undertake'.

Other contributions to this important meeting were made by D. Rhind, Secretary for Colonial Agricultural Research, who talked about biological research in Colonial territories; Prof. A. H. Bunting, who considered the problems of biologists in the transition of Colonial countries to independence; Prof. G. F. Asprey, who examined the problems of biologists in university colleges overseas, and Prof. R. D. Purchon, of the University of Malaya, who was particularly concerned with the problems of his own university.

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* Colonial No. 306. (London: H.M. Stationery Office.)

TRADE WASTES

As a result of public demand for the abatement of pollution of rivers, the River Boards Act, 1948, and the Rivers (Prevention of Pollution) Act, 1951, all those concerned with the disposal of polluting liquids, and particularly industrialists and local authorities, have found it necessary in recent years to give serious consideration to the development of efficient methods of treating such liquids to reduce their polluting character. During the past three years, several symposia on industrial effluents have been held in Britain, and a report has been issued* on the proceedings of a successful and well-attended symposium held by the Midland Branch of the Institute of Sewage Purification at the University of Birmingham on April 9, 1957. The chairman was Dr. A. Key, senior chemical inspector, Ministry of Housing and Local Government, and the proceedings were opened by Alderman A. Paddon Smith, chairman of the Birmingham Tame and Rea District Drainage Board. The papers presented dealt with the problems concerned with acceptance of trade effluents into public sewers, the obligations imposed on local authorities and traders by the rivers pollution prevention Acts, and methods of treatment of particular waste waters.

Mr. M. A. Kershaw, in a paper on the first of these subjects, makes the point that one of the effects of industrial expansion is the aggravated pollution problem occasioned by increased volumes of trade effluent, frequently of a highly complex character. He accepts the view that trade effluents are best disposed of by discharge to the public sewers, provided that treatment is applied to the effluents so that they will not damage the sewers, or cause danger to workmen, or interfere with the processes of purification of sewage. Methods of removing constituents most likely to cause difficulty are outlined, and an organized system of trade effluent inspection and control operated by the local authority is advocated to ensure co-operation between the authority and manufacturers.

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* Symposium on Trade Wastes held at the University of Birmingham. Pp. 167. (London: Joint Secretaries, Institute of Sewage Purification, 1957.) 10s.

Dealing with the obligations imposed by the pollution prevention Acts, Mr. M. Lovett directs attention to the fact that, although during the interim period of seven years after the passing of the 1951 Act a river board may not, without the consent of the Minister of Housing and Local Government, institute legal proceedings against a person who "causes or knowingly permits to enter a stream any poisonous, noxious or polluting matter", the consent of the Minister is not required for proceedings against an offender who fails to comply with valid conditions of consent relating to a new discharge. A new feature which is referred to is that river boards may now 'apprehend' that a contravention of the Act is likely to occur as a result of a proposed use of a stream, and, subject to the consent of the Minister during the interim period, may obtain an order prohibiting the use complained of. The author, however, emphasizes that river boards are much more anxious to abate pollution than to institute legal proceedings.

In four of the five examples of methods of treatment of industrial organic wastes brought together by Dr. D. H. Sharp, biological oxidation forms the final stage, after preliminary chemical and physical treatment to remove substances which would otherwise interfere with biological action. Perhaps the most interesting of these preliminary treatments is that applied to the waste water from the manufacture of pesticides. These contain bactericidal and toxic compounds which are removed partly by adsorption on activated charcoal and partly by chemical precipitation before the neutralized and diluted waste is applied to percolating filters.

The paper on acid wastes by Dr. S. H. Jenkins and Mr. C. H. Hewitt is of particular interest in the Birmingham district, where a great deal of metal working is done, with consequent discharge of acid liquors and washings from preliminary pickling of the metal. Examples of acid discharges are quoted which reduced the pH value of sewage reaching a treatment works to less than 3 for several hours. At this degree of acidity damage to the sewer occurs, the conversion of urea to ammonia is inhibited, and there is serious depression of the biological activity on which purification of sewage depends. Neutralization of acid discharges is therefore essential, and the authors describe (with illustrations) a range of neutralization plants of different sizes and designs.

Discharge of electro-plating wastes is also very common in the Midlands, and in a paper on treatment of these liquids Mr. A. E. J. Pettet stresses the need to consider conservation of water and chemicals in the plating shop before treatment of wastes unavoidably discharged is undertaken. Chemical methods of oxidation, reduction or precipitation are usually used for treatment, but cyanides can be destroyed biologically. Waste chromic acid anodizing solutions can be regenerated for re-use by means of recently developed ion-exchange resins resistant to the action of this acid.

The disposal of gas works effluents, dealt with by Mr. W. T. Lockett, is a problem of national concern, and investigators in the Midlands are particularly active in seeking a solution. The author traces the changing nature of the problem from the time when horizontal gas retorts were in use, ammonia was worth recovering from the liquor, and each gas works served a restricted area, to the present day when vertical retorts are most commonly used, ammonia can be recovered only at a loss, and small gas works are being superseded by centralized works serving large areas. Investigations fifty years ago showed that gas liquor could be treated biologically, the researches of the Institution of Gas Engineers during 1928–37 defined the conditions under which gas liquor could be satisfactorily treated when mixed with sewage, and revealed that certain changes in the operation of gas works could make treatment easier, and present-day researches are concerned with both chemical and high-rate biological methods of treatment.

Much discussion, reported in a separate booklet, centred around the mode of application of the 1937, 1948 and 1951 Acts and the cost to manufacturers and local authorities of treating industrial effluents. It was urged that by alteration of processes and by using conservation methods within factories, water and valuable materials could be saved and the cost and difficulty of treatment could be much reduced. Among examples quoted were that in one factory waste sulphonation acid was reconcentrated to give a crude but saleable product, and that in another small factory 10,000 gallons of water were saved a day by alteration of process and by introduction of a re-circulatory water system. A. E. J. Pettet

BASIC RESEARCH IN THE UNITED STATES

Details of expenditure on basic research in the United States are given in various surveys published by the National Science Foundation, but the report "Basic Research—A National Resource", recently issued by the Foundation, is more in the lineage of Vannevar Bush's "Science—The Endless Frontier" and the Steelman report, "Science and Public Policy". It attempts to convey to the general citizen the meaning of basic scientific research and its bearing on the national economy, welfare and security. The growth of basic research in the United States is briefly described in a chapter which illustrates some of the possibilities implicit to-day in virus research, in translation by electronic methods and in the study of other problems of social communication in leadership. After a brief reference to some unsolved problems, the following chapter outlines the present position of basic research in the United States, both in scale and in organization, while in the final chapter the strengthening of basic research is discussed and various suggestions listed in the general summary are amplified.

Stress is laid upon the establishment of more favourable conditions for its continued growth, including an increasing awareness on the part of the public of the methods, aims and significance—cultural as well as material—of basic research, as well as upon increased financial support. A more active participation by private industry is particularly urged as well as reduction in the amount of development work in universities and colleges under contract with Government agencies. Although in general terms the report contains little that is not to be found in the Barlow and other reports in Great Britain, it presents the case for basic research in cogent terms that are equally applicable in Britain and elsewhere.

ORIGIN OF CHONDRULES IN METEORITIC STONES

By DR. L. J. SPENCER, C.B.E., F.R.S.

THE chondrules (χόνδρος, a grain) in meteoritic stones are quite distinct from the spherulites in terrestrial volcanic rocks and from the ooliths and sand grains in sedimentary rocks. They occur in chondrites (chondritic meteoritic stones); other rarer meteoritic stones in which they are not present are classed as achondrites. They are usually quite small (1–3 mm.), about the size of millet seed, usually spherical, and are embedded in a finely brecciated matrix of the same materials (olivine, pyroxene, felspar, glass, nickel-iron, etc.) of which they themselves are composed.

Their mode of origin has long been a puzzle, giving rise to much speculation. In recent reviews[1] of the various hypotheses, mention has been made, but with little support, of an early suggestion by H. C. Sorby[2] of glassy globules of 'fiery rain'. This mention of 'fiery rain' calls to mind the findings at the meteorite craters of Wabar in Arabia[3].

Mr. H. St.J. B. Philby's expedition in 1932, with eighteen Arabs and thirty-two camels wandering in the desert for three months, had the object of finding the legendary city of Wabar, supposed to have been "destroyed by fire from heaven". Two meteorite craters were found, and there were indications of others buried beneath the desert sand; their walls are formed of cindery blocks and bombs of silica glass. Nearby, pieces of meteoritic iron were collected, the largest weighing 25 lb.; but a mass of iron as "big as a camel" could not be found. The locality is known to the Arabs as Al Hadida (place of the iron). Scattered around were numerous shining black pellets. These were thought by the Arabs to be pearls, blackened by the fire, that had been worn by the ladies of the court of the wicked king 'Ad ibn Kin'ad. With a lust for wealth, the Arabs filled the camel saddle-bags with these 'pearls', but on the return to Mecca they were rejected by the dealers and thrown away. Fortunately, a few were preserved in Mr. Philby's collection. These consist of a vesicular white silica-glass (SiO_2, 92·88 per cent), coated outside with a lustrous black glass (SiO_2, 87·45 per cent), with some iron and nickel.

Larger blocks or bombs show in some cases a corrugated surface resembling ropy lava, and covered with minute pimples, which perhaps represent dew-drops of silica. Broken surfaces show a breccia of white, grey, and black glass with a few shattered grains of quartz, and many round bubbles varying widely in size. Thin sections under the microscope show in addition large numbers of minute black specks. These specks I had at first assumed to be small holes filled with the grinding and polishing materials used in the preparation of the sections. But Dr. Leonard Hawkes, when he crushed a fragment of the glass on a microscope slide, saw minute metallic spheres rolling about. A piece of the glass crushed (not ground) in an agate mortar yielded a powder from which a magnetic needle picked up bunches of bright spheres by the thousands. These range from 0·1 to 0·0005 mm. in diameter. Two counts of the black dots over areas of a square millimetre on the thin sections gave estimates of one and two million in a cubic centimetre of the glass.

In a solution of copper sulphate the spheres become coated with copper. Analyses gave: Fe 91·2, Ni 8·8 per cent; Fe : Ni = 10·4, as compared with 12·6 in the meteorite. X-ray examination by Dr. F. A. Bannister showed the material to be body-centred cubic α-iron. Metallographic examination by Dr. J. M. Robertson showed that the smaller spheres consist of a single crystal, while larger ones consist of several crystals with inclusions (probably silica-glass) between the irregular boundaries of the grains.

At Wabar there evidently was a shower of large masses of meteoritic iron. The sudden transformation of the kinetic energy into heat gave rise to violent explosions, and broken fragments of iron were ejected from the craters. The Earth's atmosphere was blasted aside by vapours of iron and nickel, and of silica (from the desert sand). Temperatures were far in excess of:

	Nickel (° C.)	Iron (° C.)	Silica (° C.)
Melting point	1,452	1,535	2,900
Boiling point	2,900	3,200	3,500?

A rain, or rather drizzle, of globules of molten nickel-iron and silica fell into pools of boiling silica. Conditions such as these, with some variations, would seem to be quite suitable for the formation of chondrites.

A shower of hail-stones into a mush of broken snowflakes (both grown from water-vapour) would produce a somewhat similar structure. Curious hail-stones fell at Menabilly in Cornwall on October 20, 1791. One of them, weighing nearly one ounce, was sketched by Philip Rashleigh and a glass model was made. Enclosed in clear ice were four white spherical hail-stones of the usual kind[4]. This is perhaps another example of chondritic structure.

At other meteorite craters different conditions have prevailed. The Tunguska meteorite of 1908 in central Siberia appears to have been entirely vaporized, and only quite recently have traces of meteoritic material been detected in soil samples[5]. The Meteor Crater in

Arizona shows silica-glass, and from the soil of the surrounding country globules of nickel-iron have been collected with a magnetic rake. Magnetic globules have also been collected from the soil at the place of fall in 1947 of a large shower of iron meteorites in the Sikhote-Alin Mountains in eastern Siberia; but here they represent drops of molten material swept from the surface during passage through the Earth's atmosphere. When steel plates are cut with the oxy-acetylene blowpipe, showers of sparks fall to the ground as minute globules of magnetite, and quantities can be separated from floor sweepings.

The bright streaks radiating from some of the larger craters on the Moon probably consist of myriads of tiny spheres of nickel-iron from the vaporization of iron meteorites[6].

According to Bode's law (1772) on the relative distances of the planets from the Sun, there is one missing between Mars and Jupiter. How this catastrophe happened will never be known. However, it seems safe to assume that the asteroids between Mars and Jupiter are fragments of the missing planet. The largest, Ceres, 480 miles in diameter, was the first to be discovered in 1801; other large ones are Pallas (306 miles), Vesta (241), and Juno (121); others, amounting to more than 1,500, are much smaller, and no doubt fragments are plentiful. All these exert mutual attractions, and their orbits have a high degree of eccentricity, overlapping one another and even the orbit of the Earth. From the trajectory of the Sikhote-Alin meteorite of 1947, its orbit has been calculated to embrace the zone of asteroids[7]. Under such conditions, there are good chances for frequent and violent collisions, resulting in further breaking up, brecciation, melting, vaporization, and rearrangement of materials—just as happened, on a much smaller scale, at Wabar.

Sorby (*loc. cit.*) pointed out that when a fused globule (for example, a blowpipe bead) cools, crystallization starts from the exterior. This is how chondrules have crystallized, and is in complete contrast with the growth of spherulites, where crystallization has proceeded radially outwards from a central nucleus; and of ooliths and pisolites with a concentric structure.

The striking pictures of radiating eccentric chondrules are fully displayed only when the section plane passes through the centre of the sphere and the point where crystallization commenced on the rim. Other section planes perpendicular to this direction may display a barred structure, and sections in other directions will show different patterns.

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A THEORY OF ANTIBODY FORMATION INVOLVING EOSINOPHILS AND RETICULOENDOTHELIAL CELLS

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THERE have been many attempts to determine the precise cellular mechanisms involved in antibody formation. Although there is general agreement that cells common to the reticulo-endothelial, lymphoid and hæmatopoietic systems are involved, there has been a wide diversity of opinion as to the specific cell or cells in these systems capable of synthesizing the antibody. Plasma cells, lymphocytes, macrophages and certain transitional cells have been proposed as cells capable of producing antibody (see reviews by Taliaferro[1] and McMaster[2]).

The problem of determining the mechanism of antibody production has been complicated by the fact that the site of production varies, depending upon the manner in which the antigen was introduced into the host. Under various experimental conditions, local formation of antibody has been reported in the spleen, regional lymph nodes, bone marrow, thymus, omentum, skin, muscle, fat, etc. Once antibody synthesis has occurred *in vivo*, it is possible to continue the production after transferring viable lymphoid or exudative cells to other animals[3-7] or by culturing the cells *in vitro*[8-12]. However, initiation of antibody synthesis following the addition of antigen to cells *in vitro* has been very difficult or impossible to attain, suggesting that a primary *in vivo* step must be necessary. These and other experiments warrant the proposal that at least two steps are involved in antibody production[13-16]: (1) A primary step which consists of the reaction of certain cells with antigen, bringing about specific enzymatic changes or the formation of an enzymatic template. This step appears to be radio-sensitive and occurs *in vivo* at the site of penetration of antigen into the organism. (2) The second stage consists of the utilization of the specific enzymes for the synthesis of antibody. This step can occur *in vitro* as well as *in vivo*, and appears to be somewhat radio-resistant. It occurs in the lymphoid or reticulo-endothelial tissues of the animal. It is quite possible that these two steps occur in two different cells. However, none of the present theories of antibody production gives a satisfactory explanation for the specificity, mobility and radio-sensitivity of the first step. There appears to be a missing link in the theories, and it is quite possible that some cell, heretofore not considered by immunologists, is involved.

Recent studies in our laboratory[17-20] have indicated that there are three phases of local cellular response at the site of injection of a non-toxic antigen. The first phase, which lasts up to 48 hr., is characterized primarily by a neutrophilia and sometimes a tran-

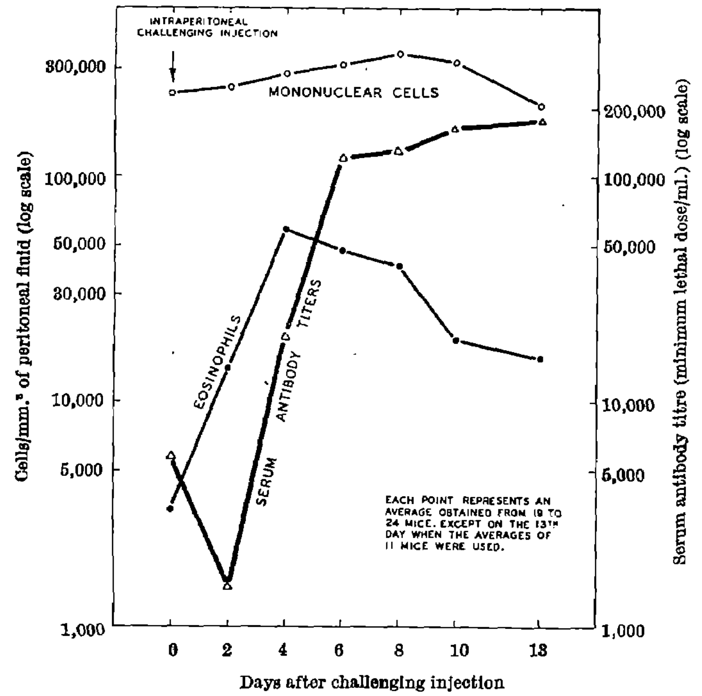

Fig. 1. Local cellular responses and serum antibody titres following a challenging injection of tetanus toxoid in immunized mice (semi-log plot)

sitory eosinophilia. The second phase is characterized by a relatively large prolonged accumulation of eosinophils, reaching a peak on the fourth day after antigen injection. This phase occurs only in animals capable of rapid formation of large amounts of antibody and does not occur in passively immunized animals[21,22]. The third phase is characterized by an increase in local histiocytes (mononuclear cells) and a stimulation of the draining lymph nodes. The time relationship of the second and third phases with the appearance of serum antibody is shown in Fig. 1.

It may be seen that the accumulation of eosinophils precedes the appearance of serum antibody, otherwise the logarithmic increase in these cells is very similar to the logarithmic rise in antibody titres. Moreover, there appears to be a close correlation between the number of eosinophils responding to an injection of antigen, and the resulting serum antibody titres. Factors, such as large doses of cortisone or whole-body X-irradiation which inhibit antibody formation, also inhibit the accumulation of eosinophils[23,24]. Furthermore, in irradiated animals which were allowed to recover before challenging, a prolonged local eosinophilia was observed that coincided with a prolongation of the time for peak serum antibody titres. Irradiation appears to decrease the number of reticulo-endothelial cells capable of phagocytizing the eosinophils and accounted for the slow rate of removal of these cells (unpublished results). Additional experiments have indicated that eosinophils do not contain measurable amounts of antibody, but as they are phagocytized after coming into contact with the antigen, there is a concomitant appearance of antibody in the blood serum.

The preceding findings and other experiments have led us to believe that eosinophils are involved in the initiation of antibody synthesis[25,26]. I suggest the following working hypothesis: Antigen introduced into an organism produces two general types of cellular reactions. First there is a migration of granulocytic cells into the inflamed area. If the host has been previously exposed to the antigen, there is a specific eosinophil response at the site of injection and in the region of antigen fixation. The eosinophils are chemotactically attracted to the antigen and react with it, producing specific enzymatic changes on or within the cell. The second step involves the phagocytosis of eosinophils by reticulo-endothelial cells and the utilization of the specific enzyme by these cells to form antibody. During and following the process of antibody formation, reticulo-endothelial cells undergo nuclear changes, increase their cytoplasmic basophilia (pyroninophilia) and are known as plasma cells[8,12].

The chief merit of the above hypothesis is that it directs attention to the fact that granulocytic cells, such as the eosinophil, may take an important role in antibody formation. It would explain the repeated observations of the close association of eosinophils and plasma cells, and the role of these cells in immune reactions. Furthermore, the hypothesis would explain why reticulo-endothelial cells are capable of continuing antibody production *in vitro*, but are incapable of initiating it. The ability of an animal to form antibody depends upon two factors: the number of eosinophils responding to the antigen, and the capability of phagocytic cells to remove the eosinophils after they have been in contact with the antigen. It is possible that some of the diseases of hypersensitivity may be due to a failure of phagocytosis of eosinophil cells and utilization of the enzymatic templates by reticulo-endothelial cells to form antibody. Further experiments are in progress to elucidate the role of these cells in defence mechanisms.

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POSSIBLE POLYMORPHISM OF BOVINE α-LACTALBUMIN

By B. S. BLUMBERG* and M. P. TOMBS
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OPPORTUNITY arose during recent trips to Iceland and Nigeria to collect samples of milk from the indigenous herds of cattle. These were examined to determine the type or types of β-lactoglobulin they contained.

There are two β-lactoglobulins[1], namely, β_A and β_B, distinguishable by paper electrophoresis. Aschaffenburg and Drewry[2] have studied their incidence in British breeds, and by family studies have demonstrated their genetic determination. Their presence or absence is determined by two allelic autosomal genes, and all three phenotypes, β_A, β_B and β_{AB}, have been identified.

Samples of milk were prepared for paper electrophoresis according to the method of Aschaffenburg and Drewry[2], and run on Whatman *3MM* paper for 17 hr. at 2 m.amp./cm. width of paper and a potential drop of about 1·5 V./cm. length of paper, in veronal buffer $I = 0{\cdot}05$, *p*H 8·6 in a 'Durrum'-type apparatus[3]. Staining was with alcoholic bromphenol blue, and washing with 2 per cent acetic acid and tap-water.

The Nigerian cattle were White Fulani or Lyre-horned Zebu[4] from the stock farm of the Veterinary Research Station, Vom. They are big humped animals, with large dewlaps and frequently extremely large horns. They are similar in appearance to the Brahmin cattle of the East. They are thought to have been brought into Nigeria by the nomadic Fulani people. Twelve of the specimens were from White Fulani–Friesian crosses.

Samples from Icelandic cattle were collected from various dairy herds on the island. The Icelandic breed is thought to have originated in Norway, and to have been isolated for a considerable period. The Icelandic cattle were selected so as to be free from close interrelationships. Some sister and mother–daughter pairs were present in the Nigerian cows.

The distribution of the β-lactoglobulin phenotypes is shown in Table 1. They fit the predictions of the Hardy–Weinberg law quite well. In the Nigerian sample the Friesian–Fulani crosses are included. Their omission does not significantly alter the results.

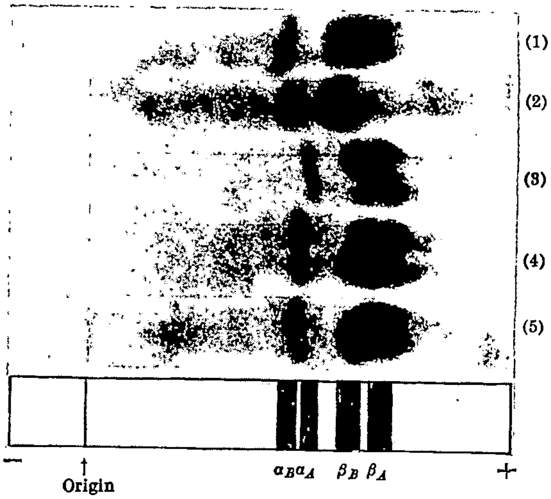

Fig. 1. Examples of electrophoresis strips: (1) Icelandic, α_B, β_{AB}; (2) Fulani, α_{AB}, β_B; (3) Fulani, α_A, β_{AB}; (4) Fulani, α_B, β_{AB}; (5) British, α_B, β_{AB}

There was no significant difference between the incidences in the Zebu, Icelandic or British breeds. (For Zebu $P > 0{\cdot}2$, for Icelandic $P > 0{\cdot}3$, each compared to British incidences taken from Aschaffenburg and Drewry[2].)

During electrophoresis of the Fulani samples a doubling of the α-lactalbumin band was noticed in some cases. Where the two bands were seen, one of them appeared to correspond in mobility with the α-lactalbumin previously found in British breeds, while the other moved more rapidly. Further search revealed a sample containing only the fast-moving

Table 1. INCIDENCE OF β-LACTOGLOBULINS AND α-LACTALBUMINS IN NIGERIAN (WHITE FULANI) AND ICELANDIC COWS
The predicted incidence is determined from the Hardy–Weinberg law. The incidence in combined British breeds is taken from Aschaffenburg and Drewry. *P* is determined by the χ^2 test

Phenotype	Nigeria (W. Fulani)				Iceland				British breeds	
	Observed No.	Observed incidence	Predicted No.	Predicted incidence	Observed No.	Observed incidence	Predicted No.	Predicted incidence	Observed No.	Observed incidence
β_A	3	0·052	2·4	0·041	6	0·115	5·8	0·112	21	0·075
β_{AB}	18	0·310	18·6	0·321	23	0·442	23·1	0·445	112	0·403
β_B	37	0·638	37·0	0·638	23	0·442	23·0	0·442	145	0·5-2
Total	58				52				278	
	$P \sim 0{\cdot}7$					$P > 0{\cdot}9$			$P > 0{\cdot}9$	
α_A	1	0·0217	1·05	0·023	0	0				
α_{AB}	12	0·260	11·9	0·259	0	0				
α_B	33	0·717	33·0	0·717	52	1·000				
Total	46				52					
	$P > 0{\cdot}95$									

Table 2. INCIDENCE OF THE α-LACTALBUMIN AND β-LACTOGLOBULIN PHENOTYPE IN FORTY-SIX PURE BRED WHITE FULANI (ZEBU) COWS

Phenotype	α_A	α_{AB}	α_B	Total
β_A	0	0	2	2
β_{AB}	1	0	12	13
β_B	0	12	19	31
Total	1	12	33	46

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* Fellow of the Arthritis and Rheumatism Foundation.

α-lactalbumin. No fast α-lactalbumins were found in the Fulani–Friesian crosses. The incidence of each of the phenotypes in the pure Fulani animals only is shown in Table 1.

The distribution of the three types agrees closely with the predictions of the Hardy–Weinberg law. Although too few samples have been examined to provide family studies, by analogy with the case for the β-lactoglobulins, it is suggested that these α-lactalbumins are also genetically determined. The symbols α_A, α_B are given to the proteins, and the symbols $L^A{}_a$, $L^B{}_a$ assigned to the genes presumably determining their presence. α_A is the faster moving component and α_B the slower on paper electrophoresis under the conditions stated above.

All twelve paired α-lactalbumins were found in animals which produced only β_B-lactoglobulin. This association is significant at less than the 5 per cent level. The one sample with only α_A-lactalbumin was found in a β_{BA}-producer (Table 2).

This might be genetic association through close linkage with selection or due to some physiological effect in the mammary gland. The fast-moving α_A-lactalbumin has not so far been found in any British breed, nor in the Icelandic. This protein may therefore provide a marker by which the affinities of the Zebu cattle, and indirectly the Fulani people associated with them, may be traced. The β-lactoglobulins do not appear to be suitable for distinguishing the breeds so far examined. No selective value has yet been found for either the α-lactalbumins or the β-lactoglobulins.

This investigation was supported in part by a research grant, *H*-3161, from the National Heart Institute, U.S. Public Health Service, and the Wenner-Gren Foundation for Anthropological Research. Milk samples were collected from the Nigerian cattle with the permission and help of Dr. J. Taylor, director of the Veterinary Research Station, Vom. One of us (M. P. T.) is indebted to the Agricultural Research Council for a travel grant, and to the Icelandic authorities and Mr. B. S. Benedikz for their assistance in Iceland. Investigations in Nigeria were carried out under the auspices of Prof. B. G. T. Elmes, Department of Pathology, University College, Ibadan.

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PROTECTION OF AUGUST RATS AGAINST LETHAL DOSES OF A DIMETHYL HOMOLOGUE OF MYLERAN BY ISOLOGOUS BONE MARROW

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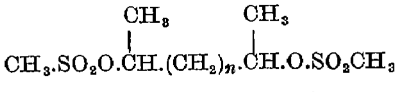
MYLERAN (1 : 4-dimethanesulphonoxybutane), introduced by Haddow and Timmis[1] and clinically by Galton[2], is now well established as a useful agent for the therapy of human chronic granulocytic leukæmia[3]. The hæmatological effects in rats of compounds of the general type $\mathrm{CH_3SO_2.O.(CH_2)_{\mathit{n}}.O.SO_2CH_3}$, of which myleran is the member where $n = 4$, have been studied by Elson[4,5]. These studies have recently been extended to the series:



$$\mathrm{CH_3.SO_2O.\overset{\overset{CH_3}{|}}{C}H.(CH_2)_{\mathit{n}}.\overset{\overset{CH_3}{|}}{C}H.O.SO_2CH_3}$$

made by Timmis and Hudson[6], and the member in which $n = 2$, namely, 2 : 5-dimethanesulphonoxyhexane (*CB* 2348), a dimethyl homologue of myleran, has been found to be three times more active than myleran in depressing the number of neutrophils in the circulating blood of rats[5]. *CB* 2348 is more soluble in water and in organic solvents than myleran, and has a higher rate of chemical reactivity as assessed by the rate of hydrolysis[6].

Clinical trials in malignant diseases indicate that *CB* 2348 has a therapeutic action similar to that of myleran in chronic granulocytic leukæmia[7], and preliminary results by Bierman[8] indicate that it may not be entirely devoid of action in acute leukæmia. In conformity with their effectiveness in granulocytic leukæmia, myleran and *CB* 2348 show a preferential action on the myeloid series of blood cells, and at suitable doses can produce in rats a marked fall in peripheral neutrophils with relatively little effect on lymphocytes or lymphatic tissue. In comparative studies of the effects of cytostatic agents and radiation, Elson[4] has suggested that the myeloid effects of X-radiation can be imitated very closely by compounds of the myleran type, whereas the lymphoid effects of radiation are imitated by compounds of the nitrogen mustard series.

The present interest in protection against lethal doses of X-radiation by means of bone marrow administered shortly after the irradiation suggested that it would be useful to investigate the effectiveness of bone marrow protection against cytostatic agents of the myleran and nitrogen mustard type. Of particular interest is the fact that with myleran compounds the protection against myeloid effects can be studied without the complication of the marked lymphoid effects which are inseparable from myeloid effects in animals treated with X-radiation.

Because of its high biological activity and rapidity of chemical action, making it unlikely that it would persist in the body in an active state for a long period after administration, *CB* 2348 was felt to be particularly suitable for this investigation.

It is now well established that mice exposed to a supralethal dose of X-radiation recover from the radiation injury if they are given intravenous or intraperitoneal injection of isologous, homologous or heterologous bone marrow[9,10]. Rats which have received supralethal doses of X-radiation usually die within 5–6 days, primarily from damage to the small intestine and before hæmatological damage is fully developed. Mice do not die until several days later than this, and death is associated with severe thrombocytopenia, leukopenia and anæmia. Therefore it is not possible to give supralethal doses of X-radiation to rats (in contrast to mice) and then prevent death by bone marrow injection, since gastro-intestinal injury, rather than hæmatopoietic depression, is the major cause of death[11].

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* Assistant professor of medicine, University of Pennsylvania. This work was conducted during tenure of a Research Fellowship of the National Cancer Institute of the National Institutes of Health.

Rats which have received X-radiation in the lethal, but not supralethal, range can be protected by isologous bone marrow, but not by homologous or heterologous marrow. This is thought to be due to the fact that in order to inhibit the immune response of the recipient animal, thereby permitting the growth of the injected 'foreign' cells, supralethal doses of X-radiation are necessary. Maisin[12] has, however, shown that the 'intestinal' effects of supralethal doses of X-radiation can be reduced by the prior administration of mercaptoethylamine, and about half the rats so treated can be saved by means of an intraperitoneal injection of isologous bone marrow.

Sartorelli and LePage[13] have demonstrated that tumour-bearing mice can be protected against lethal doses of thioguanine by means of injections of isologous bone marrow. Weston[14] has reported bone marrow protection of rats treated with lethal doses of myleran.

Our experiments were carried out in pure line August rats weighing about 120 gm. *CB* 2348, 7·5 mgm./kgm. was administered in arachis oil by intraperitoneal injection. The usual concentration was 0·75 mgm./ml. of oil.

Suspensions of bone marrow were prepared by blowing out the marrow from both femurs of each donor rat into 1 ml. of saline solution. The total final volume of bone marrow suspension, containing the marrow from 4–10 donors, varied from 1 to 2·5 ml. for each group of five recipients. Intravenous injections usually consisted of 0·2 ml. per recipient and intraperitoneal injections 0·5 ml. per recipient. Counts showed that each femur contributed about 35×10^6 nucleated cells. The lateral tail vein was used for the intravenous injections. The bone marrow was injected at various times, from 1½ hr. in one experiment to as long as 4 days in another experiment, after the chemical had been given. In some experiments, Wistar or Marshall rats were used as homologous donors. Donor rats were of approximately the same age as the recipient animals.

Table 1. BONE MARROW PROTECTION OF RATS AGAINST A LETHAL DOSE (7·5 MGM./KGM.) OF 2 : 5-DIMETHANESULPHONOXYHEXANE (*CB* 2348)

Exp. No.	No. of donors per recipient	Route	Interval between chemical and bone marrow injection (hr.)	No. of animals surviving*	Strain of donors†	Strain of recipients†
1	1	I.V.	4	0/5	*W*	*W* (1)
2	1	I.V.	3	3/4	*A*	*A* (2)
3	1	I.V.	3	2/2	*A*	*A*
4	1	I.P.	3	4/5	*A*	*A*
5	4/5	I.P.	3	0/5	*A*	*A*
6	1	I.P.	3	3/4	*A*	*A*
7	2	I.P.	3	5/5	*A*	*A*
8	2	I.P.	1½	4/5	*A*	*A*
9	2	I.P.	24	1/5	*A*	*A*
10	2	I.P.	48	0/5	*A*	*A*
11	2	I.P.	96	0/5	*A*	*A*
12	2	I.P.	2	0/10	*M*	*A* (3)

* There were five control animals in each experiment, all of which died in 10–14 days.

† *A* = August; *W* = Wistar; *M* = Marshall.

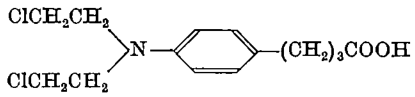
(1) Wistar → Wistar = homologous; (2) August → August = isologous; (3) Marshall → August = homologous.

The results from representative experiments are summarized in Table 1.

It is thus clear that in the majority of our experiments the lethal effects of *CB* 2348 can be largely overcome by intraperitoneal or intravenous injections of isologous bone marrow. Homologous marrow was ineffective, and attempts to protect Wistar rats were unsuccessful. It was possible to achieve protection by bone marrow injection at 1½–24 hr. after the chemical was administered, but not at 48 hr.

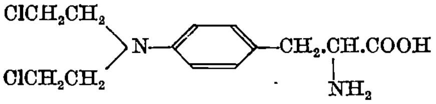
In collaboration with Dr. L. F. Lamerton and Dr. J. M. Loiselle, we have also completed a series of experiments in which August rats were exposed to 500 or 550 r. of X-radiation, followed, in ½–3 hr., by injections of isologous or homologous bone marrow. These amounts of irradiation caused death of the control animals at about 12–16 days. Isologous marrow, but not homologous marrow, was effective in preventing death in almost all animals.

There is considerable evidence that lymphatic tissue plays an important part in the development of immune responses[15]. Myleran suppresses the hæmatopoietic elements more than the lymphatic tissues. Nitrogen mustard (*HN*2) and related compounds such as chlorambucil:



have a relatively greater effect on lymphatic tissue, and their action on the other hæmatopoietic activity is of shorter duration than myleran. *CB* 2348 lies somewhere between these two compounds in its mode of action[4,5].

One would therefore expect that the nitrogen mustard derivatives would behave like X-radiation with respect to suppression of immune responses, and that if protection against the lethal effects of nitrogen mustards could be accomplished it could be achieved by the injection of either isologous or homologous bone marrow. However, the response of most animals to toxic doses of these chemicals follows one of three patterns, depending upon the dose administered: (*a*) acute convulsive seizures and death within a few hours; (*b*) death within 3–7 days in a manner similar to that which follows supralethal doses of X-radiation; or (*c*) weight-loss, diarrhœa and pancytopenia followed by rapid recovery[16]. The response described in category (*b*) is usually elicited by amounts in the range of the median lethal dose, but it is difficult to plan an experiment in such a way that death is produced in the majority of animals at 6–7 days. Chlorambucil, one of the aromatic nitrogen mustards, closely resembles *HN*2 in these patterns of response at different doses. It thus appears likely that in order adequately to suppress the immune response of rats by means of *HN*2 or related compounds, a dose must be given which leads to death in the same fashion as in (*a*) or (*b*) above. The nitrogen mustard derivatives of an aromatic amino-acid, such as melphalan (*CB* 3025):



do not produce acute death or convulsions as in category (*a*), even at more than twice the lethal dose, and there is evidence to suggest that deaths in category (*b*) above will be somewhat more delayed than with other nitrogen mustard derivatives tested so far. Protection experiments are therefore being conducted with this and similar compounds in an effort to define further the potentialities and mode of action of some of the chemotherapeutic or alkylating agents.

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METAL-CHELATING PROPERTIES OF PLANT-GROWTH SUBSTANCES

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AND

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IT has been found that several chelating compounds have auxin activity[1–4]. As a consequence, it has been suggested that the activity of the known auxins is due to their chelating action[1,2].

Auxin action has been ascribed to the two-point attachment of the growth substance to some suitable substrate, the attaching groups being the aromatic ring and a polar group of the side chain[5,6]. The complexing groups of a bidentate chelate may serve as such points of attachment. However, no chelating action has been reported for indolyl-3-acetic acid or α-naphthalene acetic acid. The chelating activity of these acids was therefore investigated.

The methods used were those described by Martell and Calvin[7]. As the auxins are only slightly soluble in water, they were dissolved in 50 per cent ethanol, which also was a suitable solvent for the metal salts. Absorption spectra of indolyl-3-acetic and α-naphthalene acetic acids and cupric nitrate were determined, using a Beckman *DU* spectrophotometer. The results are given in Fig. 1. A pronounced difference is observed when the spectrum of the mixture of the auxin and copper salt is compared with the sum of the two separate spectra. This indicates a change in chemical bonding which can be interpreted as chelating or complexing of the metal by the acids. The composition of the complex was determined by plotting absorption of the copper–indolyl-3-acetic acid complex at 360 mμ and that of the copper–α-naphthalene acetic acid at 330 mμ against the ratio acid/copper in both cases, keeping the acid concentration constant (Fig. 2). Breaks in the curves indicate the composition of the complexes in the solution; such breaks were obtained at 1 copper : 1 indolyl-3-acetic acid; 1 copper : 2 indolyl-3-acetic acid and 1 copper : 2 α-naphthalene acetic acid. The stability of the complexes was determined by the Bjerrum method, as modified by Calvin[7] to suit the MA_2 case. *p*H titration curves for free acid and acid with small amount of metal were plotted (Fig. 3). The horizontal distance between the curves is equivalent to the amount of hydrogen ions released by the complexing of the metal.

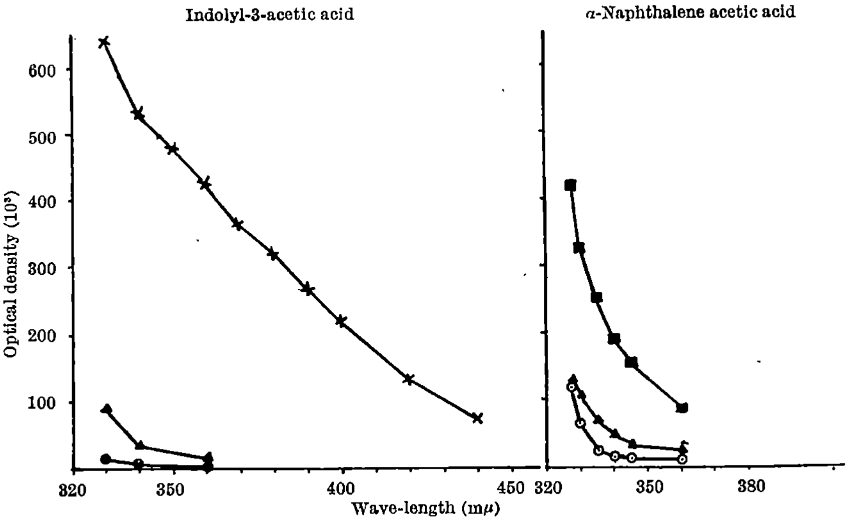

Fig. 1. Absorption spectra in 50 per cent ethanol. *p*H 3·6. ⊗, indolyl-3-acetic acid, 2 × 10^{-2} *M*; ▲, $Cu(NO_3)_2$ 3 × 10^{-3} *M*; ×, indolyl-3-acetic acid 2 × 10^{-2} *M* + $Cu(NO_3)_2$ 3 × 10^{-3} *M*; ⊙, α-naphthalene acetic acid 2 × 10^{-3} *M*; ▲, $Cu(NO_3)_2$ 2 × 10^{-3} *M*; ■, α-naphthalene acetic acid 2 × 10^{-2} *M* + $Cu(NO_3)_2$ 2 × 10^{-3} *M*

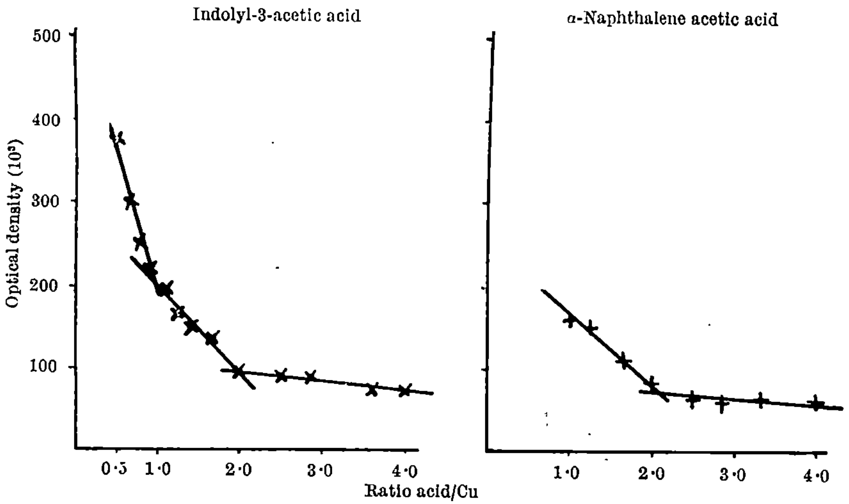

Fig. 2. Optical density of the copper–indolyl-3-acetic acid complex (360 mμ, pH 3·6) and of the copper–α-naphthalene acetic acid complex (330 mμ, pH 3·18) in 50 per cent ethanol. Concentration of acids constant at 2×10^{-2} *M*. ×, copper–indolyl acetic acid complex; +, copper–α-naphthalene acetic acid complex

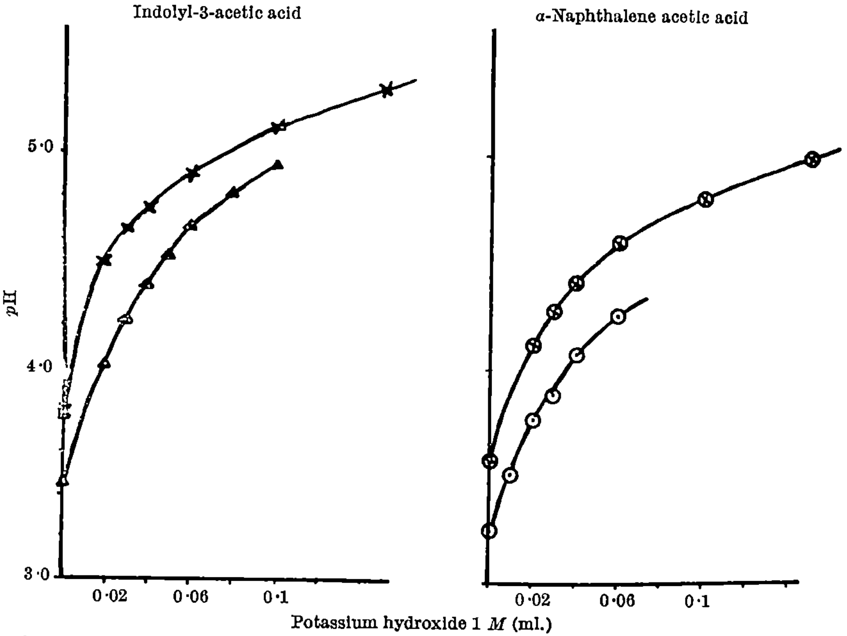

Fig. 3. pH titration curve in 50 per cent ethanol. ×, indolyl-3-acetic acid; ⊗, α-naphthalene acetic acid; ▲, indolyl-3-acetic acid + $Cu(NO_3)_2$; ⊙, α-naphthalene acetic acid + $Cu(NO_3)_2$. Concentration of acid, 10^{-1} *M*. Concentration of $Cu(NO_3)_2$, 2×10^{-3} *M*. Titration with *M* potassium hydroxide

From these titrations the degree of formation $\bar{n}$ was calculated and plotted against $-\log$ [indolyl-3-acetic acid$^-$] and $-\log$ [α-naphthalene acetic acid$^-$], respectively. The calculated stability constants for the overall reaction were: $\log K = 5{\cdot}4$ for copper (α-naphthalene acetic acid)$_2$ ($\log k_1 = 3{\cdot}2$; $\log k_2 = 2{\cdot}2$); $\log K = 5{\cdot}5$ for copper (indolyl acetic acid)$_2$ ($\log k_1 = 3{\cdot}2$; $\log k_2 = 2{\cdot}3$).

Under the same conditions indole showed only very slight complexing ability. Roberts, quoted by Heath and Clark[1], suggested that indolyl-3-acetic acid could chelate between the carboxyl oxygen and the imino nitrogen, forming a seven-membered ring. α-Naphthalene acetic acid, however, lacks a replaceable hydrogen on a basic atom in the ring. As both copper (indolyl-3-acetic acid)$_2$ and copper (α-naphthalene acetic acid)$_2$ compounds show similar stability, another mechanism of chelating activity must be applied to suit both compounds. The first complexing group is the carboxyl group, the properties of which are probably not affected by these substitutions in the acetic acid molecule, since the *pKa* acetic acid is 4·7, indolyl-3-acetic acid is 4·6 and α-naphthalene acetic acid is 4·6. The complexing action of the carboxyl group in acetic acid is low with copper ions. As the second complexing group the entire aromatic ring may function. There is some evidence for this in the recent finding of complex formation between metal ions and various aromatic compounds[8,9]. This explanation of the second active site could apply both to α-naphthalene acetic and indolyl-3-acetic acids, and could be the basis of the two-point attachment theory for auxin activity.

Some other preliminary experiments with indolyl-3-acetic acid show strong chelating activity with ferric ions and considerably less with cobaltous ions ($\log K \sim 2$). No activity could be demonstrated with calcium and magnesium ions. Consequently, if the growth-promoting activity of auxin is due to its chelating property, this could be only with heavy metals. There are several possible modes of action of auxin as a heavy-metal chelating agent. It may act as a carrier, mask functional heavy-metal ions, or remove ions inhibitory to cell wall growth.

Our thanks are due to Prof. Patai, of the Organic Chemistry Department of the Hebrew University, and Dr. J. Edelman, of the Imperial College of Science and Technology, London, for helpful criticism and stimulating discussion.

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LETTERS TO THE EDITORS

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Radio Noise from Lightning Discharges

In studies of atmospheric radio noise from thunderstorms, and of its interference with radio systems, it is useful to know the wave-forms of the atmospherics received in different frequency bands from a single lightning discharge. Although measurements of the electromagnetic field changes are the basis of much of our knowledge of the discharge processes, they have been mainly restricted to frequencies less than 100 kc./s. Norinder[1] has recorded samples of noise at 500 kc./s., but there are few records of the wave-forms of atmospherics in the high-frequency band which is important for long-distance communication. Records obtained at the Radio Research Station, Slough, during two local thunderstorms are therefore of interest both in the study of radio interference and also as a possible source of further information about the discharge processes.

During a storm on July 19, 1957, records of the wave-form of the vertical component of electric field were obtained, in a bandwidth of 300 c./s. at 11 Mc./s., from twenty-five flashes at known distances in the range 1–6 km., deduced from the delay in hearing thunder. Twenty-one flashes were seen to strike the ground; the others may have been either cloud flashes or ground flashes obscured from view.

The atmospherics were recorded on magnetic tape, at a subcarrier frequency of 10 kc./s., and later transferred to film. The wave-forms were so varied in detail that it was difficult to select any as being typical, but those reproduced in Fig. 1 illustrate the main features. Fig. 1*a* shows a single relatively large burst in an atmospheric of total duration 230 m.sec. In Fig. 1*b* the whole atmospheric is of similar duration but contains several peaks of comparable amplitude. Fig. 1*c* shows a more continuous type of atmospheric with the largest amplitude at the beginning. These atmospherics, all from ground flashes at distances of about 3 km., had peak amplitude in the range 550–900 μV./m., and the amplitudes of all twenty-five atmospherics were of this order. The durations were in the range 40–330 m.sec.

Fig. 1*d* is a record from a flash at 5-km. range which was seen to be in the form of a catenary, well above the ground, with its ends in the thundercloud. So far as could be seen, neither the amplitude nor the wave-form was significantly different from those originating in ground flashes. Although the flash appeared to be of the cloud type, it may have struck the ground outside visible range.

The suggestion has been made[2] that noise in the high-frequency band originates in the stepped-leader type of discharge which travels towards the ground and is usually followed by a high-current return stroke from the ground to the cloud. The stepped-leader part of the discharge lasts only for a time of the order of a millisecond, however, and cannot be responsible for the relatively long bursts of noise in the examples shown.

A study of the high-frequency atmospheric in relation to that recorded at very low frequencies is instructive, since a very-low-frequency atmospheric is known to contain large pulses originating in the return strokes. During another storm, on August 12, 1957, noise fields were recorded simultaneously at 11 Mc./s. and 6 kc./s., in band-widths of 300 and 200 c./s. respectively. A twin-track recorder was not available, and the two frequencies were recorded on a single track, the 6 kc./s. signal direct and the 11 Mc./s. signal after frequency-changing to 10 kc./s. The tape was then played back, through low- and high-pass filters to separate the signals, on to a two-gun cathode-ray tube for obtaining film records.

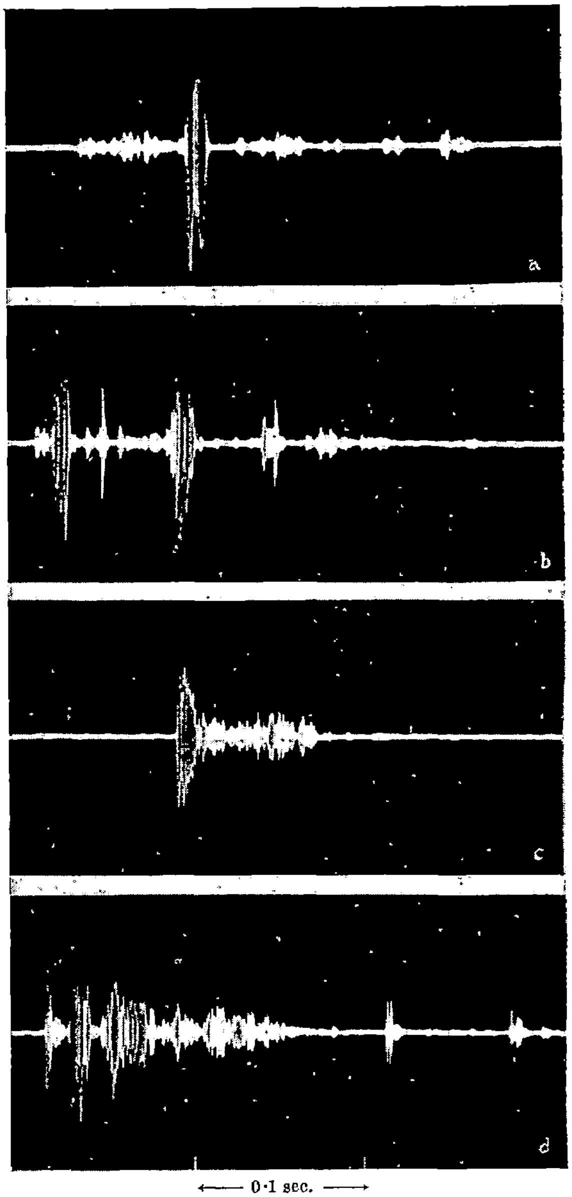

Fig. 1. 11 Mc./s. atmospherics from near storm

Most of the flashes were outside visual range (about 10 km.); only three were seen to be ground flashes, but there were no doubt many others.

The wave-forms were generally similar to those from the earlier storm, but again with a wide variation in detail. Twenty-six records from flashes at known distances between 1 and 18 km. were examined. The high-frequency atmospherics had

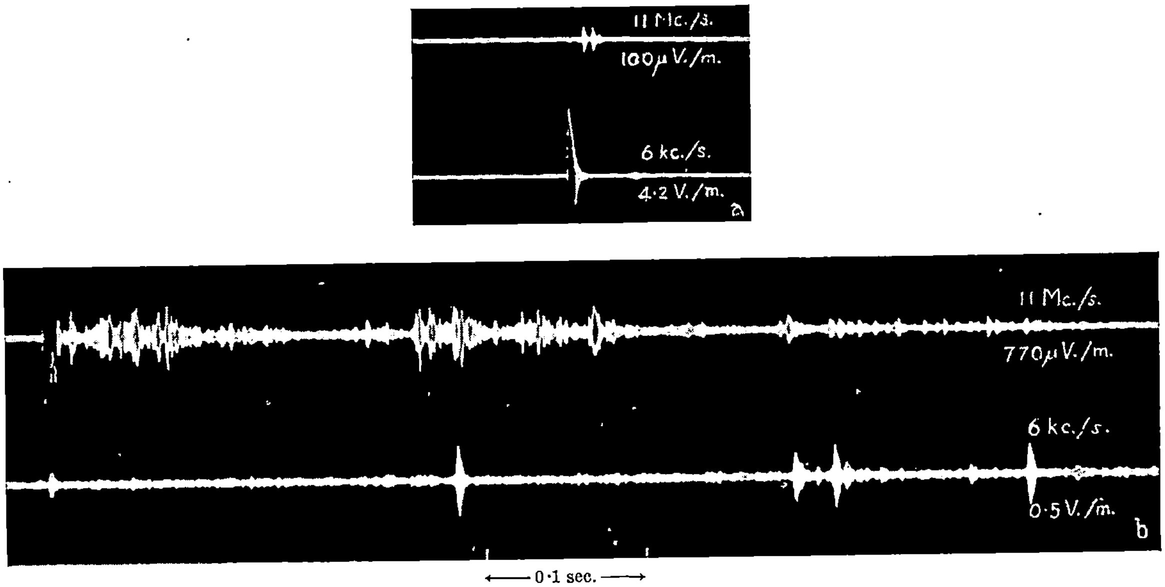

Fig. 2. Corresponding atmospherics at 11 Mc./s. and 6 kc./s.

peak amplitudes between 50 and 1,500 μV./m. and those at very low frequency between 0·3 and 30 V./m. Seventeen of the atmospherics had a ratio of very-low to high-frequency peak amplitude of 10^4, within a factor of 2 either way, but the total range was 650–42,000. Fig. 2*a* shows the atmospheric with the highest ratio and Fig. 2*b* that with the lowest. It should be noted that each record has been adjusted in amplitude to illustrate the main features clearly, and the scale therefore varies from one record to another. The absence of large pulses in the 6 kc./s. record of Fig. 2*b* may be an indication that it was a cloud flash.

Fig. 2*a* illustrates a curious phenomenon which occurred on many of the records. The main feature of the high-frequency noise was the pair of pulses, the first of which occurred about ten milliseconds after the very-low-frequency pulse (presumed to originate in a return stroke). Of the twenty-six records examined, ten showed this double-pulse effect, while four others showed a single pulse in a similar position and two showed three pulses.

Fig. 3 shows atmospherics from the nearest ground flash, about 1 km. away. The first film record taken from the tape (Fig. 3*a*) could be interpreted, using the currently accepted model of the lightning flash, as indicating a flash with two, and possibly three, return strokes, the high-frequency noise being radiated from the preliminary discharges. Another record of the same atmospheric was taken from the tape, with much greater amplification at 6 kc./s. (Fig. 3*b*). A succession of very-low-frequency pulses was then observed with a wide range of amplitudes. Also the atmospherics were clearly seen to have started simultaneously and to have had the same overall durations on the two frequencies, characteristics which would probably not have been inferred from Fig. 3*a*.

Many of the features of these records are not readily explained in terms of our present knowledge of lightning, and a more detailed study of these and similar records may lead to new information about the discharge mechanism.

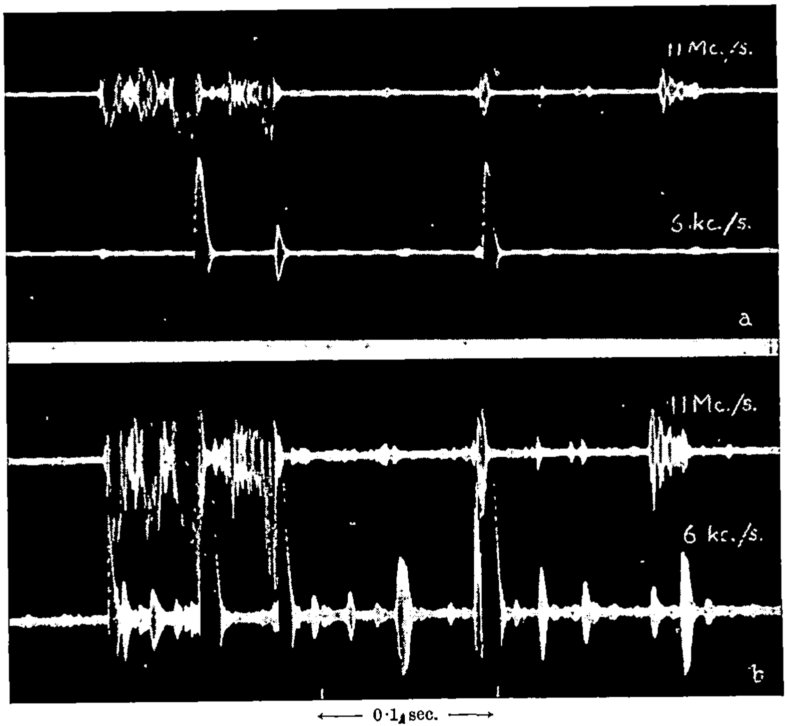

Fig. 3. Atmospherics from a very near flash. Peak amplitudes: 1·4 mV./m. at 11 Mc./s.; 30 V./m. at 6 kc./s.

This work was carried out as part of the programme of the Radio Research Board, and is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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Industrial Research),
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Solar-Flare Effect in the F2-Layer of the Ionosphere

A solar flare usually causes a simultaneous increase in the electron density of the D- and E-layers of the ionosphere in the daylight hemisphere. It is rare, however, to find any corresponding increase in the $F2$-layer, and the only previously reported case occurred in 1949[1] during an important flare which was accompanied by an unusually intense burst of cosmic radiation.

A similar, but even more intense, flare occurred on February 23, 1956, and a simultaneous increase in $F2$-layer ionization at Okinawa has been reported by Shapley and Knecht[2]. Since increases of about the same magnitude occurred on other days, and since no simultaneous increases were observed at Adak, Baguio or Guam, Shapley and Knecht suggest that the increase at Okinawa may not have been caused by the flare.

The very great increase in D-layer ionization at Singapore during the flare of February 23, 1956, has already been described[3]. A simultaneous increase in the critical frequency (f) of the $F2$-layer was also observed but, since the behaviour of the $F2$-layer is notoriously erratic, a critical examination of the data is necessary to establish the validity of the obvious inference that the increase was caused by the flare. Fig. 1*a* shows the measured values of f on February 23, 1956, and a comparison curve based on the median values for the ten control days. Owing to the very high D-layer absorption during the flare, it was impossible to measure f at 1100 L.M.T., but a value has been estimated by extrapolating backwards from the measured values obtained between 1123 and 1200 L.M.T. A comparison between the two curves suggests that the values of f on February 23 were unusually high at 1100 L.M.T. and just afterwards. The visible flare began at about 1034, reached maximum intensity near 1045 and had almost vanished by 1200 L.M.T. There is, therefore, a *prima facie* case for suggesting that there is a correlation between the two events; but, to prove this, an objective method of measuring the frequency of occurrence and the magnitude of any other similar increases must first be found.

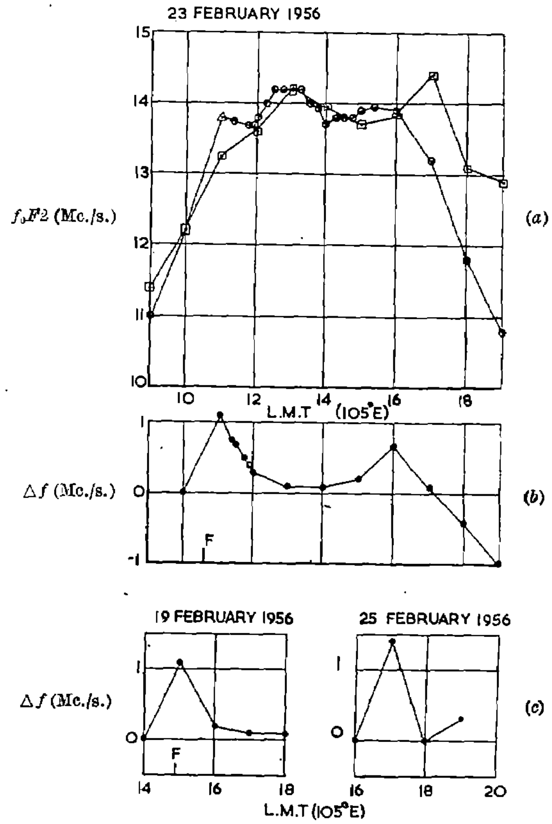

Fig. 1. Changes in f_0 (*a*) and Δf (*b*) for the $F2$-layer on February 23, 1956, and in Δf (*c*) on February 19 and 25, at Singapore. ⊙, Observed; △, extrapolated values; ⊡, 1·13 × median f_0F2 on control days February 18–28. F, commencement of flare

The measured critical frequency, $f_m(t)$, at time t (in hours) varies in an erratic manner from one day to another, but there is a close correlation between $f_m(t)$ and the value for the following hour, $f_m(t+1)$, on the same day. For each value of t, therefore, it is possible to fit a line through a series of points ($f_m(t)$, $f_m(t+1)$) obtained over a period of a few weeks; this has been done for each hour for the range of times t = 0900–1800 for the twenty-two day period February 14–March 6. For any given measured value of $f_m(t)$, the appropriate line may then be used to give the most probable value of f 1 hr. later: $f_p(t+1)$; the difference $\Delta f = f_m(t+1) - f_p(t+1)$ may then be used to represent the departure of the measured value from its 'normal' value. Fig. 1*b* shows the variations in Δf for February 23 using $f_m(1000)$ to derive $f_p(1100)$, $f_p(1100)$ to derive $f_p(1200)$ and so on. The presumed flare effect is seen to be a positive 'pulse' of amplitude 1·1 Mc./s. which is followed by a second smaller pulse at 1600 L.M.T. The same procedure was repeated for each of the twenty-two days mentioned above for t = 0900–1800; in addition to the two positive pulses on February 23, only two others were discovered which had amplitudes of 0·5 Mc./s. or greater. These occurred on February 19 and 25, and there was also a negative pulse of amplitude 0·5 Mc./s. on February 22.

An analysis of the statistics of the fluctuations in Δf has been made and from this it is possible to calculate the probability that a pulse exceeding any specified amplitude should occur by chance. From these calculations it follows that the second pulse on February 23 and the negative pulse might have occurred by chance. On the other hand, the number of pulses of amplitude not less than 1·1 Mc./s. expected to occur by chance during the twenty-two day period is 0·06, as compared with three pulses actually observed. It seems reasonable to conclude that the pulses on February 19 and 25 and the first pulse on February 23 are most unlikely to have occurred by chance and that some physical cause remains to be identified.

Table 1. Coincidence of Flares and Pulses

	Flare	No flare	Totals
Pulse	2	1	3
No pulse	14	181	195
Totals	16	182	198

The pulse on February 23 at 1100 L.M.T. was preceded by a class 2–3 flare which began at 1034 and and that on February 19 by a class 2 flare which began at 1455. No flare was observed during the hour preceding the pulse on February 25. During the period of 198 hours covered by the analysis, fourteen flares of class 2 or greater intensity were recorded which did not coincide with ionospheric pulses. These and other relevant data are included in Table 1. Since the 'expected' numbers in the two upper cells are small, the simple χ^2 test for significance cannot safely be used, but Yates's method gives $P = 0{\cdot}017$. The observed number of coincidences of flares and pulses (2) is greater than the number expected to occur by chance (0·24), and it is concluded that there is probably an association between the two phenomena.

The pulse on February 25 occurred during a severe geomagnetic disturbance and, since such disturbances are often accompanied by ionospheric disturbances, this may account for its having occurred in the absence of a flare. Although it appears that pulses of the type described can sometimes be caused by fairly intense flares, some additional factor must also be involved which is not always favourable and which permits the occurrence of pulses after only a small fraction of all such flares.

This work was carried out as part of the programme of the Radio Research Board, and is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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A New Thermal Image-Converter

A simple thermal image-converter can be made, using the dependence upon temperature of the absorption threshold in a semiconductor. When a sample of a suitable material is viewed by transmitted monochromatic light at a wave-length near the threshold, any variations in temperature appear as differences in the transmitted intensity. If a scene in which there are objects of various temperatures and emissivities is focused on the semiconductor, a visible picture will result.

The complete image-converter (Fig. 1) consists of a self-supporting film of amorphous selenium, metallized on one side, and mounted in a vacuum at the focus of a parabolic mirror. The film is viewed in transmission by light from a sodium lamp.

To achieve high sensitivity three requirements must be satisfied: (*a*) The semiconductor should have an extinction coefficient which is strongly dependent on temperature. This is determined by the product of two factors, the steepness of the absorption edge and the temperature coefficient of the forbidden energy gap. (*b*) The semiconductor must have low lateral heat spread; it must therefore be made as a thin film, and be of low thermal conductivity. (*c*) The film must be coupled strongly to the scene of view via the imaging mirror, and weakly to its surroundings.

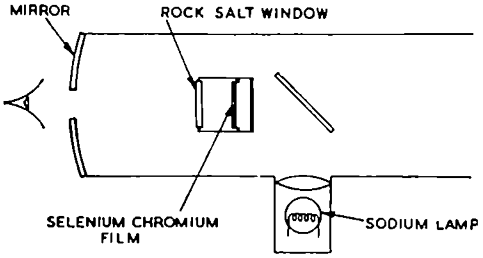

Fig. 1

For a simple tube it is also necessary that the absorption edge should be at a wave-length to which the eye is sensitive.

We have found amorphous selenium to be the most suitable semiconductor for the application. It has a thermal conductivity[1] less than 5×10^{-4} cal./gm. and can easily be prepared as a thin self-supporting film. At 5890 A. its extinction coefficient is $1{\cdot}7 \times 10^4$ cm.$^{-1}$, with a temperature coefficient[2] of 190 cm.$^{-1}$ deg.$^{-1}$. The energy gap changes by $9{\cdot}7 \times 10^{-4}$ eV. deg.$^{-1}$. The edge is not as steep as in semiconductors such as germanium and silicon, but the large change of energy gap with temperature more than compensates for this.

Since, like most semiconductors, selenium is transparent to thermal radiation, some absorbing layer must be added to the film. It has been shown elsewhere[3] that a composite metal–selenium film has a high absorption for radiation incident on the selenium side at angles of incidence less than 50°, but low absorption for larger angles of incidence, or for radiation incident on the metallized side. Its average emissivity will therefore be quite low.

The last requirement is therefore met by using a selenium–metal combination in an enclosure, evacuated to eliminate convective losses, with the selenium side facing a mirror of high aperture ratio. The selenium should be about 1μ thick, but the sensitivity is not strongly dependent on the nature or thickness of the metal.

Using an absorption-edge tube of this nature, with an *f*/1 parabolic mirror, objects 15 deg. C. above ambient temperature can be seen. Fig. 2*a* shows the image of a kettle 60 deg. C. above ambient. The sensitivity limit is determined by the smallest contrast which the eye can detect. Fig. 2*b* shows the image of a head. In this photograph the contrast has been doubled by a photographic technique.

The resolution obtained is 2 line-pairs per mm. and is probably equally limited by the performance of the mirror and of the film. The time-constant is less than 0·5 sec., and an exposure of 2 sec. is sufficient to photograph the image.

For objects hotter than 200° C. the aperture of the mirror must be reduced to avoid crystallization of the selenium. Crude sealed-off tubes have been made in which the two windows are waxed to the glass, and the vacuum required (10^{-4} mm. of mercury)

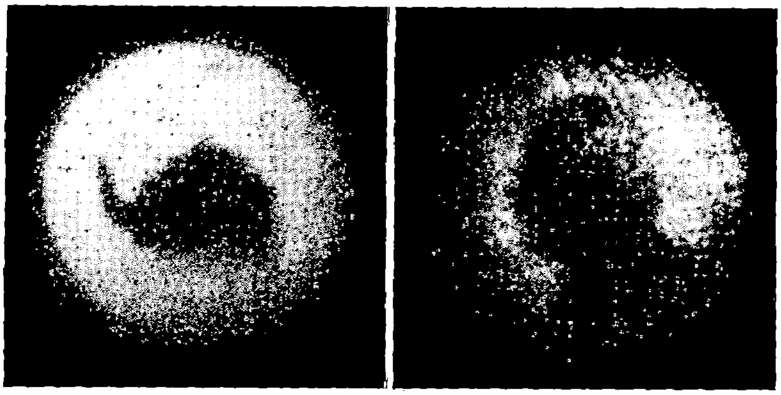

Fig. 2

maintained by getters. The life before re-pumping was needed was about two months. If longer life is required it is necessary to use a more complicated rock-salt-to-glass seal[4] and to out-gas the tube. The film must be kept cool during this process.

We are grateful to the Admiralty for permission to publish this communication.

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Stress Optical Coefficients of Different Specimens of Vitreous Silica

In a recent communication[1] the results obtained from a study of the stress optical coefficient of a sample of vitreous silica and its variation with wave-length were described. This sample was obtained from the Thermal Syndicate, Ltd., England, a few years ago. In order to find out whether there was any variation of stress optical coefficient from specimen to specimen, two specimens of vitreous silica one of '*OH*' quality and the other of '*OG*' quality were recently obtained from the same firm. Each specimen was in the form of a rectangular plate (20 mm. × 20 mm. × 5 mm.) with polished faces. Using the same experimental technique as before[1], accurate determinations have been made of the stress-optical coefficient, *C*, of these two samples over the wave-length range 2300 A.–5400 A. Measurements were made for not less than 25 different wave-lengths well distributed throughout the range investigated. The variation of *C* with wave-length for the two new specimens is represented graphically in Fig. 1. The errors in the value of *C* for the various wave-lengths for the '*OH*' and '*OG*' quality specimens are less than 0·5 per cent. The values obtained for the earlier specimen are shown as curve *P* in Fig. 1. It is seen that for any wave-length the stress optical coefficient *C* for the '*OH*' quality specimen is less than that for the '*OG*' quality, the difference being of the order 2 per cent. It is found that dispersion for all these specimens remains practically the same.

The '*OH*' quality was irradiated by neutrons in the APSARA reactor (Trombay) by the courtesy of the Indian Atomic Energy Commission. The integrated neutron flux hours were 47×10^{11} neutrons/cm.^{2}. The specimen was coloured violet-brown after irradiation. The variation of *C* with wave-length for the irradiated specimen is represented by the broken curve in Fig. 1. It is found that neutron irradiation increases the value of the stress optical coefficient. At 5000 A. the increase amounts to 1·7 per cent, while at 2500 A. it is about 2·9 per cent. The trend of the curve for the neutron-irradiated specimen appears to be different from that of '*OG*' quality.

The colour of the neutron-irradiated specimen was partly bleached by exposure for about twelve hours to ultra-violet radiation (λ 2536). The resulting specimen did not exhibit any appreciable variation of the stress optical coefficient from the unbleached specimen.

Thus it is seen that the observed values of *C* for any particular wave-length are different for different specimens of fused quartz. This could only be due to three factors, namely, the variation from specimen to specimen of (1) refractive index, (2) homogeneity and (3) impurity.

According to the Thermal Syndicate, the difference between '*OG*' and '*OH*' quality lies only in the homogeneity of the specimens—'*OH*' being more homogeneous than '*OG*'—and not in a difference in the impurity content. The specimen employed in our earlier investigation[1] is less homogeneous than the present '*OG*' quality. Besides, the variation in refractive index between '*OG*' and '*OH*' quality is of the order of two units in the fourth decimal place. This cannot account for the observed difference in the variation of *C*. Therefore the difference in the stress optical coefficients of the specimens must be due to the variation in the homogeneity of the different specimens. An improvement in the homogeneity decreases the value of *C* for any particular wave-length and vice versa.

Intense neutron irradiation changes the refractive index of fused silica slightly[2]. For the neutron dosage employed here, the change in the refractive index will be too small to account for the observed effect on the stress optical coefficient. It is possible

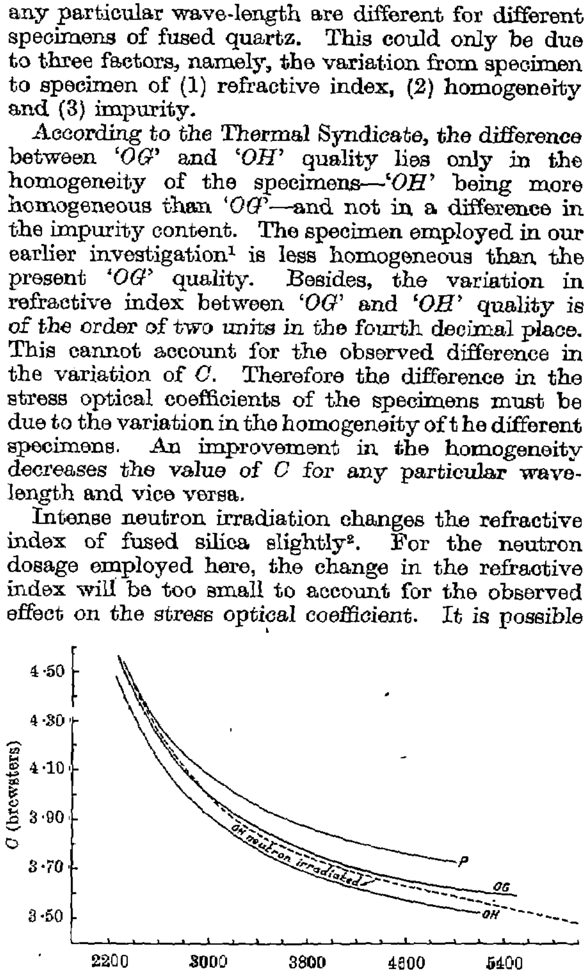

Fig. 1. The stress optical coefficient of different specimens of vitreous silica. *P*, previous sample

that neutron irradiation causes a decrease in the homogeneity of the '*OH*' quality specimen and this might explain the increase in the stress optical co-efficient following irradiation.

We wish to thank Dr. G. E. Stephenson, of the Thermal Syndicate, Ltd., for the information concerning the refractive index and homogeneity of the specimens, and the Indian Atomic Energy Commission for the neutron irradiation.

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An Improved Orientation Stage for Microscopic Optical Crystallography

A PRELIMINARY description has been published[1] of an accessory to the polarizing microscope embodying novel principles which allow a full range of optical qualitative studies, quantitative measurements, and refractive index determinations to be carried out simply and accurately on diverse crystalline material such as well-developed crystal individuals, fragments, and sectioned aggregates. The crystal occupies the centre of a glass sphere, formed of two easily detachable segments, which has complete freedom of rotation about its centre, thus allowing the conoscopic or orthoscopic phenomena to be observed for any desired direction of transmission within the crystal. Morphological and optical data representing axial or planar directions within the crystal, as, for example, the optic axes, are adjusted to the cross-hairs and recorded by an automatic plotting device in their equivalent positions on the outer surface of the sphere. Simple great circle and polar relationships only are involved, and the angular data plotted upon the surface of the sphere is measured on a vernier to one-tenth of a degree, on the periphery of a single horizontal graduated circle.

Owing to refraction by the glass of the sphere, however, quantitative data so plotted are subject to correction and re-plotting to yield the true undeviated direction and angular values within the crystal. The necessity for this correction has been now successfully overcome by a modification of the sphere, described below, which greatly simplifies procedure.

In the original design, a given ray, traversing the crystal, is refracted upon meeting the plane surface of the upper segment, the direction of the new path depending on both the angle the ray makes with the normal to this plane surface, and the difference between the refractive index of the given ray and that of the glass.

The purpose of the new sphere design is to eliminate deviation and the need for correction, and this is accomplished by providing the upper segment with a small hemispherical hollow truly concentric with the outer spherical surface of the segment. Provided the refractive index of the immersion liquid within the hollow and surrounding the crystal is equal to that for the transmitted ray within the crystal, the ray suffers no refraction, being always normal to the hollow spherical surface, and therefore points of emergence of optical directions recorded on the sphere occupy their true positions. The sphere, inscribed with the labelled directional data, becomes an accurate model of the crystal, depicting the optical indicatrix within its morphological scaffold. True cardinal directions are presented for principal refractive index observations by the immersion method, and the optical situation is clearly illustrated, facilitating complete determination of the specific characteristics of the crystal. In order to confine the immersion liquid to the centred grain under observation, independent of the attitude of the sphere, and also to facilitate the change of liquids in refractive index determinations, the upper segment is provided with a shallow annular trough surrounding the hollow, the resulting surface tension effects causing the preferential retention of the liquid at the centre, surrounding the crystal and filling the hollow. Only one sphere, of ordinary serviceable low refractive index glass, is needed to cover the whole range of crystal substances.

The advantage of the improved sphere is also applied to the projector for interference figures[2], and the phenomena observed by normal vision upon the screen occupy their undeviated positions, giving true readings for optic axial angles and other relationships.

The simplicity of operation of these instruments may extend the application of optical studies in fields where the complexity of other methods has been a hindrance. An experimental model of the orientation stage is being developed by Messrs. James Swift.

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Triboelectricity and Electron Traps in Insulating Materials : Some Correlations

THE contact electrification between metals has been explained by Harper[1] in terms of electron transfer due to the difference of work function of the metals, but the frictional charge on insulating materials is not so easily explained. Frenkel[2] has suggested that the friction develops high temperatures locally and instantaneously so that electrons in the full band in the insulators can be excited to the conduction band and may then be transferred and trapped in impurity levels on the surfaces. Vick[3] and Gonsalve[4] also postulated the existence of surface electron levels and assumed that the electron transfer between insulators is determined by the differences in energy of these levels[5]. Fowler[6,7] has investigated the detailed distribution of electron traps in a number of insulators by measuring the conductivity induced by X-rays. We have carried out the measurement of triboelectricity on the same materials that were used in the study of X-ray induced conductivity[6], in order to investigate the correlation, if any, between triboelectricity and the distribution of electron traps. These distributions had been derived from measurements of predominantly volume conductivity ; but the effects of surface traps could not be excluded.

The specimens were carefully cleaned with alcohol, and surface static charges were eliminated by the ionic atmosphere of a gas flame. Two specimens were rubbed lightly together and each rubbed surface was presented in turn to the measuring electrode,

Table 1

	PTFE	Poly-ethylene	Poly-styrene (U.S.A.)	Poly-styrene (British)	Moulded amber	Natural amber	PMMA (plast-icized)	PMMA (red)	PMMA (unplast-icized)	Mica
PFTE		−	−	−	−	−	−	−	−	−
Polyethylene	+		−	−	−	−	−	−	−	−
Polystyrene (U.S.A.)	+	+		−	−	−	−	−	−	−
Polystyrene (British)	+	+	+		−	−	−	−	−	−
Moulded amber	+	+	+	+		−	−	−	−	−
Natural amber	+	+	+	+	+		−	−	−	−
PMMA (plasticized)	+	+	+	+	+	+		−	−	−
PMMA (red)	+	+	+	+	+	+	+		−	−
PMMA (unplasticized)	+	+	+	+	+	+	+	+		−
Mica	+	+	+	+	+	+	+	+	+	

PTFE = Polytetrafluoroethylene. PMMA = Polymethylmethacrylate.

which was connected to the grid of an $ET3$ electrometer triode in a bridge circuit. The measurement of absolute value of the charge was abandoned because of the different shapes of specimens. The signs of the surface charges were, however, readily determined, and the specimens could be placed in a well-defined triboelectric series as illustrated in Table 1. The positive or negative sign in Table 1 indicates that the material in the left-hand column is charged with that sign when rubbed against the material in the top line.

The order of the substances given in Table 1 by virtue of their triboelectric properties may be compared with the order of the same substances given in ref. 6 by virtue of the shape of the distribution of traps, where they were listed in order of progression from 'exponential' distributions of traps to 'uniform' distributions. The shape of distribution was defined by the parameter T_1 in the relation

$$M_E\, d_E = A\exp(-E/kT_1)\, \mathrm{d}E$$

where M_E is the number of traps between E and $E+\mathrm{d}E$ in depth (energy). When T_1 is small, approaching room temperature, the distribution will be steeply exponential. This is merely a formalized way of expressing the physical condition that there are many more shallow traps than deep ones, and it may apply only over a limited region of energy-depth.

Table 2 gives the values of T_1 for the substances listed in the same order as Table 1. In addition, a parameter E_x is given, representing an approximately exponential factor in change of conductivity with temperature when free electrons are being produced by X-rays. E_x was related to T_1 by the measured dependence of induced current upon X-ray intensity[6]. In addition, the total number of traps, M per cm.^{3}, is given: for the materials with low values of T_1 only a lower limit of M could be derived. While the correlation has some anomalies, particularly for unplasticized polymethylmethacrylate, it appears that in general the substances at the negative end of the triboelectric series are those with the largest values of T_1, that is, the most uniform distributions of traps and the smallest numbers of traps per cm.^{3}.

Table 2

Substances in order of triboelectric sign	T_1 (° K. × 10^3)	E_x (eV.)	M
Negative			
Polytetrafluoroethylene	0·58	0·5	10^{19}
Polyethylene	1·4	0·35	10^{19}
Polystyrene (United States)	0·9	0·18	10^{19}
Polystyrene (British)	0·5	0·44	10^{19}
Moulded amber	10	0·06	10^{15}
Natural amber	10	0·22	10^{16}
Polymethylmethacrylate (plasticized)	10	0·1	10^{16}
Polymethylmethacrylate (red)	4·3	0·07	10^{17}
Polymethylmethacrylate (unplasticized)	0·41	0·5	10^{19}
Mica	5·5	0·18	10^{16}
Positive			

It may be tentatively suggested that the partition of electrons between two substances is determined as follows: free electrons are produced when the substances are rubbed together, either by abrasion processes not yet understood or by local heating, and these free electrons are then shared between the traps of both substances, so that the substance with the greater number of traps below the Fermi limit will accept the greater number of electrons, becoming negatively charged. It would be expected that substances with an 'exponential' distribution, having a greater number of traps, should become negatively charged. The experimental evidence appears to confirm this expectation in general.

It should be emphasized that this conception is very crude and is only an attempt to explain the order of a particular triboelectric series from some previously determined trap distributions. The conception differs in detail from those mentioned in the introduction.

We wish to express our thanks to Dr. R. W. B. Stephens for his interest in this work and Dr. F. T. Farmer for providing the specimens. One of us (E. F.) expresses his appreciation to the British Council for granting him the scholarship during the tenure of which this work was carried out in the Department of Physics, Imperial College of Science and Technology, London.

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Observation of Metal Sections by means of the 300-kV. Electron Microscope

Fernandez-Moran[1] has reported the preparation of ultra-thin sections of metal, and showed electron micrographs and diffraction patterns of sections of pure germanium used for transistors. He cuts the metal with the Moran ultra-microtome equipped with a diamond knife.

We have cut aluminium, copper and steel with an improved Minot-type microtome equipped with a Latta-Hartman type glass knife, and observed the

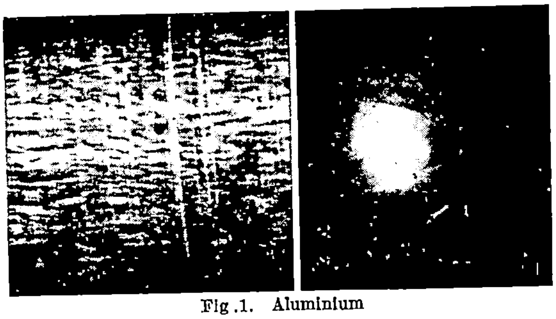

Fig. 1. Aluminium

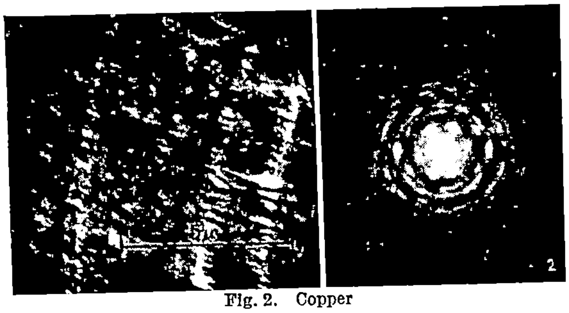

Fig. 2. Copper

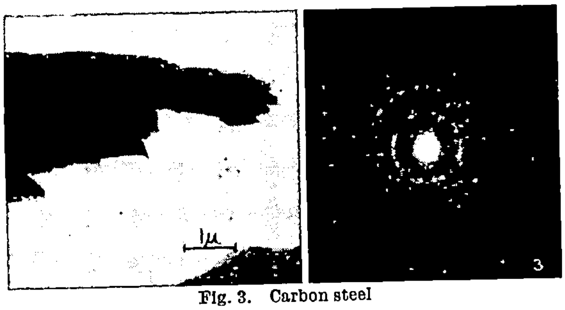

Fig. 3. Carbon steel

sections by means of the 300-kV. electron microscope[2]. The feeding mechanism of the microtome has been improved to give sections of 0·5 micron. The glass knife is set on the microtome with the cutting angle at about 50°–60°. The edge of a knife which has the cutting angle smaller than 50° is apt to be broken in the course of cutting. A relatively slow cutting speed is necessary to obtain sections. A small specimen of about 1 mm. × 1 mm. × 5 mm. is embedded in methacrylate resin to hold the specimen, and the sections are floated off the knife on the surface of 40 per cent ethanol or watchmakers' oil.

Even the 300-kV. electrons do not penetrate sections of 0·5 micron sufficiently, so the section is thinned by etching in hydrochloric acid or potassium cyanide. The etching may also serve to remove the residual strain in the sliced sections.

Fig. 1 shows the electron micrograph and diffraction pattern of a section of aluminium single crystal. Many lines and steps can be observed, which seem to correspond to the deformation of the crystal due to the non-uniformity or vibration of the knife edge. This fact is in contrast with the net-like diffraction pattern with Kikuchi patterns. Hence the section looks morphologically irregular in the electron micrograph, but crystallographically regular in the diffraction pattern.

Fig. 2 shows pictures of a section of copper. As in the case of aluminium, the diffraction pattern is from a relatively regular crystal, contrasting with the irregular shape in the electron micrograph. The diffraction pattern illustrates the oriented deformation of the crystal.

Fig. 3 shows pictures of a section of 0·1 per cent carbon steel. In this case the section is so thick that detail is not shown in the micrograph. The diffraction pattern, however, is clear enough to identify the specimen.

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Rapid Assessment of Surface Radioactive Contamination

WHEN radioactive contamination occupies an extended area, as, for example, the surface of laboratory benches, its determination by the usual method of β-ray counting is tedious and is relatively not precise. However, the activity can be assessed in this case by a very simple, fast and sensitive method —the discharge of a conductor. The loss of charge of a conductor is due to the aerial ions of opposite sign generated by ionizing radiations, and the method of the discharge of a conductor has formerly been used for routine measurements of atmospheric conductivity[1]. I can give here only a very brief account of this method, which is based on the relation between the charge Q on a conductor and rate of loss of charge, given by Coulomb[2]:

$$dQ/dt = -aQ \qquad (1)$$

It can be easily shown that the constant a of Coulomb's equation is equal to $4\pi nw$, n being the number of ions per cm.^{3} of air surrounding the conductor and w their mobility in the electric field. From (1) we finally get the relation:

$$n = K/t \qquad (2)$$

where K is a constant implying the capacity constants of the measuring device, and t the time which corresponds to the drop of potential from V_0 to V_t. The validity of (2) supposes that V_0, V_t and w do not vary during the experiment, a condition practically always fulfilled for laboratory measurements.

When the ionizing radiation produces q ions of one sign per sec. per cm.^{3} then the total number of ions per cm.^{3} of air is given by the equation:

$$n = (q/\alpha)^{1/2} \qquad (3)$$

where α is the recombination coefficient for small ions, in our measurements a constant. The rate of ion-production q is proportional to the intensity J of ionizing radiation. When the source of this radiation is a radioisotope deposited on a plane surface with the activity A_0 per square cm. and the respective intensity of radiation J_0, we can put, according to (2):

$$t^{-1} \sim A_0^{1/2} \sim J_0^{1/2} \qquad (4)$$

The validity of (4) was tested with phosphorus-32 and strontium-90 + yttrium-90. A circular filter paper, with diameter 98 cm., was uniformly impregnated with the radioactive solution of which the activity was 33·8 μc. (4·48 × 10^{-3} μc./cm.^{2}) for phosphorus-32 and 59·3 μc. (7·85 × 10^{-3} μc./cm.^{2}) for strontium-90 and yttrium-90. The time t was determined for various distances x of the charged conductor from the active surface and the respective values of the

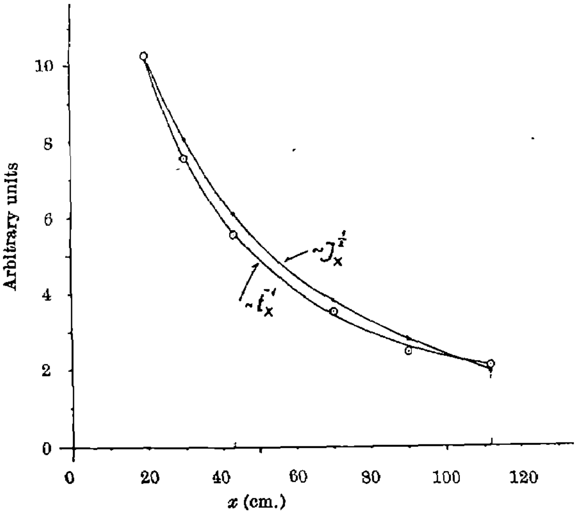

Fig. 1

intensity J_x of β-radiation were computed from the well-known absorption relation of King[3]:

$$J_x = -\tfrac{1}{2} J_0[Ei(-\mu x) - Ei(-\mu r)] \qquad (5)$$

In this equation μ is the absorption coefficient of the β-rays in air, x the minimum and r the maximum distance of the centre of the conductor from the active surface and Ei the exponential integral. Since the expression in front of the brackets in (5) is constant for a given experiment, J_x is determined by the difference of the two exponential integrals. The results obtained for phosphorus-32 are shown in Fig. 1. Within the limits of accuracy of this method (about 15 per cent) the curves reduced to the same origin agree very well. The parallel course of the two curves proves that the validity of (3) is not markedly impaired by the presence of large ions formed from the condensation nuclei. This fact is partly due to the weak electric field being unable to carry the large ions on the conductor to any considerable extent, and partly to the formation of these ions, governed by a relation similar to (3).

A simple measuring device has been used: the conductor, a piece of insulated aluminium wire (length about 9 cm., diam. 0·1 cm.), is screwed on the charging contact of a routine protection pocket electrometer of the stylo type. For current measurements the electrometer is supported by a very light wire frame in the form of two parallel letter X's connected by a cross wire. Sudden changes of the capacity of the exposed wire caused by the approach of a hand or a head to the microscope have no lasting effect on the reading of the electrometers. The fibre is deflected but returns immediately to its original position.

The conductor method is very sensitive because the measured value, n, varies with the square root of the activity. So for the previously mentioned sample of phosphorus-32 t had the value of 9·23 sec. for $x = 20$ cm., $V_0 = 145$ V. and $V_t = 120$ V. Since at the same time t for the natural background was about 1,200 sec., it is obvious that a specific activity as low as 10^{-4} μc. per cm.[2] can be easily detected. Analogous figures have been obtained for strontium-90 and yttrium-90, which suggests a simple method for the continuous registration of radioactive atmospheric fall-out from nuclear tests.

A detailed account of this work will be published elsewhere. I am indebted to Mr. Kočí, Mrs. Majerová and Mrs. Zelenková of the Institute of Nuclear Physics for their collaboration.

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Electrical Discharges between Coaxial Electrodes

Luminous corona discharges occur when transient voltages, lasting about a microsecond, are applied between a wire and a small coaxially mounted ring in air. I have photographed these discharges and find that their shapes differ with the polarity of the electrodes. When the wire is made the negative electrode the discharge has the form of diffuse tufts, which are grouped around the wire into a roughly symmetrical brush; when positive, the discharge occurs in radial filaments (Figs. 1 and 2). Viewed along the axis the shape of a corona discharge resembles the Lichtenberg figure corresponding to the same polarity, which is produced by a discharge in air on an insulating surface between concentric electrodes[1] (Figs. 3 and 4).

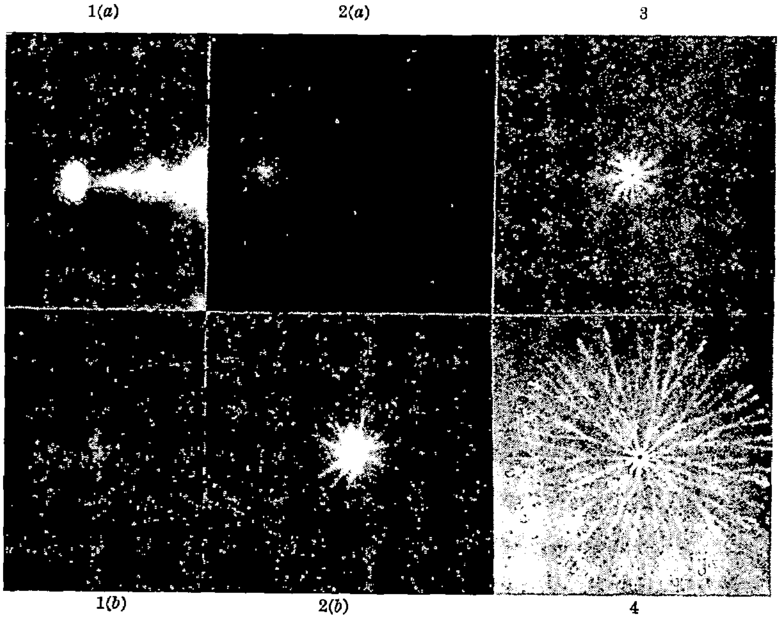

Fig. 1. Side views of wire: (a) negative, (b) positive. Fig. 2. Axial views of wire: (a) negative, (b) positive. Fig. 3. Lichtenberg figure, negative inner electrode. Fig. 4. Lichtenberg figure, positive inner electrode

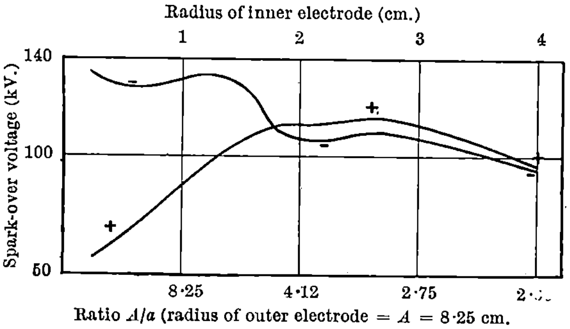

Fig. 5. Impulse spark-over voltage as a function of radius, *a*, of inner electrode

It appears from the photographs that the impulse corona forms a sheath around the negative wire, but has no such effect when the wire is positive. The form of the relation between wire-radius and impulse spark-over voltage in a system of coaxial cylinder and wire[2] (Fig. 5) is consistent with the assumption that a sheath, which protects the system against spark-over, is also formed in that geometry around the negative wire. The protection is greater than would be afforded by an extension of the wire-radius, which merely reduced the electric field; such an extension could raise the spark-over voltage no higher than the peak at $A/a = 3{\cdot}6$ (Fig. 5).

Differences of impulse spark-over voltage with polarity are observed not only in coaxial electrode-systems but also in many others, the value being almost always higher when the electrode at which the stress is greater has negative polarity[3]. It is surmised that protection of negative electrodes by impulse corona which precedes spark-over may be a general effect.

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Distribution of Radioactivity in Rocks and Minerals, and the Effect of Weathering on Determinations of Uranium

In determining the uranium content of a series of rocks for the purpose of studying its geochemical behaviour, difficulties are often encountered because of the loss of uranium by leaching. In some cases it is almost impossible to ascertain whether or not a rock has been affected by leaching. Late-stage hydrothermal activity will remove (by solution) some uranium, but in addition to this a certain amount is removed by weathering. Because of the heterogenous distribution of uranium in acid rocks (for example, granites), the effect of hydrothermal solutions, mineralization and variations in uranium and thorium ratios, the geochemical behaviour of uranium is best approached by studying more homogeneous rocks, in particular basaltic types.

Adams[1] notes that the alpha-particle activity (as determined by scintillation counting) of a series of rocks when plotted against the uranium content gives rise to a linear plot. This indicates that the uranium–thorium ratio in the rocks studied was constant. In the Lassen Peak series studied by Adams, weathered rocks and mud flows did not show such a well-defined correlation of activity to uranium content. I have also observed (with a series of differentiated basic rocks, basalts, granophyres and granites) that a linear relationship exists between the uranium content of a rock and the alpha-particle activity (as determined by nuclear emulsion techniques). In the case of some basic rocks studied (uranium content, 0·05–1 p.p.m.) the uranium content of weathered samples is decreased by a factor of 30–50 per cent, but the linear relationship still holds. This indicates that some thorium was probably removed together with the uranium. In addition, there is apparently no separation of uranium and thorium towards the end of the differentiated series studied. This supports Adams's[1] view, and not those of Kirsch and Hecht[2], who believed that the process of differentiation would separate uranium and thorium. In order to undertake a more comprehensive study it is necessary to determine the total uranium and thorium content of weathered and unweathered samples. Unfortunately it is difficult to determine small amounts (< 10 p.p.m.) of thorium satisfactorily.

The distribution of radioactivity in the major rock-forming minerals has been fairly well established by Picciotto[3] and me[4]. There is no preferential increase of importance in the major minerals such as felspar, pyroxene olivine and quartz. Significant increases of radioactivity occur only in the accessory minerals such as zircon, epidote, orthite, sphene, xenotime, apatite and others. The distribution of radioactivity in intercrystal areas is very sporadic. A study of this intercrystal radioactivity is best approached by using nuclear emulsions; but even then it is possible that this loosely bound intercrystal material containing uranium and thorium may be partly removed during the preparation of thin rock sections. Another method of determining the easily leached radioactivity is by refluxing a rock sample with dilute acids, as described by Brown[5]. Great care must be exercised when carrying out such experiments, as radioactive minerals such as uraninite may be present. Deutsch[6] has described the presence of uraninite in the Baveno granite while I have observed it in the granites of Dartmoor and Shap.

While isolated intercrystal material containing radioactive elements may be totally removed by weathering by solutions percolating along cracks, this is not comparable to the weathering of such radioactive minerals as xenotime, monazite, uraninite, thorite, epidote, orthite and fergusonite. In the 'iron stain' halo surrounding these minerals it is observed that considerable amounts of radioactivity are present. On a smaller scale altered minerals often contain the bulk of the radioactivity on ferruginous secondary material. It is of interest to note that in the case of some preliminary studies carried out on the radioactive minerals of Norwegian pegmatites, the mineral may contain a certain percentage of uranium and thorium and be surrounded by a radioactive 'iron halo', while the surrounding felspar emits as much radioactivity as that present in the felspar of an oceanic basalt.

Finally, the distribution of radioactivity in a single mineral still involves a consideration of the radioactivity both within the body of the mineral and that present in cracks. Unfortunately, even with long exposures using nuclear emulsion techniques, it is difficult to determine these two factors on 'normal' zircons in a granite. Zircons are of particular interest as they are so widely used in age determinations. A study of zircons from Great Britain, Norway and Ceylon indicates the following.

(1) A zonal distribution of radioactivity in zoned specimens.

(2) Presence of highly radioactive point sources perhaps due to submicro inclusions of a very radioactive material or aggregates of radiocolloids.

(3) Either: (*a*) homogenous distribution of radioactivity; (*b*) increase of radioactivity in central areas of a crystal; (*c*) increase of radioactivity in peripheral regions.

(4) In zircons in particular as much as 50 per cent of the total radioactivity may be present in iron-stained intra-crystal cracks.

In conclusion, it has been observed that:

(1) A plot of total alpha-particle radioactivity against uranium content can indicate whether or not the uranium thorium ratio is constant, and the effect of weathering on the ratio.

(2) The radioactivity of the major rock-forming minerals is essentially constant.

(3) Weathering can lead to a loss of about 50 per cent of the total radioactivity and sometimes up to 50 per cent of the uranium content.

(4) The distribution of such rare accessory minerals as uraninite and thorite may be far more common than realized. The presence of such minerals prevents the determination of purely intercrystal radioactivity by acid-leaching studies.

(5) In some accessory and even major minerals appreciable amounts of radioactivity may be present in 'iron halos' surrounding the mineral and on cracks within the mineral. The radioactive material in such locations is easily leached.

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Thermal Stability of Polytetrafluoroethylene

POLYTETRAFLUOROETHYLENE is notable among addition polymers for its high thermal stability. It decomposes at temperatures above about 400° C. to give tetrafluoroethylene as primary product[1]. It seems possible to account for this high stability in thermodynamic terms. A useful, though arbitrary, measure of the ultimate stability of a polymer, or more correctly of its free radical form, with respect to its monomeric precursor, is the temperature at which a particular pressure of monomer is supported over the polymer. This is given by[2]:

$$T_c' = \Delta H_{gc}/\Delta S_{gc}$$

where ΔH_{gc} and ΔS_{gc} are the heat and entropy of polymerization for the chosen monomer pressure at a suitable temperature, conveniently taken as 25° C. in most cases. Thus the ultimate stability is determined by the heat of polymerization of the monomer (which is in the range -16 to -25 kcal./mole for most monomers), and the entropy of polymerization (which increases with the molecular weight and complexity of the monomer). The heats of formation of tetrafluoroethylene and of its polymer (-152 kcal./mole[3] and -199 kcal./tetrafluoroethylene mole unit[4], respectively) give the heat of polymerization of tetrafluoroethylene as about -47 kcal./mole. The entropy of polymerization at 67° C. (which temperature is chosen to avoid anomalies resulting from the second-order phase transition of the polymer at room temperature), derived from the measured entropies of monomer[5] and polymer[6], is about -45 entropy units/mole for one atmosphere pressure of monomer. These compare with the values[7] $\Delta H_{gc} = -24 \cdot 7$ kcal./mole and $\Delta S_{gc} = -37$ e.u./mole for ethylene at 25° C., and account for the strikingly greater thermal stability of tetrafluoroethylene.

Thermochemical considerations suggest that other olefines containing the $=CF_2$ group will have heats of polymerization greater than those of better-known olefines, but lower than that of tetrafluoroethylene. The ultimate stabilities of polymers derived from these olefines will therefore be intermediate between those derived from normal olefines and from tetrafluoroethylene. In practice, however, the polymers may be less stable than these thermodynamic considerations suggest, since they may decompose more readily into other products. Examples are polyvinylidene fluoride and polytrifluoroethylene, which yield hydrogen fluoride as the first decomposition product[1].

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Paper Chromatography of the Polycyclic Tar Hydrocarbons

WHATMAN No. 4 filter paper impregnated with 10 per cent paraffin oil, and methanol saturated with paraffin oil (prepared by shaking methanol with paraffin oil in a separating funnel) as the ascending mobile phase, were found suitable for paper chromatography of the polycyclic tar hydrocarbons (for others, see ref. 1).

The paper was impregnated by dipping it into a 10 per cent petrol–ether solution of paraffin oil, quality as in "Pharmacopoea Bohemoslovenica" (second edition), and by evaporating the petrol–ether during 15 min. The technique of paper chromatography employed is already adequately described[2]. After developing the chromatogram for about 4 hr. (30 cm. from the front to the starting point is sufficient), it was possible to see characteristic fluorescence spots under ultra-violet light.

The average R_F values and their colour under ultra-violet light, both of control substances and of

Table 1

Order of spots	Control compound	R_F (control)	Fluorescence* (*C*, *T*)	R_F (Coal tar compound)	Notes*
1			Violet	0·60	
2			Greenish-grey	0·50	In excess only
3	Anthracene Phenanthrene	0·43 0·41	Violet	0·44	Violet spot separating from following green (*T*)
4	Pyrene	0·36	Green	0·38	
5	Chrysene†	0·34	Blue-violet		Chrysene (*C*)
6		0·31	Yellowish-green	0·32	Possibly 1,2-benzanthracene (*C*, *T*)
7	3,4 Benzpyrene	0·28	Violet	0·28	
8	1,2,5,6 Dibenzanthracene†	0·254 0·252	Violet Yellowish-green	0·25	1,2,5,6 Dibenzanthracene (*C*) Possibly 1,2,7,8 dibenzanthracene (*C*,*T*). The second is concentric with the first (*C*) in excess only
9			Violet	0·21	Possibly coronene (*T*)
10			White-bluish	0·20	These spots are not always so well separated (*T*)
11				0·18	
12				0·16	
13				0·14	
14				0·12	
15				0·10	
16			Yellow	0·09	This forms the first of the yellow series which will be developed in a different solvent system (*T*)

* (*C*) refers to control compound ; (*T*) refers to coal-tar compound.
† Two spots due to an impurity in the control compound.

the spots obtained from coal tar with the phenols and nitrogen compounds removed (by shaking a cyclohexane solution of the tar with 2 *N* aqueous potassium hydroxide, and, after rejecting the aqueous layer, with 2 *N* sulphuric acid), are shown in Table 1.

I am grateful to Prof. Jan Šula, of Prague, for the control compounds.

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Carbohydrases in the Sugar-Gland Juice of *Cryptochiton* (Polyplacophora, Mollusca)

Although considerable work has been done on the digestive enzymes of snails and mussels[1], very little is known about those of the marine chitons. Fretter, working with the two British species, *Lepidochitona cinereus* Gray and *Acanthochitona crinitus* Gray, has reported[2] that the fluid in the sugar gland (a pouch-shaped organ connected with the œsophagus) hydrolyses starch, with a *p*H optimum at 5·6, and glycogen, with a *p*H optimum at 6·4–6·8.

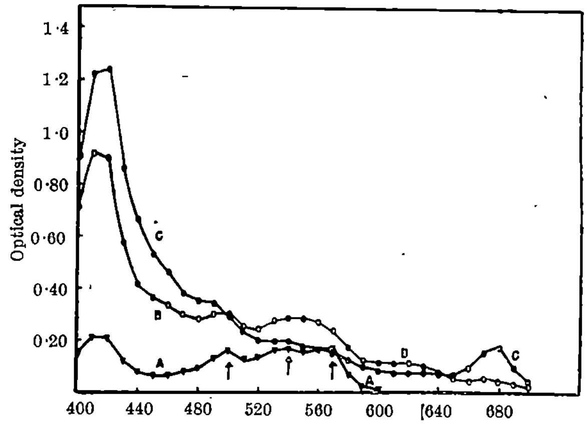

Fig. 1. Absorption spectra of different samples of *Cryptochiton* sugar-gland juice. The peaks indicated by the arrows (sample *A*) coincide exactly with those of phycoerythrin *R*. The peak at 680 mμ is probably caused by the presence of a chlorophyll

In 1956, we studied the enzymes in the sugar-gland juice of the giant chiton, *Cryptochiton stelleri* Middendorff, which is common along the Pacific coast of the United States. In most cases the juice, which can be obtained in considerable quantities, is salmon-coloured ; examination in the spectrophotometer reveals, very surprisingly, that phycoerythrin *R* is often present, while chlorophylls, such as chlorophyll *D*, may also occur (Fig. 1). The conclusion that the animal feeds largely on seaweeds is confirmed by the observation that large pieces of green, red and brown algae, including whole 'branches' of the hard coralline algae, can be found in the intestinal tract. A study of the mobilization of the algal carbohydrates by the chiton is imperative not only because of its intrinsic interest but also because of its ecological and biochemical implications.

Thus far, the following substrates were found to be hydrolysed energetically by the juice : starch, glycogen, laminarin, sodium-alginate, xylan from the red alga, *Rhodymenia palmata* ; cellulose and substituted celluloses, cellopentaose, cellotetraose, cellotriose, cellobiose, maltose, *iso*maltose, panose, turanose, salicin, α- and β-methyl glucoside, and melezytose. Agar is probably attacked by two enzymes in the juice ; one of these modifies the iodine reaction, whereas the other causes this reaction to disappear completely. Moreover, a drop in viscosity under the influence of the juice could be observed in very weak agar solutions after a few days. Weak or doubtful activity was displayed towards gentiobiose, fucoidin, tunicin and bacterial dextran ; no hydrolysis took place in the cases of sucrose, trehalose, lactose, melibiose, stachyose, raffinose and inulin. The *p*H optima for the hydrolytic actions were generally in the vicinity of *p*H 5 (Fig. 2), which is the natural *p*H of the sugar-gland juice ; cellulase, which seems to have a somewhat lower *p*H optimum (Fig. 3) forms an exception.

Thus α- as well as β-glucosidic 1 : 4 linkages between glucose residues (starch, glycogen, cellulose) and β 1 : 3 linkages between such residues (laminarin) can be broken. The evidence on α 1 : 6 linkages between glucose residues is less conclusive ; from the fact that *iso*maltose is hydrolysed with ease and that almost all the glucose theoretically expected is formed in the breakdown of starch (which has some 1 : 6 linkages) one must conclude that they are hydrolysed, but on the other hand the breakdown of bacterial dextran (which has an abundance of α 1 : 6 bonds) is very slow.

Some sugar-gland enzymes show synthetic as well as hydrolytic properties. For example, in digests with turanose, evidence was obtained for the transient occurrence of a new sugar with a slightly lower R_F value than turanose, and in *iso*maltose digests there were clear indications of trisaccharide formation.

The invulnerability of trehalose, sucrose and inulin is remarkable in view of the fact that these substances have been reported as constituents of blue-green algae (trehalose) and *Dasycladales* (sucrose, inulin), respectively. It is obvious that information on the activities of other parts of the digestive tract of *Cryptochiton* is needed. Most experiments were performed on the sugar-gland amylase, which was shown to be a true α-amylase, activated by halide ions (Fig. 4); it is able to digest native *Codium*-starch, and acts in conjunction with a powerful maltase. The *p*H optima for the breakdown of starch and of glycogen are identical. Some purification of the amylase could be achieved by procedures involving ammonium sulphate fractionation, adsorption on native potato starch and elution with weak ammonium phosphate solutions. The origin of the sugar-gland enzymes is not clear; they may be produced by symbiotic bacteria. It is possible that the activation of the amylase by halide ions may provide a clue, since it seems to be a general feature of the amylases of snails and bivalves, noticeable even in those cases where the presence of bacteria is at least doubtful.

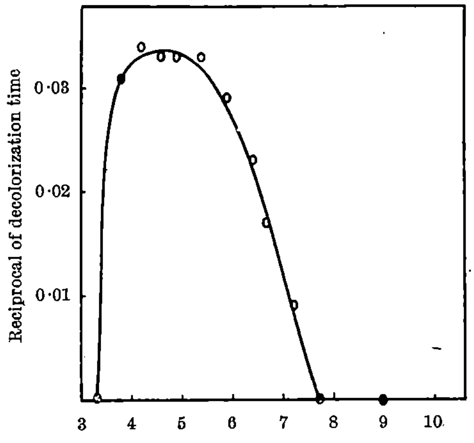

Fig. 2. *p*H optimum for *Cryptochiton* sugar-gland amylase. Activity studied by following the disappearance of the iodine reaction of a starch solution (Wohlgemuth method)

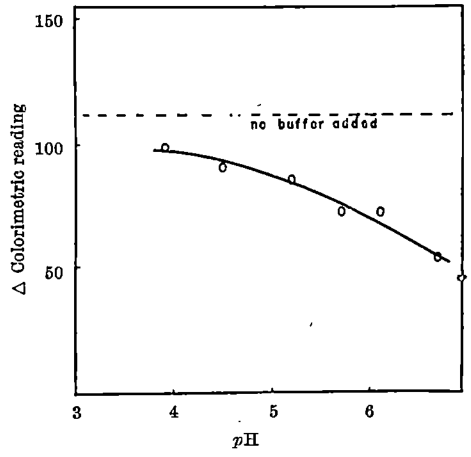

Fig. 3. *p*H optimum for the breakdown of cellulose by *Cryptochiton* sugar-gland enzyme. (Turbidity measurements on expanded cotton cellulose)

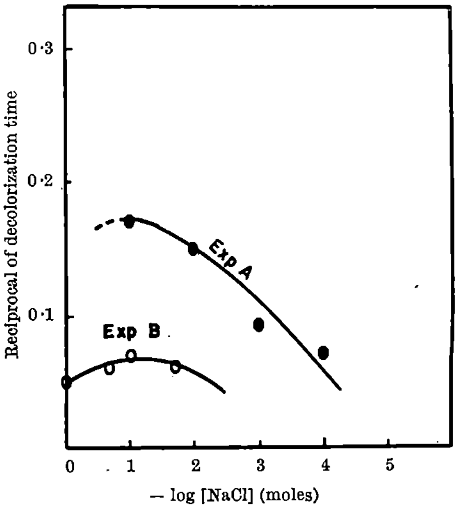

Fig. 4. Activation of *Cryptochiton* sugar-gland amylase by chloride ions

A systematic survey of the biochemical activities of the sugar gland is in progress.

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Formation of β-Alanine from Spermine and Spermidine by *Pseudomonas aeruginosa*

THE importance of β-alanine, especially as a constituent of pantothenic acid, in biological systems is well recognized; but little is known about its biosynthesis. One possible mechanism of formation involves the decarboxylation of aspartic acid though this has been established only for a small number of bacteria[1]. It has been recently found that β-alanine might also be formed from uracil by a certain species of *Clostridium*[2].

Studying the degradation of the naturally occurring polyamines spermine and spermidine, we found that these substances were oxidized by *Pseudomonas aeruginosa*. Carbon dioxide and ammonia were evolved, and a ninhydrin-positive compound accumulated during the reaction. This compound behaved like β-alanine when analysed by paper chromatography using various solvent systems[3-5]. A similar result was obtained by paper electrophoresis, in phthalate buffer of *p*H 3·2[6].

The results are illustrated in Fig. 1; spermine (*a*) and spermidine (*b*) rapidly disappeared during the reaction, while β-alanine was formed. β-Alanine was then further metabolized by *Ps. aeruginosa*, as can be seen in all experiments. Quantitative measurement[8] showed that about twice the amount of β-alanine was formed from spermine compared to spermidine. This might be expected from the composition of the two compounds, since spermine

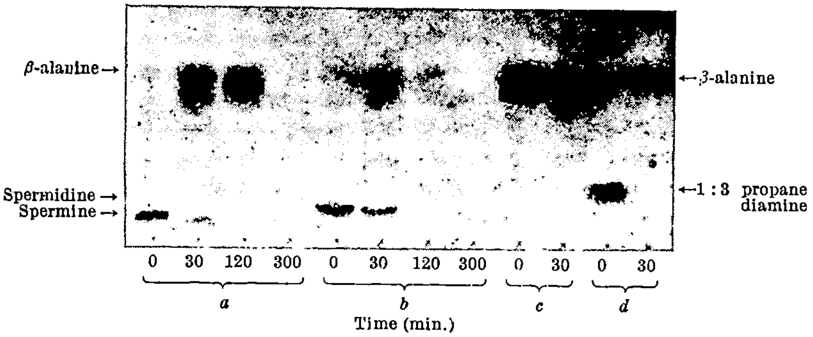

Fig. 1. Formation of β-alanine by resting cells of *Ps. aeruginosa*. Cells were grown on a semi-synthetic medium (ref. 7) enriched with 0·3 per cent spermine. Washed cells, suspended in 0·022 *M* phosphate buffer, *p*H 7·0, were incubated at 30° in Warburg flasks containing (*a*) 2·5 μ*M* spermine; (*b*) 2·5 μ*M* spermidine; (*c*) 5 μ*M* β-alanine or (*d*) 5 μ*M* 1 : 3 propane diamine, respectively. Samples were taken at the times indicated, centrifuged, and the supernatants analysed by paper chromatography (ref. 8)

contains two $(CH_2)_3$ fragments and spermidine only one:

$$NH_2(CH_2)_3NH(CH_2)_4NH(CH_2)_3NH_2$$
spermine

$$NH_2(CH_2)_4NH(CH_2)_3NH_2$$
spermidine

That these $(CH_2)_3$ fragments participate in the formation of β-alanine, is borne out by the fact that 1 : 3 propane diamine was oxidized by *P. aeruginosa* to β-alanine, whereas putrescine was not.

The formation of β-alanine from spermine and spermidine thus opens up a new possibility for the biosynthesis of this important compound. This approach is especially attractive in view of the wide distribution of spermine and spermidine[9,10] and their role as growth-factors for various micro-organisms[11–13].

A detailed report of this study will be published elsewhere.

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Substrate-Selective Inhibition of Mitochondrial Oxidations by Enhanced Tonicity

During an investigation of factors controlling rates of oxidation by mitochondria, it was found that variations of sucrose concentration in the suspending medium profoundly inhibited the oxygen consumption with some substrates but had much less effect with others. Earlier studies[1,2] have indicated that the use of 0·88 *M* sucrose as the diluent during homogenization and isolation of mitochondria resulted in lower rates of mitochondrial oxidations than when 0·25 *M* sucrose was used. This was true despite the dilution of the mitochondria with other components of the final reaction mixture.

In the present studies, rat-liver mitochondria were prepared in 0·25 *M* sucrose and 0·5 ml. of the washed suspension (equivalent to 0·5 gm. original liver) was placed in Warburg vessels containing, in 1 ml. of solution, 6 μmoles adenosine triphosphate, 50 μmoles inorganic phosphate, 15 μmoles magnesium sulphate, 50 μmoles glucose, 1 mgm. of partially purified yeast hexokinase and 20–40 μmoles of substrate. Final volume was brought to 3·0 ml. by the addition of sucrose solutions of appropriate concentration.

Typical experiments with each of ten different substrates are shown in Table 1. In our routine experiments the final sucrose concentration is 0·17 *M*. Lowering tonicity to 0·075 *M* sucrose seemed to have no adverse effect on either respiration or phosphorylation. However, raising the sucrose concentration above 0·17 *M* progressively inhibited the oxidation of glutamate, α-keto-glutarate, citrate, pyruvate (to aceto-acetate) and caprylate virtually to complete suppression at 0·48 *M*. Glutamate oxidation was 50 per cent inhibited at 0·37 *M* sucrose. It is interesting that oxidation of other pyridine-nucleotide linked substrates such as malate, *iso*citrate, proline[3] and β-hydroxybutyrate were much less inhibited. Succinate oxidation was relatively little affected.

It is possible that the selective effect with different substrates results from selective permeability of the mitochondria in higher concentrations of sucrose. Citrate must be oxidized via *iso*citrate, yet it is more strongly inhibited than the latter, indicating a selective permeability or an effect of high-sucrose on aconitase activity. Cooper and Lehninger[4] have reported high sucrose concentrations to inhibit dinitrophenol-stimulated adenosine triphosphatase and the exchange

Table 1

Substrate	Molarity of sucrose						Inhibition by hypertonicity (per cent)
	0·075		0·17		0·48		
	Q_{O_2}(N)	P/O	Q_{O_2}(N)	P/O	Q_{O_2}(N)	P/O	
Glutamate	35·8	2·8	31·5	2·7	0	—	100
α-Keto-glutarate	29·7	2·8	29·1	3·1	0	—	100
Pyruvate	18·1	2·7	19·0	3·1	0	—	100
Citrate	23·0	2·5	20·9	2·9	0·7	—	96
DL-*Iso*-citrate*	4·8	2·0	5·1	1·8	1·2	0	77
l-Malate	8·8	2·7	9·5	2·8	1·9	3·6	82
Caprylate	24·5	1·8	26·8	1·9	0	—	100
DL-β-Hydroxy-butyrate	20·0	2·2	19·7	2·1	11·3	2·3	43
Proline	31·0	2·2	28·0	2·4	12·8	2·2	55
Succinate	24·2	1·8	25·8	2·1	17·3	1·9	33

Q_{O_2}(N) = c.mm. oxygen consumed per mgm. mitochondria nitrogen per hr. The experiments were of 8–20 min. duration to permit comparable amounts of oxygen (6–10 μatoms) to be consumed despite differences in rate of oxygen consumption.

* *allo*-Free, obtained from California Biochemicals Foundation. The low rate of oxygen consumption reflects inhibition by the unnatural enantiomorph. *iso*Citrate isolated from *Bryophyllum* is oxidized as rapidly as citrate.

reaction between adenosine triphosphate and inorganic phosphate in submitochondrial particles prepared with digitonin.

Additions of diphosphopyridine nucleotide, coenzyme *A*, 2,4-dinitrophenol or triiodothyroacetic acid did not relieve sucrose inhibition of glutamate or β-hydroxybutyrate oxidation. The inhibition was completely reversed by centrifuging mitochondria from the medium containing 0·48 M sucrose and transferring to one containing 0·17 M sucrose.

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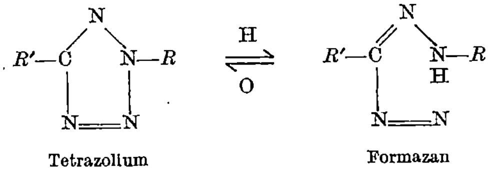
Cytochemical Localization of Succinic Dehydrogenase in Mitochondria from *Periplaneta americana*

Morphological[1,2] and biochemical[3-5] studies indicate that the mitochondrion is a structurally complex organelle in which certain oxidative enzyme systems are localized. The succinic dehydrogenase system, in particular, has been shown to be situated almost exclusively in the mitochondrial fraction of tissue homogenates.

Histochemical methods for showing this enzyme system depend on the acceptance of hydrogen by water-soluble tetrazolium salts and their reduction to coloured, insoluble, formazan dyes.



This reaction is not reversible in biological systems, and the amount of formazan deposited in tissue sections can be related directly to the amount of succinic dehydrogenase[6]. Localization of the succinic dehydrogenase system within the mitochondria is not possible, however, with the mono- and di-tetrazolium salts in current histochemical use. This is due partly to the slow rate at which they penetrate biological membranes and partly to the large crystal size of their formazans.

Recently, metal chelation of the formazans of mono-tetrazolium salts containing N-thiazol-2-yl groups has been successfully used for the intracellular localization of the succinic dehydrogenase system[7]. The present report concerns observations on the isolated mitochondria of the cockroach *Periplaneta americana* made during a series of experiments designed to evaluate the accuracy of localization of the succinic dehydrogenase system afforded by various metal-formazan complexes.

The pooled fat bodies of several cockroaches were homogenized in 0·44 M sucrose with a Potter–Elvehjem homogenizer and centrifuged at $800g$ for 10 min. The sediment was resuspended and washed once. The supernatants were centrifuged at $7,000g$ for 15 min., resuspended and washed twice. 2 ml. of a medium containing 3,5-diphenyl-2-(4,5-dimethylthiazol-2-yl) tetrazolium bromide[8], cobaltous chloride, various electrolytes, phosphate buffer at pH 6·3 and sodium succinate, was added to 1 ml. of a 10 per cent mitochondrial suspension in sucrose.

Details of the preparation of this medium have been published elsewhere[7]. The reaction in duplicate samples was completely inhibited by 1 ml. of 0·1 M iodoacetic acid added prior to incubation. The suspensions were incubated at 37·5° C. for 10–15 min. in an atmosphere of pure nitrogen. The reaction was stopped by the addition of 0·05 ml. of 10 per cent formalin and the suspensions were mounted in 10 per cent gelatin.

It was observed[7] that in thin fresh sections of tissues the metal chelation method did not reveal the mitochondria as they are usually shown by conventional staining methods but rather as rows of small black bodies. The present studies of isolated mitochondria show that each mitochondrion contains 2–5 of these 'bodies' the size of which depends to some extent on the length of incubation. They may appear (Fig. 1) as round objects 0·6–1·0μ in diameter. With longer incubation these can be seen to grow and finally to burst the mitochondrial membrane, an observation in keeping with the view that substrates must penetrate into the mitochondrion before being oxidized[9]. With short incubation times they appear (Fig. 2) in the form of straight or curved transverse bars, orientated at right angles to the long axis of the mitochondrion, the appearance of which suggests a relationship to the cristæ mitochondriales observed in electron microscope studies. Admittedly the characterization of these structures by the metal-formazan technique is much coarser. At higher magnifications (Fig. 3) further details of the 'cristæ' are revealed.

A composite tracing (Fig. 4) has been made of the localization of metal formazan at different levels in

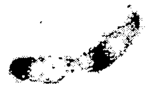


Fig. 1. Isolated cockroach mitochrondrion. Shows two round deposits of cobalt-formazan. (× 4,000)

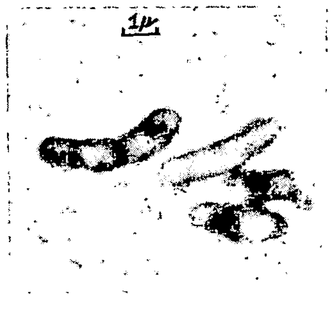


Fig. 2. Isolated cockroach mitochondria. Shorter incubation. Shows deposits as dots and straight and curved transverse bars. (× 4,000)

Fig. 3. Photograph of a single mitochondrion showing metal-formazan deposition on structures resembling cristæ mitochondriales. × 8,000

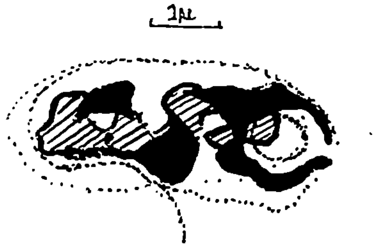


Fig. 4. Composite tracing of deposition of cobalt-formazan at various levels within a single mitochondrion. Shows the spiral form referred to in the text. × 8,000

the body of a single mitochondrion, by superimposing the photographic images obtained at different depths of focus. The tracing clearly shows that the structure revealed by the metal-formazan deposits exists in the form of a helix, and we suggest, therefore, that the cristæ mitochondriales may occur not as complete or incomplete transverse bars but as a single continuous spiral.

The presence of a similar arrangement of mitochondria in the axial filament of mammalian spermatozoa and of the sites of succinic dehydrogenase activity in *B. subtilis* suggests, furthermore, that the helix may represent a pattern of enzyme localization common to many biological forms.

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Electrical Responses of Frog Spinal Ganglion Cells in Sodium-free Media

Since Lorente de Nó[1] found that a group of small axons ("Et fibres") in the frog are able to conduct prolonged action potentials when the external sodium is replaced by certain quaternary ammonium ions, special attention has been directed to the effects of these compounds on other excitable tissues. Fatt and Katz[2] observed that the electrical responses of crustacean muscle fibres are maintained and even intensified when choline, tetramethylammonium, tetraethylammonium or tetrabutylammonium ions are substituted for the sodium in the external medium. No other excitable tissue, however, has been reported to show active responses after complete replacement of sodium by these ions. Choline, in particular, has repeatedly been used as an 'inert' osmotic substitute in experiments on sodium depletion in the extracellular spaces. At low concentrations, for example, 10–20 per cent replacement of sodium, tetraethylammonium lengthens the falling phase of the action potential of crustacean nerve[3] and of frog twitch muscle[4]. The intracellular injection of tetraethylammonium into the giant axon of the squid prolongs the duration of the action potential[5]. In frog nerve fibres, the enhancement of the negative after-potential produced by addition of tetraethylammonium to the Ringer's solution is more prominent in the terminal endings than in the nodes[6], suggesting that quaternary ammonium ions might act in different degrees on the various parts of the neurone.

Cell-bodies in the spinal ganglion of the frog have characteristic properties as compared with the axonal node[7], and it was therefore expected that specific effects of quaternary ammonium compounds could be revealed on the cell membrane. In the course of the investigation with these ions, it was found that the electrical activity of the ganglion cells could be maintained when the sodium of the Ringer's solution was totally replaced by choline or tetraethylammonium. The ninth or tenth lumbar spinal ganglion was isolated from *Rana pipiens*, together with the sciatic plexus branch and the dorsal root. The capsule covering the ganglion and the connective tissue adhering to the cells were carefully removed. The individual nerve cell-bodies (about 60μ diam.) could then be clearly seen so that the insertion of a microelectrode could be carried out under visual control. By use of the arrangement previously described[8], the superficial cells were directly stimulated with short pulses and the action potentials recorded through a single intracellular microelectrode.

When the preparation was soaked in a sodium-free sucrose–Ringer's solution for 3 hr., there was no appreciable effect on the resting potential of the cells, and no spike potential could be detected. Occasionally, a graded abortive response to very large stimuli was still observed in a few cells. After 3–5 hr. in sodium-free choline–Ringer's solution, the resting potential had a normal value (about 65 mV.) immediately after insertion of the micro-electrode, but tended to fall with time. No action potential could be indirectly evoked in the cell-bodies by stimulation of either root or nerve fibres. If direct stimulation was delivered through the microelectrode, however, large responses were regularly produced in the cell-body membrane. In Fig. 1, records 2 and 3 represent action potentials recorded in choline–Ringer's solution, while records 1 and 4 represent control responses obtained in normal Ringer's solution before and after the choline treatment respectively. The threshold for initiation of 'choline potentials' was higher than for 'sodium potentials', while the rate of rise of the spikes was diminished and their falling phase enormously prolonged. The entire configuration of the action potential was somewhat similar to that of crustacean muscle fibres in choline[2]. The excitability of the nerve cell-bodies was maintained even after several hours in choline, and the effect of the latter was perfectly reversible by re-immersing in Ringer's solution. In other experiments, the occurrence of

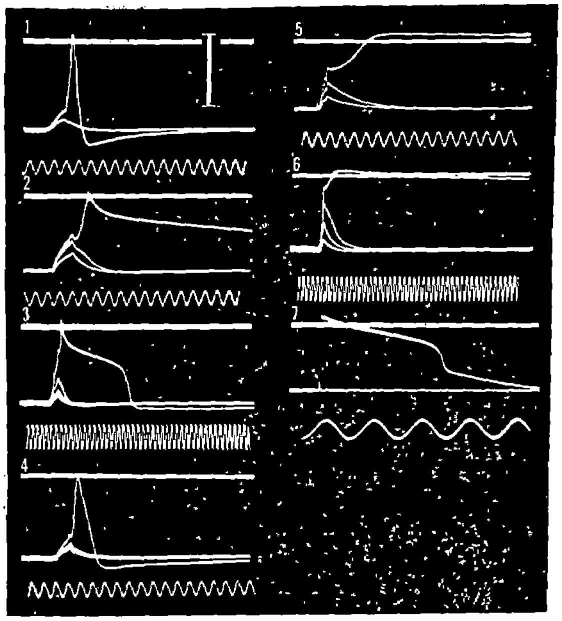

Fig. 1. Records 1–4 were obtained from the same preparation. Records 2 and 3 are 'choline potentials' recorded at different sweep speeds, and records 1 and 4 are 'sodium potentials' recorded before and immediately after soaking in choline Ringer's solution. Records 5–7 show 'tetraethylammonium potentials' at different sweep speeds obtained from another preparation. Time marks: 1 msec., except for Record 7 (100 msec.). Calibration: 50 mV.

'choline potentials' was confirmed in preparations previously blocked after several hours in sucrose Ringer's solution. The action of tetraethylammonium was even more striking than that of choline; action potentials were tremendously prolonged, their duration reaching usually ½–1 sec. Records 5–7 show typical 'tetraethylammonium potentials' recorded at different sweep speeds.

These results demonstrate that choline and tetraethylammonium ions are not 'inert' on the neurone cell-body of the spinal ganglion, but have a specific action which apparently reinforces the membrane excitatory processes. In discussing the nature of action potentials observed in media where the sodium has been completely replaced by choline or tetraethylammonium, it might be argued that some residual sodium exists in the intersticial spaces immediately surrounding the cell-bodies or accumulates as a result of slow leakage from the cell interior. This possibility cannot easily be disproved, but the conservation of cell excitability even after 8 hr. soaking in choline, and its rapid recovery in the latter after a prolonged immersion in sucrose–Ringer's solution apparently argue against an appreciable retention. Indeed, the concentration of extracellular sodium is probably less than the intracellular, particularly in the case of the superficial cells. If ionic currents underly the electrical activity observed in these experiments, there are three conceivable ways of accounting for the mechanism of the 'choline' or 'tetraethylammonium potentials': (1) by an influx of residual extracellular sodium (along a low or even reversed concentration gradient) or of some other cation (for example, calcium) through the active membrane; (2) by an outflux of an internal anion; or (3) by an inward transfer of charges transported by choline or tetraethylammonium ions. The first explanation would imply that, in the cell-body, choline and tetraethylammonium somehow facilitate the normal excitatory process. There is no evidence, as yet, that choline or tetraethylammonium ions penetrate the nerve cell during its electrical activity.

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A Histological Stain for Newly Calcified Tissues

During investigations in which sudan black *B* was used for studying the lipoid inclusions in cells of bone and teeth[1], it was found that dentin, enamel, cartilage and bone did not stain significantly unless they were previously extracted with pyridine at 60° C., when characteristic staining reactions were obtained.

Rats' upper incisor teeth with the surrounding tissue and the proximal ends of tibias were used. After fixation and treatment with pyridine, and decalcification in some instances, they were embedded in gelatin and cut frozen. The sections were stained with sudan black *B* (George T. Gurr), using Baker's method[2] and mounted in glycerine jelly. Unextracted sections were also stained with toluidine blue and examined mounted in water, only undecalcified tissues being used. The perchloric acid technique for the removal of ribonucleic and deoxyribonucleic acids and the periodic acid–Schiff method were also employed. Some sections were treated with hyaluronidase for 24 hr. at 37° C. at *p*H 5·7.

When they were stained with sudan black without preliminary treatment with pyridine, the hard tissues were a uniform pale blue colour. After treatment with pyridine all areas where calcification was being initiated stained deep blue or black. These areas were at the predentin–dentin junction (Fig. 1), the

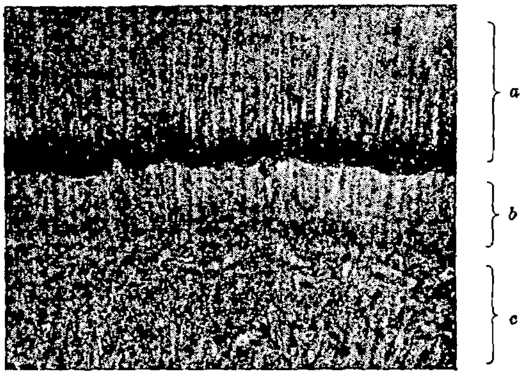

Fig. 1. Transverse section of labial side of formative end of undecalcified rat incisor tooth. (*a*) Dentin, (*b*) predentin, (*c*) odontoblasts and pulp. Note darkly stained line at dentin–predentin junction. Stained with sudan black *B* after treatment with hot pyridine, as described in the text. × 430

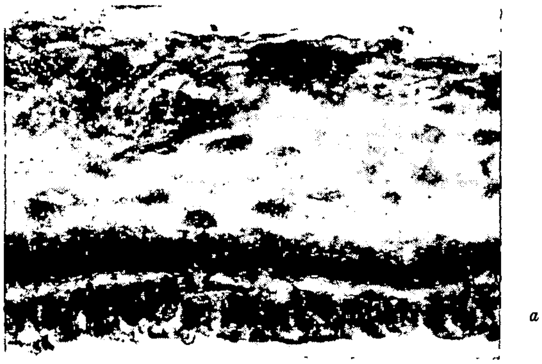

Fig. 2. Part of maxillary alveolar bone of rat. At the top an osteoclast can be seen and below a row of osteoblasts (*a*). Note intense staining line on appositional side of bone, separated from the osteoblasts by a narrow rim of matrix. Stained with sudan black *B* after treatment with hot pyridine, as described in the text. × 430

part of the organic enamel where it became acid-soluble, a line on the appositional side of bone, but a short distance inwards (Fig. 2), and the intercellular matrix between the hypertrophic cells of the epiphyseal cartilage just before their removal (Fig. 3). These areas in the incisor were also metachromatic, but bone and epiphyseal cartilage could only be examined after decalcification, when the whole tissue was metachromatic. Treatment with pepsin did not affect the staining of the teeth. Hyaluronidase did not abolish either the metachromasia of the teeth or the sudan black staining of any of the tissues. Treatment with perchloric acid did not change the staining reactions. No specific staining of the dentin–predentin junction was observed with the periodic acid–Schiff technique.

For sudan black to stain in these ways, treatment with pyridine had to precede decalcification, though decalcification was not necessary. Treatment with hot formalin solution instead of pyridine did not cause the characteristic sudan black staining. Extraction with pyridine made no difference to the metachromatic staining.

It seems probable that under the conditions of these experiments, sudan black is staining some fraction of the mucopolysaccharides, but is a good deal more selective in this respect than toluidine blue. The process underlying pyridine treatment seems from the work of Hadadian and Pirrie[3] to be some sort of precipitation. This makes the material insoluble in acid and stainable with sudan black.

Fig. 3. Longitudinal section of part of tibial epiphyseal cartilage of young rat, showing large hypertrophic cells and, below, the zone of cell erosion. Note the staining of the intercellular matrix between the hypertrophic cells. Stained with sudan black *B* after treatment with hot pyridine, as described in the text. × 430

Leblond *et al.*[4] have found the dentin–predentin junction to be strongly metachromatic, and Bélanger[5] reported that sulphur-35 is laid down here two hours after injection. The puzzling aspect is that both sudan black and toluidine blue stain this area only, although the zone of sulphur-35, as seen by autoradiographs, moved progressively outwards with accretion of more dentin[5]. What is the difference between the mucopolysaccharide at the dentin–predentin junction and that in the depths of the dentin ? Scott and Pease[6], in electron microscope studies, have noted that a fibrous preosseous matrix exists between the osteoblasts and calcified bone matrix, and the width of this zone is about the same as that in the present findings. But, as with dentin, only the first narrow strip of calcified bone stained with sudan black.

Although it was not possible to compare the staining with sudan black and toluidine blue in bone, I consider that the similarity of the two appearances in teeth is sufficient to conclude that the same constituent of the tissue is being stained.

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Rubidium-86 as a Tracer of Potassium in Man

Serial estimations of exchangeable potassium cannot be made after a single dose of potassium-42 because the half-life of the isotope (12·4 hr.) is too short. Rubidium-86 (half-life, 19·5 days) and potassium appear to be handled similarly in man, and Burch *et al.*[1] have suggested that this isotope could be used as a potassium tracer in prolonged studies.

We have compared changes in potassium-balance in three subjects measured by a metabolic-balance technique (in which intake and output by all routes are estimated by chemical methods) with changes in exchangeable 'potassium' measured by the cumulative excretion isotope dilution method after a single dose of 100 μc. of rubidium-86 by mouth. 5–8 days were allowed for equilibration and samples of lysed red cells and of 24-hr. and 'spot' collections of urine were counted in a Geiger–Müller dip-counter and in a scintillation counter. The double counting was necessary because sodium-22 was given simultaneously[2]. Errors of counting and of flame photometry were estimated to be 3·8 per cent.

We found that the specific activities of red cells and particularly of urine fluctuated unpredictably

Table 1

Subject	Duration of study (days)	Changes in balance during study (m.equiv.)		
		Chemical method	Rubidium-86 method, specific activities calculated from : 'Spot' urine	Red cells
Premenstrual fluid retention	9	− 30	+ 10	+ 5
Steroid withdrawal after adrenalectomy	7	+ 70	+400	+140
Removal of adrenal adenoma causing Cushing's syndrome	16	+150	−120	+340

from day to day, and calculations of exchangeable 'potassium' were therefore made from figures obtained from idealized graphs of observed values. The specific activity of urine was always less than that of red cells collected at the same time. In one patient, after nine days equilibration, there was close agreement between the specific activities of red cells and muscle (each 1,740 counts/min./m.equiv. potassium) and adrenal tissue (1,750 counts/min./m.equiv. potassium), while fasting urine collected at the same time had a specific activity of 1,220 counts/min./m.equiv. potassium. The overall results for the three patients are shown in Table 1 and the day-to-day results for one of them are shown in Fig. 1.

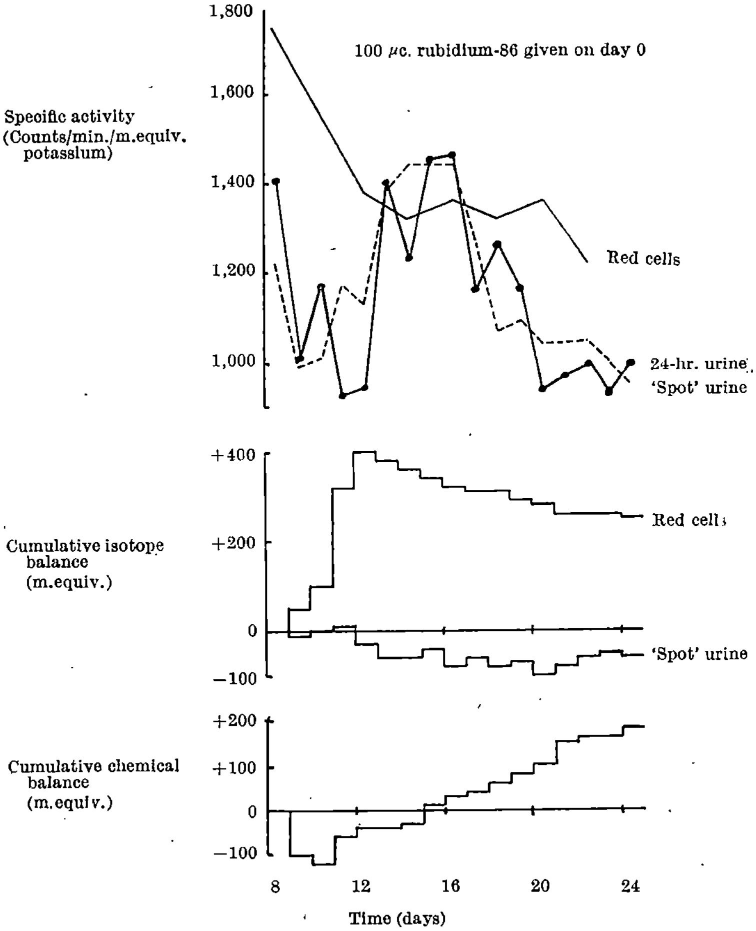

Fig. 1. Woman aged 35. Removal of adrenal adenoma on day 9

We feel that the magnitude of the errors and the variations of specific activity make rubidium-86 unsuitable as a potassium tracer, certainly for prolonged studies. We thank Prof. J. E. Roberts, Dr. J. D. N. Nabarro and Dr. K. Jones for their advice. The work was done during the tenure of a Leverhulme Research Scholarship by one of us (M. M. M.).

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Lymphotrophic Antibiotics

MOST antibiotics are crystalloid molecules and are, for this reason, primarily circulated through the body by a vascular route. Concentrations of antibiotics in lymph and lymph nodes are often difficult to raise to significant levels. On the other hand, it is an established fact that macromolecules and colloidal particles have a particular affinity for the lymphatic system and can therefore attain high concentrations in lymph and lymph nodes.

We have combined streptomycin, neomycin, viomycin and streptothrycin with carboxyl, sulphonic or phosphorylated high molecular compounds and studied the changes in their pharmacological properties.

In one series of experiments the question of the colloidal versus the crystalloid behaviour of these preparations was examined. To this end these substances were infused into a peripheral lymph vessel of the hind extremity of a dog at a constant rate and the amount appearing in the thoracic drainage was measured over a period of 4 hr. The results were compared with the perfusion with a colloidal (dextran) and a crystalloid substance (*para*-aminohippuric acid).

Further experiments were performed in dogs in which blood- and lymph-levels (thoracic duct cannulation) were measured after intramuscular, intraperitoneal, intrapleural, etc., administration. In another series of experiments these substances were injected intramuscularly, intrapleurally, etc., and concentrations were followed in local lymph nodes. We further investigated the blood-levels of these new substances after various means of application as compared with streptomycin and neomycin.

Finally, we have investigated changes in the acute toxicity of these substances in macromolecular combinations.

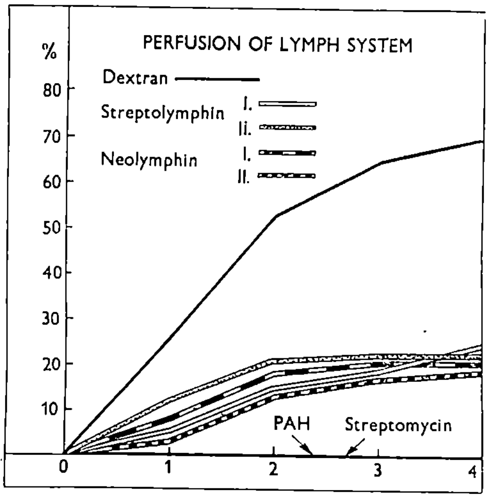

Fig. 1. The percentage of substance in the thoracic lymph drainage infused into the peripheral lymph vessel, with: dextran, neolymphin I, neolymphin II, streptolymphin II, *para*-aminohippuric acid, streptomycin, neomycin, penicillin (basic zero-line)

These macromolecular salts, which have been termed 'antibiolymphins', fall under three headings: (1) salts of antibiotic bases with polyacrylic acids (streptolymphin I, neolymphin I); (2) salts of antibiotic bases with sulphonic or phosphorylated polysaccharides (streptolymphin II, neolymphin II); (3) salts of antibiotic bases with natural polycarboxyl acids from a series of polyuronic substances and polysaccharide derivatives containing carboxyl groups (streptolymphin III, neolymphin III).

Antibiolymphins have the following pharmacological properties:

(1) Their physiological behaviour comes somewhere between a pure crystalloid and a pure colloid. This is shown in Fig. 1, which shows the percentage of substance appearing in the thoracic drainage with dextran infusion and *para*-aminohippuric acid. In 4 hr., 70 per cent of dextran appeared in the thoracic lymph drainage, whereas the *para*-aminohippuric concentration in lymph was insignificant. Streptomycin, neomycin and penicillin acted like *para*-aminohippuric acid. Streptolymphin and neolymphin acted more like a pure colloid, since in 4 hr. 20 per cent collected in the thoracic duct.

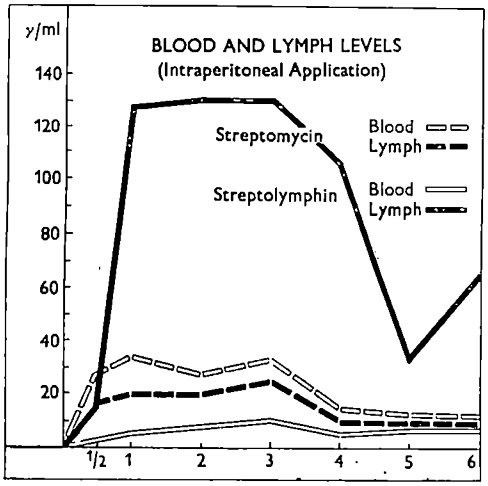

Fig. 2. Blood- and lymph-levels of streptomycin and streptolymphin (thoracic duct cannulation) after intraperitoneal application

(2) Antibiolymphins, as compared with the generally used antibiotic preparations, are absorbed from the injection locus primarily by the lymphatic system. Fig. 2 shows the rate of absorption of streptomycin and streptolymphin I from the peritoneal cavity in a dog. It can be seen that streptomycin concentration is high in blood, low in lymph, while the reverse obtains with streptolymphin I.

(3) A high concentration of long duration may be produced in the lymph nodes of the drainage channels. Fig. 3 shows the tissue concentration of streptomycin and streptolymphin I in the para-aortal lymph nodes after intramuscular application into the hind extremity of a dog at various intervals after the application. It is seen that streptomycin is producing relatively low concentrations and disappears rapidly (after the fourth hour). The streptolymphin-levels are far higher and the time of their disappearance is 72 hr. and more. Similar results have been obtained with sternal and mediastinal nodes after intrapleural application.

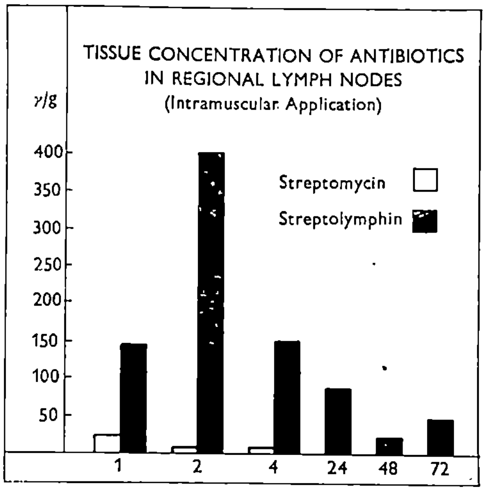

Fig. 3. Tissue concentrations of streptomycin and streptolymphin I in the para-aortal lymph nodes after intramuscular application into the hind extremity of dogs

(4) In comparison with the normal antibiotic equivalent, the blood-level is lower but maintained for a longer time, since the absorption of macromolecules via the lymph system is a slow process. Thus, neomycin disappears from the pleural cavity after 4 hr., while neolymphin was still present after 48–72 hr. and more.

(5) The acute toxicity is much less. For example, the *LD*50 in rats and mice is raised five times with streptolymphin I and ten times with neolymphin I.

In conclusion, we believe that the same chemical principle of tissue localization can be applied with other substances as well, be they antibiotic, cytostatic, chemotherapeutic, etc.

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Experimental Suppression of the Early Inflammatory Phenomena of Turpentine Pleurisy in Rats

Previous work[1–3] has indicated that the increased capillary permeability and resultant exudate that follows intrapleural injection of turpentine in rats might be due at first to local release of histamine or 5-hydroxytryptamine, or both, and later to activation of other mechanisms.

In order to obtain experimental support for this hypothesis it was decided, by employing measures solely designed to block the specific action of histamine and 5-hydroxytryptamine, to attempt to suppress the formation of the very early exudates, leaving the later exudates unchanged.

Repeated injections of the histamine liberator 48/80 deplete many body tissues of histamine and 5-hydroxytryptamine and prevent certain reactions dependent on release of these substances[4–6]. In the present work 150-gm. albino rats were given 100 µgm. intraperitoneally of 48/80 twice daily for seven doses, then two further doses of 200 µgm. 5 hr. after the last injection, 0·1 ml. of turpentine was injected into the right pleural cavity and the animals killed 30 min. later. As can be seen from Table 1, prior depletion of the rats with 48/80 led to virtually total suppression of the 30-min. pleural exudate. When the interval between injection of turpentine and killing the animal was prolonged to 1–2 hr., the volume of pleural exudate obtained from rats depleted of histamine and 5-hydroxytryptamine with 48/80 increased. However, even at 2 hr. the amount of exudate was less than half of that withdrawn from non-depleted controls. When the interval between injections of turpentine and death was prolonged to 4 hr., however, no significant difference in the volume of exudates was observed between depleted and control groups.

A further injection of 200 µgm. of 48/80 at the time the rats received their intrapleural turpentine failed to decrease the volume of the 4-hr. exudate.

When, instead of a course of such injections, rats were given a single dose of 200 µgm. of 48/80 4½ hr. before injection of turpentine, and killed 30 min. later, the volume of pleural exudate obtained did not differ significantly from that obtained from control animals.

These experiments were repeated using the histamine liberator 'Polymixin *B*' instead of 48/80 [7]. Rats were given 0·5 mgm. 'Polymixin' intraperitoneally twice daily for nine doses and the experiment commenced 5 hr. after the last injection. As can be seen from Table 1, the results were essentially similar to those obtained with 48/80 except that suppression of the volume of the 30-min. exudate was not as complete.

Table 1

Time after intrapleural turpentine	Group	No. of animals	Mean vol. of exudate (ml.)	Standard deviation	*P*
30 min.	Controls	18	0·96	±0·07	
30 min.	48/80	18	0·1	±0·07	< 0·001
30 min.	'Polymixin'	10	0·26	±0·11	< 0·001
30 min.	Anthisan	8	0·1	±0·05	< 0·001
2 hr.	Controls	11	1·35	±0·39	
2 hr.	Anthisan	8	0·86	±0·3	< 0·02
2 hr.	48/80	6	0·43	±0·18	< 0·001
4 hr.	Controls	11	1·5	±0·74	
4 hr.	48/80	15	1·2	±0·25	< 0·8 (N.S.)
4 hr.	Anthisan	7	1·6	±0·6	< 0·8 (N.S.)

To confirm the role of histamine suggested by these depletion experiments 'Mepyramine' maleate[8] was injected intravenously in a dosage of 1 mgm./kgm. and turpentine injected intrapleurally 10 min. later. As can be seen from Table 1, the results were similar to those of the depletion experiments. In order to determine whether the appearance of an unaltered volume of exudate at 4 hr. was due to the effect of the drug wearing off, a group of rats was given two further intravenous injections of the same dose of 'Mepyramine' maleate at 45-min. intervals in the 4-hr. period between injection of turpentine and death of the animal. However, these rats showed no reduction in the volume of their pleural exudates, which again did not differ significantly from those of 4-hr. exudates in control animals. To confirm that the action was shared by another antihistamine, promethazine hydrochloric acid ('Phenergan'), 1 mgm./kgm., was substituted for 'Mepyramine'. Once again practically total suppression of 30-min. exudates was obtained, the 4-hr. exudates not differing significantly in volume from the controls.

Previous experiments[2,3] had suggested that 5-hydroxytryptamine might play a part as chemical mediator in the early stages of turpentine pleurisy. Reserpine, a *Rauwolfia* alkaloid, depletes much of the 5-hydroxytryptamine in tissues[7,9]. The substance was injected intraperitoneally into eight 150-gm. rats, four doses of 1·0 mgm. being given over 3 days. 18 hr. after the last injection, 0·1 ml. of turpentine was given intrapleurally and the animals killed 30 min. later. Six rats had pleural exudates the volume of which ranged between 0·8 and 1·1 ml., that is, within the range observed in control animals. The remaining two rats had only 0·1–0·2 ml. of exudate; but both these animals were in a state of profound collapse and unconsciousness and showed no reaction even when the pleural cavity was opened. That extreme hypotension existed in these animals could be shown by the almost non-existent blood flow on cutting the carotid artery. Under these conditions it seems likely that the blood pressure was too low for effective filtration to occur through the permeable pleural capillaries. The failure of reserpine to alter the initial response of the pleura to turpentine was confirmed by the use of '*BOL* 148' (2-brom-D-lysergic acid diethylamide bitartrate). This substance is a powerful inhibitor of 5-hydroxytryptamine[10]. 0·5 mgm. was given intravenously to 150-gm. rats and 10 min., and in some instances 30 min., later 0·1 ml. turpentine was injected into the right pleural cavity, the animals being killed 30 min. afterwards. No significant difference was observed in the volume of pleural exudates of these and of control rats also killed 30 min after intrapleural turpentine.

That the effect of 48/80 and 'Mepyramine' was not due to a general depression of capillary permeability was shown by skin tests on rats injected intravenously with trypan blue.

A greatly increased rate of removal of fluid and protein from the pleural cavity might in theory account for the great diminution in 30-min. exudates. That this is not in fact the case was shown by injecting 1 ml. of rat serum into the pleural cavity of control rats depleted with 48/80 and rats pre-treated with 'Mepyramine'. The serum was absorbed at a similar slow rate in all three groups.

The present results appear to provide strong support for the hypothesis that the initial inflammatory phenomena of turpentine pleurisy in the rat are largely due to local release of histamine and that other factors then come into play to prolong the increased capillary permeability thus initiated, the two systems apparently working quite independently. That 5-hydroxytryptamine may play a subsidiary part in the 'histamine phase' is possibly suggested by the diminished effectiveness of 'Polymixin' relative to 48/80 and by more rapid accumulation of exudate seen in 'Mepyramine'-treated rats compared with rats depleted of histamine and 5-hydroxytryptamine by 48/80. Further work is in progress, and the results will be discussed more fully elsewhere.

We thank Sir Roy Cameron for guidance and encouragement, Dr. R. Moulton for helpful discussion and Messrs. Sandoz for supplying '*BOL* 148', and Messrs. Burroughs Wellcome for supplying compound 48/80.

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Vanillic Acid Excretion during Stress

Recent reports of the metabolic conversion of the 3 : 4-dihydroxyphenyl into the 4-hydroxy-3-methoxyphenyl grouping[1,2] and of the occurrence in urine of 4-hydroxy-3-methoxymandelic acid[3], a metabolite of adrenaline and noradrenaline, prompt us to record briefly our own findings along these lines. Aromatic compounds extracted by ether from acid-hydrolysed urine have been examined chromatographically by a method[4] derived from that described by Boscott[5]; methylated products have been found to be invariably excreted by human subjects following oral administration of small doses (100–300 mgm.) of catechols. The compounds fed and metabolites detected are so similar to those described previously as to need little further comment ; however, it has been observed, in one case at least, that methylation is not necessarily confined to the hydroxyl group in the 3-position, since 3-hydroxy-4-methoxycinnamic acid has been identified, together with the isomeric 4-hydroxy-3-methoxy compound, among the substances detected following administration of caffeic (3,4-dihydroxycinnamic) acid. Both these acids have been regularly detected in normal urines following acid hydrolysis.

These experiments were stimulated by the observation that some subjects exposed to prolonged periods of stress were found to excrete abnormally large amounts of a substance apparently chromatographically identical with 4-hydroxy-3-methoxybenzoic (vanillic) acid. Ten urine samples were successfully collected over 5–10 hr. periods late in the first or second day from subjects participating in a motor-car rally necessitating continuous vigilance and lack of sleep for 48 hr. One subject excreted large amounts of the acid on both days, two subjects on the first day only and one on the second day only. Two further subjects, who each gave only one urine sample, excreted only normal amounts. Many subjects failed to produce an adequate quantity of urine owing to restricted fluid intake ; some of the subjects had received large doses of nicotinamide in connexion with other investigations, but this did not appear to influence vanillic acid excretion. Although no proper dietary control was possible, it did not appear that anything unusual had been eaten by the subjects ; however, they may well have tended to eat similar meals which fortuitously may have contained vanillic acid or some precursor.

However, it is certainly tempting to postulate that excretion of vanillic acid reflects secretion of adrenaline and noradrenaline in stress situations. It would not appear profitable at this stage to contrast the finding of vanillic acid in hydrolysed urines with that of 4-hydroxy-3-methoxymandelic acid in unhydrolysed urine[3], and it is hoped that future opportunities may occur to enable us to clarify the situation. The experiments described form part of an investigation into the possibility that metabolites of adrenaline may be responsible for the mental effects of prolonged stress ; as an alternative approach to this problem, the synthesis and metabolism of compounds intermediate in structure between adrenaline and mescaline are also being studied.

We wish to thank the Director-General of Medical Services, Royal Air Force, for permission to publish this work.

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Relative Distribution and Chemical Nature of the Fuel Store of the Two Types of Fibres in the Pectoralis Major Muscle of the Pigeon

George and Jyoti[1] showed that the pectoralis major muscle of the pigeon consists of two types of fibres : a broad variety, well striated and with clear sarcoplasm, having very few inclusions, and the other a narrow type, with dense lipoid inclusions and striations scarcely visible. They also observed that the fat globules in the narrow fibres become fewer after strenuous muscular exercise and suggested the possibility of the utilization of fat in such muscular activity. In the present work, we have investigated the relative distribution of the two types of fibres in the muscle and the chemical nature of the fuel store in them.

Pieces of muscle from a pigeon immediately after it was decapitated and fixed in formalin – calcium chloride fixative[2] (1 gm. of calcium chloride dissolved in 100 c.c. of 10 per cent formalin) were sectioned with a freezing microtome and stained with sudan black *B*

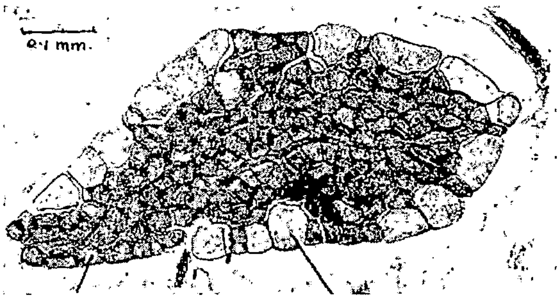

Fig. 1. Photomicrograph of a transverse section of a fasciculus in the pectoralis major muscle of the pigeon, stained with sudan black *B*

(Fig. 1). The narrow fibres were deeply stained whereas the broad ones were completely unstained, thereby showing that the former are fat-loaded fibres.

Pieces of the muscle were taken from a pigeon immediately after it was decapitated, and some were fixed in picric acid-saturated alcohol–formalin and the rest preserved in 80 per cent methanol, ice-cold fixative being used in both cases. Microtome sections of the fixed muscle were cut at 8μ and stained with Best carmine stain (after Bensley[3]) for glycogen and lightly counterstained with hæmatoxylin. The narrow fibres were faintly stained, whereas the broad ones, the majority of which are confined to the periphery of the fasciculus (Figs. 1 and 2), were stained a brilliant red (Fig. 2), denoting a comparatively high percentage of glycogen in them. A control slide, which was incubated in diastase solution in order to digest and remove the glycogen prior to staining, did not show the characteristic red colour for glycogen.

From the pieces of the muscle preserved in methanol, the broad and the narrow fibres were separately isolated in sufficient quantities to yield at least 2–3 mgm. of the material in dry weight, by carefully teasing them out by means of very fine forceps under a stereoscopic dissection microscope. The broad and narrow fibres thus collected in separate containers were dried in a desiccator under vacuum and weighed on a microbalance. The glycogen content of the two types of fibres was estimated on the dry weight of the fibres preserved in methanol. The method employed in the estimation of glycogen was a colorimetric micro-method (after Kemp *et al.*[4]) using the Beckman spectrophotometer (*DU* model). Since the fibres were preserved in methanol, which, being a fat solvent, would have dissolved some fat during preservation and, since the relative fat content of the two types of fibres differs considerably, the calculation of the glycogen content based on dry weight of the material thus preserved would not give accurate figures for glycogen. Therefore it was thought more desirable to express the relative glycogen content of the two types of fibres (per unit dry weight of the material preserved in 80 per cent methanol) as a ratio rather than in actual percentage figures.

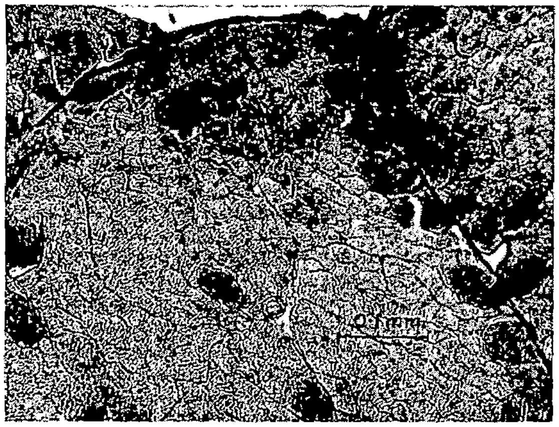

Fig. 2. Photomicrograph of a transverse section of a piece of pectoralis major muscle of the pigeon, stained with Best carmine

The diameter of the fibres in a fasciculus was measured from the section of a frozen piece of fresh muscle. The measurement was made indirectly from a camera lucida sketch using a micrometer slide. The ratio of broad to narrow fibres more or less in the middle of the muscle was found to be 1 : 16. The number of the narrow ones to one broad was found to vary in the different regions of the muscle.

Table 1

	Narrow fibres	Broad fibres
1 Appearance of fresh fibres	1 Highly granulated with fat globules and granules obscuring the striations 2 Red in colour	1 Practically devoid of fat globules and granules. Striations clear 2. White, translucent
2 Distribution within a fasciculus	Mostly in the interior	Mostly on the periphery
3 Relative number within a fasciculus	16 : 1	
4 Relative diameter of fibres in cross-section of fresh frozen muscle	1 : 2	
5 Relative glycogen content per unit dry weight of material preserved in 80 per cent methanol	1 : 5	
6 Nature of the fibres (fuel store)	Fat-loaded	Glycogen-loaded

The present work has shown that the narrow fibres are fat-loaded and that the broad ones are glycogen-loaded, having about five times the glycogen store of the other type. George and Jyoti[5] have shown that a considerable amount of fat is reduced in the breast muscle of the bird and bat during exercise and that fat is the chief fuel during sustained muscular activity (George, J. C., and Jyoti, D., unpublished work). Very recently, George and Scaria[6] have demonstrated a large amount of lipase in the breast muscle of the pigeon, obviously for the conversion of fat into fatty acids and glycerol, which is the first step in the utilization of fat for energy.

In the light of these findings, the presence of the two types of muscle fibres, the glycogen-loaded, broad ones and fat-loaded, narrow ones, in the most powerful flight muscle of the pigeon, is of special interest. Obviously the fat-loaded, narrow fibres which predominate are adapted for sustained flight, and the few, broad, glycogen-loaded ones for quick and sudden action. On the other hand, in some birds, for example, the parakeet (*Psittacula krameri*) and the bee-eater (*Merops orientalis*), the pectoralis major muscle consists of only the narrow variety of fibres, the broad ones being absent altogether, while there are others, for example, the domestic fowl

(*Gallus domesticus*) and the kite (*Milvus migrans*), in which there is only the broad variety[7]. Hence an understanding of the exact role of the two types of fibres in the pectoralis major muscle of the pigeon requires a detailed study of the fibrillar structure and its evolution in different birds, and also in relation with other body muscles, particularly those concerned with flight. This is now being undertaken.

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Effect of Human α_1-Acid Glycoprotein on Blood Coagulation

As yet no specific function of the α_1-glycoproteins has been demonstrated. The average amount of α_1-acid glycoprotein in normal plasma is 50 mgm. per 100 ml. The alpha-glycoproteins have been found to be increased in many pathological conditions, including cancer and diseases associated with tissue destruction such as in the inflammatory dermatoses.

On addition of α_1-acid glycoprotein to normal plasma we noticed a prolongation of the time of coagulation, which prompted further investigation of such effects.

Most of the methods employed have already been described. α_1-Acid glycoprotein was prepared from human plasma in the manner described by Yamashina[2]. Unless otherwise stated, 1 per cent solution of α_1-acid glycoprotein in imidazole buffer of *p*H 7·25 and ionic strength 0·15 was used for the clotting tests. The solution showed no thrombin, prothrombin, proconvertin or proaccelerin activity; it did not delay the clotting of fibrinogen by thrombin; in tests on plasma, it showed no immediate or progressive anti-thrombin activity; tested on fibrin plates it did not show any plasmin or plasminogen-activator activity; it had no plasmin inhibitory effect, but it did inhibit the transformation of plasminogen to plasmin by urokinase (P. Wallén and I. Yamashina, unpublished work).

The effect of α_1-acid glycoprotein on the activation of bovine prothrombin prepared according to the method of Seegers[3] in 25 per cent sodium citrate solution was also studied. Addition of 20 mgm. of α_1-acid glycoprotein to 9 mgm. of prothrombin did not demonstrably inhibit the prothrombin activation.

In the investigation of the mechanism of anticoagulant action of acid glycoprotein, we used the test system of Owren and Aas[4] for the determination of prothrombin and proconvertin. (Clotting mixture: 0·2 ml. of barium sulphate-adsorbed bovine oxalated plasma + 0·2 ml. of human brain thromboplastin + 0·2 ml. of α_1-acid glycoprotein solution (or buffer) + 0·2 ml. of normal citrated plasma in varying concentrations + 0·2 ml. of 0·03 *M* calcium chloride solution). The variables in this test system were prothrombin and proconvertin (citrated plasma), thromboplastin, proaccelerin (barium sulphate-adsorbed bovine plasma), calcium and α_1-acid glycoprotein. The latter was found to inhibit coagulation. For example, when the clotting mixture consisted of undiluted thromboplastin, diluted citrated plasma (1/10) and an excess of proaccelerin and calcium, acid glycoprotein in a final concentration of 2·5 mgm. per ml. prolonged the clotting time from 33 to 83 sec. and 0·5 mgm. per ml. to 43 sec. It is clear from Fig. 1 that in the presence of a constant amount of thromboplastin and excess of proaccelerin and calcium, α_1-acid glycoprotein inhibited the transformation of prothrombin to thrombin in a competitive manner. With 1/1 to 1/1,000 dilutions of thromboplastin the factor by which the slope of the line increased was invariable. Decreasing concentrations of proaccelerin in the test system did not increase the anti-coagulant effect of acid glycoprotein, neither did variations in the amount of calcium.

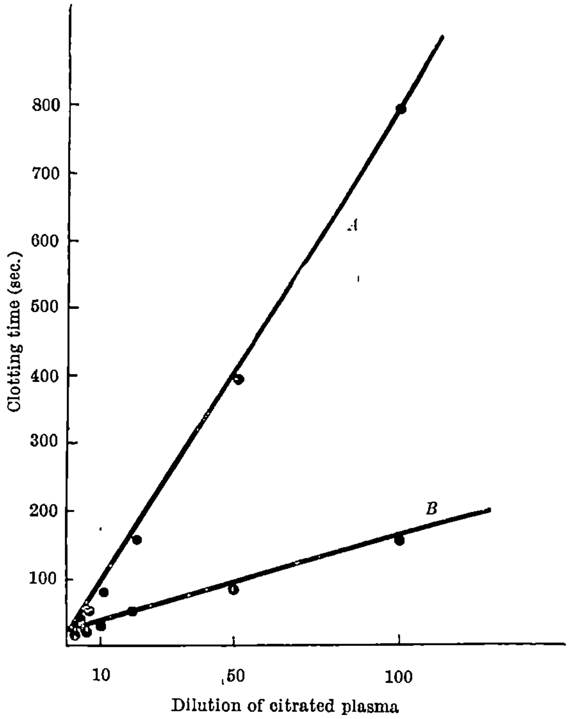

Fig. 1. The inhibition of α_1-acid glycoprotein in the one-stage prothrombin test system (expressed according to Lineweaver and Burk). *A*, acid glycoprotein (2·5 mgm./ml.); *B*, no acid glycoprotein

It was also demonstrated by the thromboplastin-generation test that acid glycoprotein inhibited the plasma thromboplastin in a manner similar to that for brain thromboplastin.

In view of these observations, the anticoagulant effect of acid glycoprotein could be attributed to an inhibition of the transformation of prothrombin to thrombin by thromboplastin in a competitive manner. Heating α_1-acid glycoprotein at 100° C. for 30 min. did not impair its anticoagulant effect, in agreement with the fact that boiling produces no change in its electrophoretic and ultracentrifugal patterns[5].

Corresponding experiments were carried out with albumin prepared according to Cohn's method 6 and reprecipitated. A 5 per cent solution of albumin in the same buffer as that used for the acid glycoprotein experiments showed no antithrombin effect. The albumin solution was, however, found to inhibit the citrate activation of prothrombin to thrombin. Thus, when 50 mgm. of albumin was added to 11 mgm. of prothrombin only 60 per cent of the prothrombin was activated. In the one-stage prothrombin test system used for acid glycoprotein described before, albumin in a final concentration of 12·5 mgm. per ml. prolonged the clotting time from 33 to 42 sec., instead of to 83 by 2·5 mgm. of acid glycoprotein per ml. The inhibition was interpreted as being noncompetitive.

The fact that acid glycoprotein has an antithromboplastic effect suggests the possibility that it plays a part in the coagulation of blood. Even the concentration of α_1-acid glycoprotein in normal plasma is sufficient to influence the clotting time. In diseases associated with a decrease of prothrombin or an increase of acid glycoprotein-levels, a more significant anticoagulant effect of acid glycoprotein can be expected because of the competitive inhibition for prothrombin activation by thromboplastin.

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Interaction of Phenolic Compounds with Bacteria

THE interaction of several phenolic compounds with bacteria has been examined as part of an investigation of the mode of action of various antibacterial substances[1]. This communication summarizes the results obtained using hexylresorcinol and *Escherichia coli*.

Addition of hexylresorcinol to washed suspensions of *E. coli* (originally N.C.T.C. 5933) effected the release of substances which absorb in the ultra-violet (for convenience, these substances will be referred to as cell exudate) ($\lambda_{max.}$ 260 mμ) from the bacteria, reminiscent of the effects reported for various antibacterial surface-active agents[2]. Solutions containing hexylresorcinol and cell exudate were analysed spectrophotometrically after a quantitative separation involving a liquid–liquid extraction with an organic solvent. At low hexylresorcinol concentrations, the cell exudate released from the cell in 10 min. at 25° was proportional to the drug concentrations added. However, as the latter were increased, a limiting value was reached which corresponded to the bactericidal concentration of hexylresorcinol, defined in terms of the single mean survivor time of *E. coli* in an aqueous solution at 25°. Similar concentrations of the phenol greatly increased the light-scattering properties of suspensions of *E. coli* immediately upon contact between drug and bacteria.

The amount of hexylresorcinol taken up by the bacteria was proportional to the concentration of the drug to which they were exposed : no limiting value was reached, possibly due to the limited aqueous solubility of hexylresorcinol. At a bactericidal concentration of hexylresorcinol (single mean survivor time of 48 min.), the amount of drug bound per bacterium was greater than that required to form a close packed monomolecular layer surrounding the organism, whatever the orientation of the molecules with respect to the surface (assuming that the surface area of the cytoplasmic membrane approximates to the surface area of a cylinder, of maximum size 3μ × 0·8μ, in the living organism). The uptake of hexylresorcinol by isolated cell-wall preparations of *E. coli* was negligible. The observed changes in light-scattering properties of isolated cell walls and intact cells on addition of hexylresorcinol were not of comparable magnitude; the changes in light-scattering properties of the latter are attributed to the interaction of the drug with the cytoplasmic membrane.

The evidence available in the literature[3] suggests that the site of action of phenolic compounds is at the cytoplasmic membrane; the present results provide further evidence in favour of this hypothesis.

Phenolic compounds have little value as preservatives in preparations containing non-ionic surface-active agents[4]; the results obtained on addition of 'Cetomacrogol' to the hexylresorcinol–*E. coli* system provides evidence concerning the nature of this inactivation. Addition of 'Cetomacrogol', in as low a molecular ratio as possible without effecting insoluble complex formation, reduced the uptake of hexylresorcinol from solutions by *E. coli* at all concentration levels of the phenol studied. (Hexylresorcinol was determined colorimetrically in the presence of 'Cetomacrogol' due to difficulties associated with solvent extraction procedures in presence of surface-active agents.) The changes in light-scattering properties of suspensions of *E. coli* caused by the presence of hexylresorcinol were prevented by the addition of 'Cetomacrogol' to the drug solution. The antibacterial activity of hexylresorcinol (bactericidal and bacteriostatic activity) against *E. coli* was completely abolished in the presence of the non-ionic agent. However, sufficient hexylresorcinol was taken up by the bacteria from a solution containing the maximum attainable drug concentration and a low molar ratio of 'Cetomacrogol' to exert a bactericidal action in the absence of the surface-active agent. The 'Cetomacrogol' would therefore appear to prevent or interfere with the interaction of the drug with the cytoplasmic membrane.

A full account of experimental techniques and observations will be published elsewhere.

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Filarial Infection in *Simulium griseicolle* Becker

In the course of a *Simulium* survey at Lokoja, Kabba Province, Northern Nigeria, in September 1956 adult *Simulium griseicolle* were found to be very abundant. Hitherto adults of this species had not been collected although it was known to breed along several hundred miles of the Niger River[1]. The flies were particularly numerous on the window-panes of the Lokoja catering rest-house, but they were also seen in villages some distance from Lokoja and one fly was collected 24 miles from the nearest breeding-site in the Niger.

In the Sudan *S. griseicolle* can be a troublesome man-biter[2,3]; but no evidence was found that the flies at Lokoja were biting man and sucking human blood although flies would frequently settle on the skin and crawl about for a short time, especially in the early morning (6.30–7.30 a.m.).

Although flies had not been seen to feed on man it was decided to dissect specimens and examine them for developing filariæ, for it had recently been found[4] that filarial infection occurred in *Simulium bovis* de Meillon, which although it occasionally feeds on man in Northern Nigeria[4] is not normally an anthropophilic species. Flies for dissection were collected on the window-panes in the Lokoja rest-house which lies about 1½ miles from the breeding-ground in the Niger.

It was surprising to find that some flies were infected with filarial worms, for so far as is known filarial infection in *S. griseicolle* has not previously been observed. The results are summarized in Table 1.

Table 1

Flies dissected	Flies with caudate 'sausage' forms	Flies with infective forms	Total flies infected
321	3 0·93 per cent	4 1·25 per cent	7 2·18 per cent

The caudate 'sausage' worms were embedded, as is usual with this stage, in the thoracic muscles, and the three flies harbouring caudate forms had one, two and three worms respectively. Of the four flies with infective forms the first had one worm only in the head, the second had one worm in the thorax, the third had two worms (one in the head and one in the thorax), and the fourth had two worms (one in the head and one in the abdomen). The caudate worms measured $240\mu \times 30\mu$ and the infective forms $350\text{–}400\mu \times 20\text{–}25\mu$.

The identity of the worms seen is of course not known; but it seems very unlikely that they were *Onchocerca volvulus* (Leuck.) since, although onchocerciasis is endemic at Lokoja, the *S. griseicolle* were not observed actually feeding on man. The 'sausage' forms seen in the *S. griseicolle* were considerably larger than those of *O. volvulus* when seen in *S. damnosum* Theobald; but a size difference in the 'sausage' stage is probably not of much significance as *O. volvulus* is normally only seen in its intermediate host at definite intervals in the development (because flies are usually only dissected after they have been caught coming to bite), whereas the *S. griseicolle* had not been collected when biting; on the other hand the infective forms observed in *S. griseicolle* were smaller than those of *O. volvulus* as seen in *S. damnosum*, which is against their being *O. volvulus*.

S. griseicolle is known to feed on birds in the Sudan[2,3,5], including turkeys and pigeons; it was noticed at Lokoja that flies sometimes occurred in small clouds around ducks. It is possible that the filarial infections seen in the flies had been derived from birds, and that *S. griseicolle* may be the vector of an avian filariasis. This possibility is supported by the recent work in Canada[6], which has shown that simuliids are the vectors of *Ornithofilaria fallisensis* Anderson, a filarial parasite of domestic and wild ducks. The fact that worms in the infective stage were found in the heads of *S. griseicolle* suggests that the fly is a vector of the parasite concerned, although the identities of the nematode and its primary host are not known as yet.

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Effect of Borate Buffer on the Electrophoresis of Serum

During some recent investigations (Cooper, D. R., and Johnson, P., unpublished work), the protein components present in neutral or slightly alkaline extracts of bovine hide were compared with those of bovine serum by paper electrophoresis. For these comparisons a borate buffer ($p\text{H} = 8{\cdot}6$, $I = 0{\cdot}05$)[1] was used, and the papers were treated with bromophenol blue to detect the protein bands[2].

In several runs it was found that the intense band corresponding to albumin was preceded by a less-intense band, migrating just faster than the albumin (Fig. 1). A similar effect was also obtained with two samples of normal rat serum supplied by the South African Medical Research Institute. When barbiturate buffer ($p\text{H} = 8{\cdot}6$, $I = 0{\cdot}05$) was used instead of the borate buffer, no such effect was observed with the bovine serum. This indicates that the borate ion must increase the mobility of one or more of the components of the serum.

It is suggested that the borate ion reacts with protein-bound carbohydrate, since the band gave a positive stain for protein, resulting in an increased mobility for this component. All the protein con-

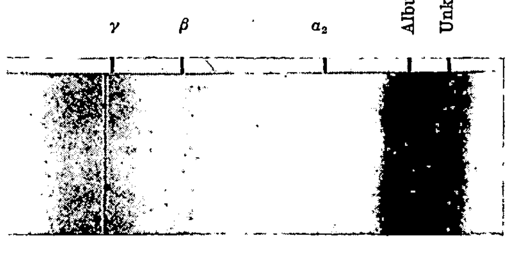

Fig. 1. Paper electrophoresis of bovine serum in borate buffer: pH 8·6; $I = 0{\cdot}05$; 0·2 m.amp./cm.; 17 hr.

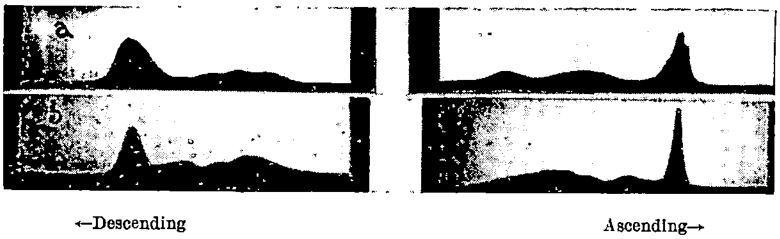

Fig. 2. Electrophoresis of bovine serum. (*b*) Barbiturate buffer, $pH = 8·6$, $I = 0·2$; (*a*) borate buffer, $pH = 8·6$, $I = 0·05$

stituents of serum appear to contain some carbohydrate, the main source being the α_1- and α_2-globulins[3]. Therefore the band obtained in borate buffer could be due to complexing between the borate ion and α_1- or α_2-globulin.

Further evidence for the effect of the borate ion on serum proteins was found by moving-boundary electrophoresis in a Tiselius apparatus at 4° C. As shown in Fig. 2, the electrophoretic pattern for bovine serum in barbiturate buffer ($pH = 8·6$, $I = 0·2$) differs considerably from that in borate buffer ($pH = 8·6$, $I = 0·05$). In the borate buffer no peak corresponding to α_2-globulin is obvious, whereas a small peak is seen to migrate just faster than the albumin in the ascending boundary, which presumably corresponds to the extra band obtained by paper electrophoresis. The albumin peak in the descending boundary is unusually diffuse and asymmetrical.

The sedimenting components of bovine serum in the two buffers were the same when examined in a 'Spinco' ultracentrifuge.

I acknowledge the technical assistance of Mr. van Berge; and I am indebted to the South African Council for Scientific and Industrial Research for facilities placed at my disposal.

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Physicochemical Investigations of Erythrocyte Membranes

A small drop of citrated human blood is placed on a slide next to a somewhat larger drop of Ponceau 2*R* and the two drops are mixed, covered with a cover glass and examined both with ordinary and polarized light. Under the double action of the dye and the hypotonicity, all the red cells become perfectly spherical with a diameter ranging from 5·0 to 5·6μ and stain weakly orange-red. No birefringence is observed.

A small drop of 1 per cent acetic acid solution or of 0·5 per cent hydrochloric acid is placed at the edge of the cover glass. As this penetrates by diffusion the red cells undergo a series of changes. Those reached by the diffusing acid first become pale and swell progressively, their surfaces being perfectly spherical. At the same time they become strongly birefringent. Most of the surface membranes form spheres of 7·5–8·5μ in diameter, while others are larger, up to 11 or even 14μ. This means a volume increase of 3·8–21·8 times the initial volume. Accompanying the swelling and the birefringence, the red cell surfaces (membranes) become stained an intense red. Some red cells show an interior concentration of hæmoglobin, and the membrane of these cells, which has no direct contact with the condensed hæmoglobin, becomes red, spherical and birefringent. In the case of other cells, the hæmoglobin is expelled while the hæmoglobin-free membrane becomes spherical and birefringent.

Sometimes, especially with stored red cells, the expulsion of the hæmoglobin through the membrane leads to the formation of a long, curved and stiff 'myelin tube' at the point at which it is expelled. This 'myelin tube' is violently projected so that the cell itself is jerked back with force and moves the other cells with which it is in contact.

The membranes of the largest empty red cells are the most birefringent, a phenomenon which is dependent upon the presence of the dye. The direction of the birefringence is tangential to the surface of the spheres.

Similarly, if a drop of 4 per cent aqueous phenol is added at the edge of the cover glass beneath which there is a red cell suspension, the erythrocytes in the contact zone between the red cell suspension and the phenol solution soon become birefringent spheres, similar to those produced by the action of the acidulated dye solution. Again, if one volume of washed red cell suspension is shaken vigorously with 20 vol. of 2·8 per cent phenol in distilled water, all the red cells lose their hæmoglobin, their membranes becoming spherical and birefringent with diameters 7·5–11μ.

Of the variety of dyes, only alkaline and acid fuchsin (1 per cent aqueous solution) behave similarly, and there seems no doubt that the birefringence of the red cell membrane is due to the oriented absorption of these dyes in concentric layers. If the red cells are hæmolysed by saponin before adding the dyes, there is no separation or birefringence of the membrane, and adding saponin to the swollen birefringent coloured membranes does not result in hæmolysis; this is probably due to the dye precipitating and fixing the protein components of the membrane. Ponceau 2*R* produces the phenomenon of swelling and birefringence of the red cell surface only if the dye solution is made acid. This is probably due to there being a close chemical combination between the lipid membrane and the interior hæmoglobin both in the normal red cell as well as in the red cell hæmolysed with distilled water, that is, to their being lipoprotein cœnapses of the type described by Rubinstein and Rudberg. While these complexes exist, the staining affinities of the lipids are marked or blocked by the protein molecules, but as soon as the bonds between the proteins and lipids are broken by hydrogen ions, valences are freed which allow the absorption of the dye and its action in fixing the protein components, thus transforming the isotopic membrane into a birefringent one. Again, the extent to which the surface structures of the red cells swell can be explained by the myelinic character of the isolated membranes, myelin forms being notoriously capable of extending their surface.

The membrane of the red cell does not seem to have a morphologically differentiated structure in that it has no cytological structure, no elasticity, mechanical resistance, etc. It appears to be fluid and unorganized, able to detach itself from its contents and to swell like any other myelin sphere consisting of fluid or semi-fluid lipids. It is highly probable that this membrane possesses a mobile statistical structure which is in a state of dynamic equilibrium with the lipids of the plasma in which the cells are suspended, lipid and protein molecules constantly leaving the red cell surface and their place being taken by similar molecules from the plasma.

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Muscular Exercise and Adrenal 17-Hydroxycorticosteroid Secretion in Dogs

Evidence of increased adrenocortical secretory activity elicited by muscular exercise has been provided by indirect evaluations such as fall in ascorbic acid or cholesterol content of the adrenal gland[1–3]. However, no direct measurements of corticosteroid secretion in response to muscular exercise have been reported. The present studies were undertaken to evaluate quantitatively the effect of muscular exercise on adrenocortical activity by estimating directly the rate of secretion of adrenal 17-hydroxycorticosteroid in unanæsthetized dogs.

For collecting the adrenal venous blood under physiological condition, the lumbar route method of Satake, Sugawara and Watanabe[4] was employed. The dorsal spinal roots corresponding to the surgical operation area were cut under 'Evipan'-sodium and ether narcosis and about three weeks or more later the experiments proper were carried out. The procedures for exposing the lumbo-adrenal vein, inserting a small cannula into the vein and collecting the adrenal venous blood were performed without anæsthetizing, fastening or evoking any pain. About two hours were allowed to elapse between the cannulation and beginning observations. After collecting the control adrenal venous blood sample, the dogs, paced by an attendant on a bicycle, were run 5·1–14·7 km. at average speeds of 109–276 m. per min. In all dogs, except one, exhaustion with severe panting was observed at the end of the run. Just after and at intervals after running, the adrenal venous blood samples were taken. The plasma was separated from the blood sample by centrifugation and analysed for 17-hydroxycorticosteroids by the method of Nelson and Samuels[5].

The rate of secretion of adrenal 17-hydroxycorticosteroid before running was estimated as 0·19–0·60 μgm. per kgm. of body-weight per min., with an average of 0·34 μgm. After running, the secretion-rate was found to have increased. In one dog, which showed no signs of fatigue during and after running, only a slight increase in corticosteroid secretion was found. In four others, however, it increased markedly and reached 1·0, 1·2, 1·9 and 2·7 μgm. per kgm. per min., respectively. Maximal increase was mostly found at 60 min. after the end of the run.

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Zone Electrophoresis of *Myrothrecium* Cellulase

The cellulase activity of culture filtrates of the mould *Myrothecium verrucaria* (Alb. and Schw.) Ditm. ex Fr. has been variously attributed to: (i) a single hydrolytic enzyme[1] which, *inter alia*, is homogeneous in free-boundary electrophoresis at *p*H 7; (ii) at least two and possibly three hydrolytic enzymes which migrate at different rates under the same conditions of electrophoresis[2]; and (iii) an enzyme, C_1, of unspecified function which enables cellulose to be further degraded by C_x, a group of enzymes characterized by hydrolytic activity towards carboxymethylcellulose[3], which can be resolved[4] into at least eight components by zone electrophoresis at *p*H 7. Other controversies centre on the specificity of the enzyme(s) with respect to the chain-length of cellulose and its hydrolysis products and involve certain other enzymes as well. The need to resolve these controversies prompts us to report some procedures which enable the electrophoretic homogeneity and substrate specificity of cellulases to be tested simultaneously.

The supporting media for the electrophoretic separations were strips of Whatman 3*MM* filter paper (Fig. 1), Reeve-Angel glass-fibre filter paper (Fig. 2*A*) and a thinner glass-fibre paper of very fine texture (Fig. 2*B*) obtained by courtesy of Dr. R. B. Hobbs, of the National Bureau of Standards, Washington, D.C. The enzyme preparations[1] were applied at positions indicated by dotted arrows in the figures; the amounts added were 1 mgm. of protein in 0·01 ml. of buffer when applied in one spot at the centre of the strip, 5 mgm. of protein in 0·04 ml. of buffer when applied across the width (5 cm.) of the strip as in Fig. 2*B*. Electrophoresis was carried out in a room at 3° C. with the strips of cellulose paper clamped in sets of three in an apparatus similar to that of Woods and Gillespie[5], and the glass-fibre papers in an *EC*–401 electrophoresis apparatus (E–C Apparatus Co., New York). After electrophoresis the strips were dried in a current of warm air. The solid arrows in the figures indicate the positions to which neutral components would be transported by electro-osmotic flow, as measured by the migration of trinitrobenzene or *o*-nitroaniline[6] in the cellulose paper and of glucose in the glass-fibre paper.

The strips of Whatman paper were sprayed as indicated with a 0·1 per cent ethanolic solution of

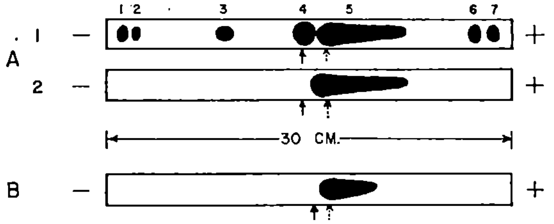

Fig. 1. Electrophoresis of crude and purified enzyme in Whatman 3*MM* filter paper.

(*A*) Crude enzyme after electrophoresis for 270 min. at a potential gradient of 14 V./cm. in phosphate buffer of *p*H 7·0 and ionic strength 0·2. Indicators: (1) ninhydrin; (2) *p*-anisidine hydrochloride

(*B*) Purified enzyme after electrophoresis for 210 min. as above. Indicator: ninhydrin

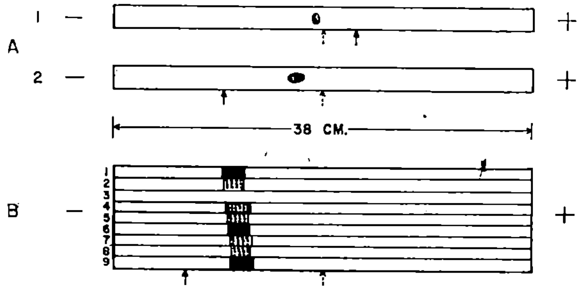

Fig. 2. Electrophoresis of purified enzyme in glass-fibre filter paper. (*A*,1) After electrophoresis for 75 min. at a gradient of 11 V./cm. in sodium acetate–hydrochloric acid buffer of *p*H 3·0 and ionic strength 0·05. (*A*,2) After electrophoresis for 90 min. at the same gradient in phosphate buffer of *p*H 6·7 and ionic strength 0·12.

(*B*) After electrophoresis for 90 min. at a gradient of 14 V./cm. in phosphate buffer as above

ninhydrin or a saturated ethanolic solution of *p*-anisidine hydrochloride and heated at 100° C. for a few minutes. Ninhydrin showed the crude enzyme to contain at least seven components, of which two (No. 4 and 5) predominated; the latter trailed as though adsorbed by the paper. *p*-Anisidine gave a typical aldohexose colour reaction which was displaced slightly in the direction of electro-osmotic flow from component 5 but conformed to its shape (Fig. 1*A*). The main change in the ninhydrin pattern after electrophoresis in acetate buffer of *p*H 5·0 was a reversal in the direction of migration of component 5; a corresponding change in the *p*-anisidine pattern was also observed. As the enzyme preparation showed no evidence of carbohydrate when tested with anthrone and gave no colour reaction with *p*-anisidine after electrophoresis in glass-fibre paper at *p*H 7 (Fig. 2*B*, strip 3) or after electrophoresis in cellulose paper at *p*H 3, we conclude that *p*-anisidine indicates reducing sugar resulting from the action of cellulase on cellulose paper during electrophoresis. Assays of cellulase activity based on the amount of reducing sugar formed when sections of a cellulose strip were incubated in acetate buffer of *p*H 5 gave a similar correlation between cellulase activity and component 5.

The glass-fibre papers to which Fig. 2*A* refers were sprayed with a 1 per cent solution of potassium permanganate in 2·5 *N* sodium hydroxide. The purified enzyme likewise showed no evidence of adsorption or heterogeneity after electrophoresis in acetate buffer of *p*H 5·0. The indicators for the individual sections in Fig. 2*B* were as follows: (*a*) alkaline permanganate (strips 1, 6 and 9); (*b*) *p*-anisidine: (i) following a spray with 0·05 *M* acetate buffer of *p*H 5·0 (strip 3); (ii) following a spray with dilute solutions of the following substrates in acetate buffer: methyl β-cellobioside (strip 8), methyl β-cellotetraoside (strip 5), cellopentaose (strip 7) and carboxymethylcellulose (Hercules Powder Co. type 50*T*) (strip 2); (iii) on Whatman No. 1 paper after strip 4 had been sprayed with buffer and left for 5 min. in close contact with the Whatman paper. The time-interval between spraying with substrate and spraying with *p*-anisidine was 20 min. for methyl β-cellobioside which, like sorbityl β-cellobioside, is hydrolysed more rapidly than cellobiose but less rapidly than cellotriose[7], and 5 min. for the other substrates. Methyl β-glucoside was not included as it is not hydrolysed by the enzyme.

This evidence of electrophoretic homogeneity in enzymatic activity toward substrates covering a wide range of degree of polymerization is in accordance with other evidence reported from this laboratory on the properties of this enzyme in hydrolysing the soluble 1,4-β linked oligoglucosides with degrees of polymerization between 2 and 6, a cellodextrin with a number-average degree of polymerization of 24 and a swollen cellulose with a weight-average degree of polymerization of 1,000[8].

The absence of polysaccharide in these enzyme preparations may be significant relative to Miller and Bloom's electrophoretic evidence of an apparent multiplicity of cellulases in an enzyme preparation containing roughly equal amounts of protein and electrophoretically heterogeneous polysaccharide[4]. Possibly *Myrothecium* cellulase, like *Stachybotrys atra* cellulase[9], forms stable complexes with polysaccharides and other metabolic products of variable occurrence in the culture medium; if so, much of the confusion in the literature on the properties of this enzyme is understandable.

A detailed report of this work will be published elsewhere.

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Effect of Adenosine Triphosphate on Cleavage of Sea Urchin Eggs

THERE is no evidence for the direct participation of adenosine triphosphate in the cleavage of sea urchin eggs, although it can remove the block to division caused by certain agents such as dinitrophenol[1], and can raise the hydrostatic pressure required to prevent cleavage[2].

In a series of experiments in which the eggs of the sea urchin *Psammechinus miliaris*, from which the fertilization membranes had been removed, were placed in adenosine triphosphate (neutralized at pH 7·5–8·0) at various times after fertilization, the eggs divided normally if the concentration of adenosine triphosphate was less than 10^{-2} *M*. Eggs placed in 4×10^{-2} *M* adenosine triphosphate within 5 min. after fertilization also divided normally, but eggs placed in this concentration 40 min. after fertilization, that is, 10 min. before cleavage, showed considerable delay and abnormalities in cleavage and sometimes failed to cleave at all. The eggs often took up irregular shapes and in those which did cleave bubbling often occurred in the furrow region. The mitotic apparatus seemed unaffected and the blockage appeared partially reversible with washing.

It is very unlikely that this phenomenon is due to some greater general sensitivity of the egg just prior to cleavage, since similar tests with a wide variety of other reagents gave no indication of this.

The simplest explanation seems to be that adenosine triphosphate participates directly in cleavage (possibly through its action on the cell cortex) and that some type of regulation of the concentration of adenosine triphosphate occurs. The early application of the adenosine triphosphate allows regulation of the level of the triphosphate to occur, but the addition of a high concentration of adenosine triphosphate close to the time of cleavage gives no opportunity for regulation to occur and causes inhibition.

It was also found that isotonic calcium chloride reversibly inhibits cleavage if applied just before cleavage starts ; also, eggs placed in isotonic magnesium chloride after fertilization usually cleave with a very characteristic bubbling in the furrow region.

There is good evidence that cleavage involves a contractile system[3,4], and these results suggest that it may be in some ways analogous to an actomyosin system in which superoptimal concentrations of adenosine triphosphate can inhibit contraction and in which behaviour of the system is very dependent on the relative concentrations of adenosine triphosphate, calcium and magnesium. A similar system is involved in the cleavage of the glycerol-extracted models of tissue-culture cells of Hoffmann-Berling[5].

A paper on the relevance of these results to a detailed theory of cleavage is in preparation[4].

This work was carried out at the Marine Station, Millport, while holding a Nuffield Biological Scholarship.

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Nitrogen Fixation in *Elaeagnus* Root Nodules

The three genera comprising the Elaeagnaceae, namely, *Elaeagnus*, *Hippophaë* and *Shepherdia* have been known for some time to bear root nodules ; but it is only within the past few years that the physiological significance of these structures has been rigorously investigated. Previously, the main interest had been cytological. Nodules of *Hippophaë*[1,2] and *Shepherdia*[3] have recently been shown, by growth experiments and by tests with nitrogen-15, to be able to fix nitrogen.

The genus *Elaeagnus* comprises 30 species widely distributed in Asia, Europe, and North America. Nobbe and Hiltner[4] reported that a nodule-bearing plant of *E. angustifolia* showed marked ability to grow in sand free of combined nitrogen, and attained a height of 120 cm. in four years as compared with 24 cm. for a corresponding plant without nodules. The authors accordingly suspected the occurrence of fixation. Roberg[5] reported that, in the course of tests which demonstrated cross-inoculation between *Elaeagnus* and *Hippophaë*, he saw signs of fixation in both genera, while Panosjan[6], whose report is available only in summary form, found that nodulated plants were independent of the presence of combined nitrogen.

In the present work, seed of *E. angustifolia* was germinated in moist sand in the spring of 1956 and the seedlings grown on in water culture in Crone's solution containing a small quantity of combined nitrogen. After four weeks, a nitrogen-free solution was substituted and a suspension of crushed nodules from a plant of *E. pungens* growing in the Glasgow Botanic Gardens (obtained by the kindness of the Curator) was applied to the roots of certain of the plants. Since no nodules had appeared after 4 weeks, it seemed that the inoculum had been inactive, and a further inoculum, prepared from *Hippophaë* nodules, was applied. After ten days, numerous nodules were present on the roots of the plants in culture solution of pH 6·0, but none at pH 5·0.

Growth of the plants was allowed to continue until autumn 1957, with periodic renewal of the nitrogen-free culture solution. Control plants without nodules showed very feeble development, but nodulated plants grew satisfactorily (Fig. 1) and accumulated substantial amounts of nitrogen (Table 1). The mean percentage nitrogen (dry weight basis) in the nodules was 3·5 as compared with 1·8 in both roots and shoots.

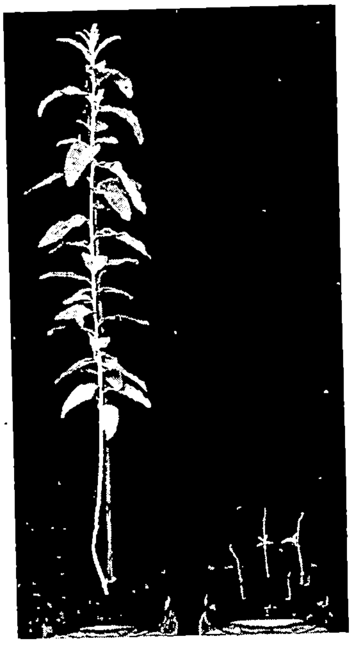

Fig. 1. Plants of *Elaeagnus angustifolia* after two seasons growth in culture solution free of combined nitrogen. The plant on the left bears root nodules. $\times \frac{1}{8}$

Table 1. HARVEST RESULTS FOR *Elaeagnus angustifolia* AFTER 15 MONTHS GROWTH IN NITROGEN-FREE CRONE'S SOLUTION

Type	Plant No.	Shoot height (cm.)	Dry weight (gm.) Root+Shoot	Dry weight (gm.) Nodules	Total nitrogen (mgm.)
Nodulated	1	43	2·22	0·11	27·0
	2	62	6·59	0·21	148·8
	3	56	5·84	0·19	128·0
	4	74	9·64	0·40	186·4
Non-nodulated	5–8	4–10	0·03–0·15	—	0·5–2·1

Although the plants were not grown under aseptic conditions, the only satisfactory explanation of the strong growth of the nodulated plants is that the nodules are able to fix nitrogen. It is reasonable to suppose that the same is true of the nodules of other species of *Elaeagnus*. Evidence[7,8] is growing that the ecological importance of non-legume nodule plants such as *Alnus*, *Myrica* and *Hippophaë* in the provision of soil nitrogen in past and present times is greater than previously supposed. The same may apply to *Elaeagnus*.

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Vesicular-Arbuscular Mycorrhiza in the Gramineae

VESICULAR-ARBUSCULAR mycorrhiza has been found to be widespread in cereals and in many grasses in Britain[1]. The incidence of root infection and the amount of endophyte mycelium on the root surface and in the rhizosphere differ greatly in different habitats and communities. For example, in sand-dune grasses—where mycorrhiza is strongly developed —the degree of infection varies between different species and with the stage in the dune succession. As illustrated in Table 1, samples collected from the sand dunes at Gibraltar Point, Lincolnshire, showed about a 20 per cent level root infection when growing in the embryo dune phase, that is on sites which have never supported plant growth previously. In the next zone in the dune succession infection falls almost to zero, but it reaches a maximum where the sand becomes stabilized in the fixed yellow dunes. In this zone, where the ranges of three grasses overlap, there is marked variation in infection between the different species. As the community matures and becomes more complex, there is a general decrease in endophyte activity. Roots of grasses in the fixed yellow dunes were often extensively covered with wefts of external mycelium as well as showing a high incidence of infection.

Table 1

Vegetation zone	Species	Root infection (per cent)	Roots with external mycelium attached (per cent)
Embryo dunes	*Ammophila arenaria*	19	15
Mobile yellow dunes	*Ammophila arenaria*	1	2
Fixed yellow dunes	*Ammophila arenaria*	37	43
	Festuca rubra var. *arenaria*	45	22
	Poa pratensis	18	20
Older fixed dunes	*A. arenaria*	6	0
	P. pratensis	3	0·5

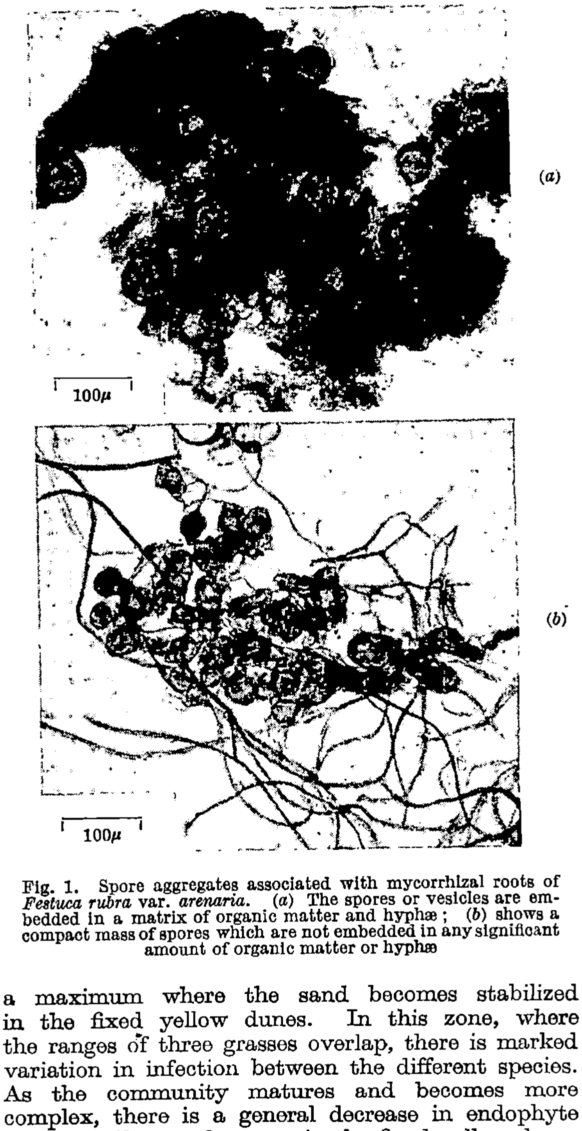

Fig. 1. Spore aggregates associated with mycorrhizal roots of *Festuca rubra* var. *arenaria*. (*a*) The spores or vesicles are embedded in a matrix of organic matter and hyphæ; (*b*) shows a compact mass of spores which are not embedded in any significant amount of organic matter or hyphæ

Compact aggregates of spores, resembling *Endogone*-type fruiting bodies, have been found on external mycelium associated with, and directly connected to, the endophytic mycelium in the roots of *Festuca rubra* var. *arenaria* and *Ammophila arenaria*. These spore masses are not as regular or uniform in size or structure as the sporocarps described by Mosse[2,3]. In size the spore aggregates on grass roots vary greatly but they are always less than 0·8 mm. diam. Three main types of structure occur: (1) the spores or vesicles may be embedded in a matrix consisting of hyphæ and some organic matter (Fig. 1*a*); (2) the spores may be embedded in a matrix of organic matter with little or no hyphæ present—many particles or organic matter which remain attached to the external mycelium or to the root surface after gentle washing contain embedded spores in this way; or (3) there may be compact masses of spores which are not embedded in any significant amount of hyphæ or organic matter (Fig. 1*b*). These different conditions possibly represent developmental or disintegration stages of distinct fruiting bodies or may be due to strain differences in the endophyte. The number of spores present varies greatly, and up to 50 have been noted in a single structure. Likewise there is variation in size of spore, the largest seen being 75μ in diameter. Frequently these spores have thick walls (Fig. 1*a*); otherwise they resemble isolated vesicles formed on external mycelium.

These observations, which include samples from a wide range of habitats, suggest that the endophytes occurring on grasses in the majority of cases are related to the genus *Endogone*, being similar to those described on a range of different plants by Peyronel[4,5] and on fruit plants by Mosse. No evidence has yet been obtained that the endophytes of grasses may be strains of *Pythium ultimum* as has been found for vesicular-arbuscular mycorrhiza in *Allium ursinum* and in other plants[6-8].

I am grateful to Dr. Barbara Mosse of the East Malling Research Station for allowing me to inspect her *Endogone* material.

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The Vitreous Body of *Galago crassicaudatus agisymbanus*

MANY aspects of the anatomy of the eye in galagos and related species have been described[1,2]. I am, however, not aware of any description of the vitreous body in these species, but in *Galago crassicaudatus agisymbanus* I have found peculiarities that I have not encountered or found described in other animals.

In vertebrates the vitreous body is generally described as a translucent gel, although its consistency varies, being most rigid in birds[3] and varying considerably in solidity among the mammals. Examination with the slit-lamp, dark-ground and phase-contrast microscopes shows that it possesses a definite structure[1,3].

The vitreous body of *Galago c. agisymbanus*, however, is in ordinary circumstances a free liquid. Thus it can be aspirated through a hypodermic needle of 0·3-mm. external diameter as easily as can the aqueous humour, the volume extracted varying between 0·8 and 1·0 ml. and leaving the globe almost empty. The fluid so extracted shows no tendency to clot and contains only a trace of substance precipitated by trichloracetic acid.

The vitreous body in this species would also appear to be structureless on examination with the slit-lamp microscope, although it must be said that good definition is very difficult in this animal because of the intense reflexion from the highly developed cellular tapetum.

The vitreous body is generally believed to exchange constituents with surrounding tissues and fluids, especially the aqueous humour, solely by diffusion of substances, and not by any mechanical mixing with other fluids or by stirring of the liquid phase of the vitreous body itself[4,5]. This fact has recently been shown to be of importance in investigating the dynamics of the exchange of substances within the rabbit's eye[5].

The following experiments were carried out on the galago in view of the apparent species differences and the implications they carry. The animal was anæsthetized (sodium pentobarbitone 30 mgm./kgm.), placed prone with the head held in a mould so that the plane of the lens of the eye was approximately horizontal. The eye was atropinized and a 0·3-mm. external diameter hollow needle pushed through the sclera at the equator until the point could be clearly seen under the lens in the centre of the vitreous, either by the naked eye with good general illumination or with the ophthalmoscope. With a micrometer syringe attached to the needle by 'Polythene' tubing, 0·001–0·002 ml. of indian ink suspended in physiological saline was injected into the eye. The needle was withdrawn, detaching the droplet, which fell smoothly and freely through the vitreous on to the fundus, where it spread over the surface, clearly visible against the brilliant gold of the tapetum. It dispersed, leaving no area of obviously high concentration, within 15–20 min.; an attempt to repeat the experiment *in vitro*, with a similar droplet falling and mixing in saline, gave a dispersion time of the same order. If the eye was manipulated or the head moved briskly during the observation, the time for dispersion was reduced to about 7 min. No definite streams of flow were seen, nor can any circulation of the vitreous be argued from the experiments; but it is almost certain that the vitreous in this species in ordinary circumstances is a homogeneous fluid, probably kept stirred by the normal head and eye movements. It should also be noted that these experiments provide no evidence of a mingling of the aqueous and vitreous fluids. There is in fact good evidence that the fluids are quite separate. Aspiration of the vitreous does not withdraw any fluid from the anterior chamber, nor does the anterior chamber fill rapidly after aspiration of the aqueous humour which one might expect if there was free mixing of the fluids. Even if this evidence is insecure, as one might suppose the possibility of an iris-lens valve mechanism that prevented flow into or out of the anterior chamber under abnormal pressure, there is the further fact that particulate matter in the form of indian ink suspended in aspirated vitreous fluid and reinjected does not appear in the aqueous humour even after vigorous movements of the head and eye.

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Size and Shape of Alfalfa Mosaic Virus

In the course of purifying alfalfa mosaic virus we have found that at least three kinds of macromolecular particles are produced by plants as a result of their infection with the virus, and that one of these is the infectious entity. In the electron microscope the virus particles, and also the other two particles, appear as small rodlets about 550 A. long and about 200 A. in diameter. Thus they are not spherical, as previous isolates of alfalfa mosaic virus apparently are, and indeed they look markedly different from any viruses reported in the literature.

The isolate used was obtained from ladino clover. Single local-lesion isolates were made from bean, one of which was retained and identified by cross protection tests to be similar to isolate No. 96 of the American Type Culture Collection[1]. It is similar in symptomatology and concentration pattern to the unobtainable alfalfa mosaic virus isolate extensively studied by Ross[2]. The virus was grown on *Nicotiana tabacum* L. var. 423[1] and purified using methods similar to those described by Ross. Alternative methods involving differential centrifugation and *n*-butanol chloroform–water extraction[3] at 6° C. yielded purified material with similar specific infectivity.

These purified preparations exhibited three closely spaced schlieren peaks in the analytical ultracentrifuge with sedimentation coefficients at infinite dilution and 20° C. of 73, 89 and 99 Svedberg units. The buffer was 0·10 ionic strength of which 0·08 was contributed by sodium chloride and 0·02 by sodium phosphates. The areas under the schlieren peaks were in the ratio 43 : 14 : 43 for top, middle and bottom components respectively. No such peaks were observed in similarly prepared extracts from healthy plants. From its sedimentation behaviour, this material does not appear to be similar in its physical properties to Ross's isolate, since his material under similar preparative conditions yielded a single sedimentation peak with a sedimentation constant of $S_{20,w} = 70\,S$.

The three components were partially separated from each other using sucrose density-gradient centrifugation techniques in a 'Spinco' *SW* 25 swing bucket rotor[4,5]. Complete separations were not achieved because the resulting three bands were very closely spaced. In one experiment three fractions were obtained for electron microscopy, sedimentation and infectivity tests. Fraction 1 removed from the topmost band contained more than 90 per cent top component and less than 5 per cent middle and 5 per cent bottom components. Fraction 2 removed from the middle band contained about 30 per cent top, 50 per cent middle and 20 per cent bottom component. Fraction 3 removed from the bottom band contained more than 90 per cent bottom component and less than 5 per cent middle and 5 per cent top components. All three fractions were serologically similar and gave identical ultra-violet absorption curves, with a maximum at 260 mμ.

Their relative infectivities were tested by assaying on the local-lesion host *Phaseolus vulgaris* L. var. Bountiful. Fraction 1 gave 5 lesions, fraction 2 gave 405 lesions and fraction 3, containing predominantly bottom component, gave 1,900 lesions. Clearly, infectivity is associated with a particle having the sedimentation characteristics of the bottom component. The residual infectivity in fraction 1, and probably also in fraction 2, could be attributed to contamination with bottom-component particles.

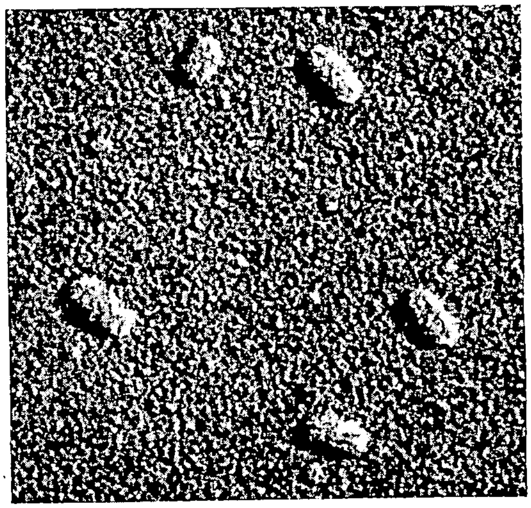

Fig. 1. A uranium-shadowed preparation of fraction 3, taken in a Siemens Elmiskop I. (× 140,000)

Electron microscope specimens were prepared using essentially the freeze-drying method of Williams[6]. Micrographs of the three fractions were indistinguishable, and all showed particles most of which had a minor dimension of about 240 A. and the majority of which had a major dimension of about 550 A. Fig. 1 is a typical micrograph of fraction 3, that is, the bottom component. Fig. 2 shows the length distribution of 100 particles lying in the proximity of the particles of Fig. 1. It shows that some short particles exist, whereas only a few are longer than 600 A.

As is the case with shadowed tobacco mosaic virus and with other elongated viruses[7], centre-to-centre distances between several particles lying side-by-side is less than the measured width of isolated particles. The former is probably the more accurate measure of particle diameter. The average centre-to-centre distance measured in this work is about 200 A. Thus the predominantly occurring macromolecular particle in our virus preparation is a short rod about

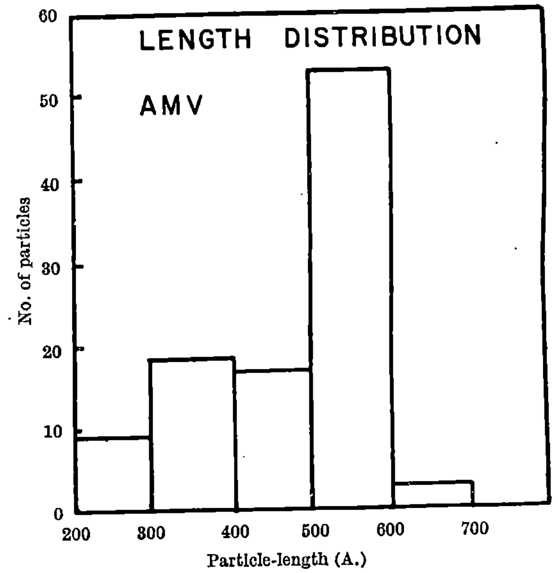

Fig. 2. The length distribution of 100 particles lying in the proximity of particles of Fig. 1

200 A. in diameter and 550 A. in length. The predominant particles in the top and middle component preparations have similar dimensions.

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Virus Transmission by *Dactynotus cichoricola* H.R.L., a New Aphid on Chicory

A SHINY, dark brown, rapidly multiplying aphid was observed in the early autumn of 1957 on *Cichorium intybus* L. var. *foliosum* cultivated as a vegetable in fields near Louvain (Belgium). Later, the insect was found on the same crop in several other places. The species, which is close to *Dactynotus tussilaginis* Wlk., was acknowledged as new by M. Hille Ris Lambers (Bennekom, Netherlands), and named by him *Dactynotus cichoricola* n. sp. In September, apterous and alate virginoparæ, unwinged oviparous females and apterous males were captured, while in October only the last two forms could be found.

Copulation of *D. cichoricola* is common under laboratory conditions; the eggs are shiny black when 1–2 days old. Oviposition takes place on the stalks and on the lower face of the leaves. Under natural conditions, some eggs were found on *Cichorium intybus*. Trials were conducted to determine whether this aphid is a vector of plant viruses. Only one aphid-borne virus, namely, cucumber mosaic virus[1,2] is known on chicory.

Young larvæ of oviparous females of *Dactynotus cichoricola*, collected on chicory in an open field, were reared in the laboratory on *C. intybus* seedlings until they were adult. They were then starved for 2–3 hr. and allowed to feed for 1 min. on tobacco leaves infected with a cucumber mosaic strain isolated from chicory. Many of them did not insert their stylets in the leaf tissues, although they had the typical feeding aspect; these were removed. The remainder were immediately transferred to the test-plants for 24 hr.

Of three inoculated cucumber seedlings var. Blanc hâtif (ten aphids on each plant), two showed the typical symptoms of the virus after 8 days. Control plants inoculated with non-infectious aphids remained unaffected.

Of three inoculated tobacco seedlings var. Samsun (five aphids on each plant), two became infected with the virus as was shown by the symptoms and by a protection test against Pierce's yellow strain of cucumber mosaic virus.

Not one of six aphid-inoculated chicory seedlings var. *foliosum* (five aphids on each plant) became infected, but two of five plants showed the typical symptoms of the virus when inoculated with infectious tobacco sap mixed with 'Carborundum'. These results agree with the very low infection-rate of chicory cultures by cucumber mosaic virus.

The same method was used with aphids fed for 1 min. on beet leaves infected with beet mosaic virus and transferred to three young beet seedlings var. Kleinwanzleben E. (five aphids on each plant). The symptoms of the virus infection became apparent on one of the beets after 13 days.

It was observed that most of the chicory leaves colonized by *D. cichoricola* in the field showed brittle areas with interveinal yellowing and thickening. Sap inoculation, and aphid transmission trials with *Myzus persicae* Sulzer, *Myzus ascalonicus* Doncaster and *Dactynotus cichoricola* H.R.L. were made from those leaves on to chicory seedlings, but no reliable results were obtained to support the idea that the symptom is associated with a virus.

I thank Prof. R. Vanderwalle for his helpful criticism during the experiments. Virus-infected material sent by Mr. F. C. Bawden, Rothamsted Experimental Station, and Dr. K. M. Smith, University of Cambridge, is gratefully acknowledged.

Plant Pathology Laboratory,
Agronomical Institute,
Gembloux, Belgium.
Dec. 6.

University College of Science
PHYSICS Dept.

[1] Smith, K. M., "Virus Diseases of Farm and Garden Crops" (Worcester, 1946).

[2] Roland, G., *Parasitica*, 12, 1 (1956).

Relationship of Tectoquinone to Durability in *Tectona grandis*

THE heartwood of teak (*Tectona grandis* L.f.) is extremely resistant to attack by insects or by fungi; but the reasons for this resistance are not known. It is usually ascribed to the presence of toxic substances, and it has been suggested that tectoquinone (β-methyl anthraquinone), which is characteristically present in teak heartwood, may be responsible. Wolcott[1] has shown this substance to be highly repellent to the dry-wood termite *Cryptotermes brevis* (Walker), and Sandermann and Dietrichs[2] have demonstrated its toxicity, in high concentrations, to the North American subterranean termite *Reticulitermes flavipes* Kol. No reference seems to have been made to its toxicity to fungi. In current investigations into the chemical basis of the durability of teak, we have examined the amount of tectoquinone in teak from Thailand and Indonesia, and its toxicity to decay fungi and to subterranean termites.

Tectoquinone was readily identified on paper chromatograms by its bright green-yellow fluorescence in ultra-violet light. It was observed at R_F 0·90 in *n*-butanol/acetic acid/water (6 : 1 : 2) at 20° C.; anthranilic acid, used as a marker, was located at R_F 0·85 under these conditions. Using *n*-butanol saturated with an ammonia buffer (Fewster and Hall[3]), tectoquinone had an R_F value of 0·94, while benzoic acid, used as a marker, had an R_F value of 0·44. The tectoquinone present in several samples of

Table 1. Tectoquinone Content and Durability of Teak Blocks

	Tecto-quinone (per cent)	Decay		Termite attack	
		C. cerebella	*T. lilacino-gilva*	*C. lacteus*	
		Weight-loss (per cent)	Weight-loss (per cent)	Weight-loss (per cent)	Survival* (per cent)
Teak 1 (Thailand)					
Outer heartwood	0·58	0·9	2·0	4·8	73
Middle heartwood	0·29	3·3	8·1	5·7	69
Inner heartwood	0·12	17·8	34·2	13·2	73
Teak 2 (Indonesia)					
Outer–middle heartwood	0·11	1·1	1·2	18·0	66
Mountain ash heartwood (control)	—	45·6	57·8	100·0	65
Unfed control termite colony	—	—	—	—	68

Each result is the mean of five blocks for fungi and eight for termites.

* All *C. lacteus* colonies (including unfed control) survived for the whole of the test (84 days); survival (per cent) is given on the 84th day.

teak was isolated by thorough extraction of the sawdust with ether followed by methanol; partial purification was carried out by paper chromatography and alkali washing. The tectoquinone was estimated by conversion to the sodium salt of dihydro-tectoquinone, and the absorption at 417 mμ (max.) compared with standards of this derivative made from pure tectoquinone (B.D.H., Ltd.). The results are given in Table 1 and show that the amount of tectoquinone in durable outer heartwood was as high as 0·58 per cent (oven-dry basis). Kafuku and Sebe[4] have isolated 0·3 per cent of tectoquinone from teak heartwood and recently Sandermann and Dietrichs[2] have isolated 0·36, 0·56 and 0·88 per cent from Indonesian, Thai and Burmese teak respectively.

The amount of tectoquinone present in different samples of teak was then compared with the resistance of matched test blocks to attack by the wood-destroying fungi *Coniophora cerebella* Pers. DFP 1779 and *Trametes lilacino-gilva* Berk. DFP 1109 and by the subterranean termite *Coptotermes lacteus* (Frogg.). The resistance of the test blocks to decay was measured by a soil-wood block decay test[5], and termite resistance was measured by the standard laboratory colony test of Gay *et al.*[6]; these results are given in Table 1.

To determine the toxicity of tectoquinone to wood-destroying fungi, known amounts of pure tectoquinone (B.D.H.) were dissolved in ether and added to known amounts of decay-susceptible sawdust from the heartwood of mountain ash (*Eucalyptus regnans* F. Muell.). The methanol was removed by vacuum-drying and 0·5-gm. samples of sawdust tested for decay resistance in the soil jar–sawdust dish technique described by Da Costa and Rudman[7]. The results (Table 2) show no evidence of toxicity even at concentrations well above those found in teak. (These two test fungi, under similar conditions of test, will not produce weight losses of more than 3 per cent in sawdust from durable teak heartwood.)

Table 2. Effect of Tectoquinone in Mountain Ash Sawdust on Decay Fungi

Tectoquinone in mountain ash (per cent)	*C. cerebella* Weight-loss (per cent)	*T. lilacino-gilva* Weight-loss (per cent)
0·00	44·8	23·4
0·05	47·4	23·5
0·10	49·1	21·5
0·20	47·0	23·6
0·40	48·4	22·2
0·80	46·8	23·4
1·60	44·6	22·0

Each result is the mean of four replicates

The toxicity of tectoquinone to termites was determined by dissolving known amounts in benzene and mixing the solution into 100-gm. samples of mountain ash sawdust. The sawdust was bonded with melamine powder under pressure into a compact board, the temperature being maintained at 70° C. for the first ½ hr. of the 24-hr. pressing period. Test samples, approximately 3½ in. × ½ in. × ½ in., were sawn from these boards and tested in standard laboratory termite colonies of *C. lacteus* and of *Nasutitermes exitiosus* (Hill); the results are given in Table 3. Although the progressively smaller amounts eaten (weight-loss) with increasing loadings indicate that tectoquinone is distasteful and/or nutritionally unsatisfactory to these termites, the amount of attack is far greater than that obtained on samples of durable teak heartwood of smaller tectoquinone content. Comparison of survival-rates with those of the unfed colonies indicates that there is no actual toxic effect.

Table 3. Effect of Tectoquinone in Mountain Ash Sawdust on Subterranean Termites

Tectoquinone in mountain ash (per cent)	*C. lacteus*		*N. exitiosus*	
	Weight-loss (per cent)	Survival (per cent)	Weight-loss (per cent)	Survival (per cent)
0·00	83·4	56·9	90·4	40·0
0·30	68·1	61·0	75·6	37·5
0·60	31·5	55·0	50·7	29·1
1·20	15·3	60·6	16·2	0·0*
Unfed control colony	—	57·7	—	0·0†

Each result is the mean of three, except for unfed control which is the mean of two. Duration of test: 84 days.

* Colonies only survived a mean of 54 days.

† Colonies only survived a mean of 50 days.

In general, it may be concluded that although tectoquinone occurs in appreciable quantities in teak heartwood, it shows no sign of toxicity to wood-destroying fungi; its effect on subterranean termites is relatively slight, and it is not solely responsible for the termite resistance of teak.

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Nov. 29.

[1] Wolcott, G. N., *J. Agric. Univ. Puerto Rico*, 39, 115 (1955).

[2] Sandermann, W., and Dietrichs, H. H., *Holz als Roh-und Werkstoff*, 15, 281 (1957).

[3] Fewster, M. E., and Hall, D. A., *Nature*, 168, 78 (1951).

[4] Kafuku, K., and Sebe, K., *Bull. Chem. Soc. Japan*, 7, 114 (1932).

[5] Da Costa, E. W. B., Aplin, T. E. H., and Tamblyn, N., "The Comparative Resistance to Decay of Eight Australian Timbers under Different Conditions of Testing", Division of Forest Products, C.S.I.R.O., Melbourne. Project P.13-5, Prog. Rep. No. 1 (Nov., 1957).

[6] Gay, F. J., Greaves, T., Holdaway, F. G., and Wetherly, A. H., "Standard Laboratory Colonies of Termites for Evaluating the Resistance of Timber Preservatives and Other Materials to Termite Attack", Bull. No. 277 (C.S.I.R.O., Melbourne, 1955).

[7] Da Costa, E. W. B., and Rudman, P., *Aust. J. Biol. Sci.* (in the press).

FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

Monday, March 10

University College, London (in the Physiology Theatre, Gower Street, London, W.C.1), at 5 p.m.—Dr. J. D. Judah: "Oxidative Phosphorylation".* (Further lecture on March 17.)

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Sir William Pugh, O.B.E., F.R.S.: "The Geological Survey of Great Britain". (First of two Cantor Lectures. Further lecture on March 17.)

Institution of Electrical Engineers, London Graduate and Student Section (joint meeting with the Institution of Civil Engineers, at Great George Street, London, S.W.1), at 6.30 p.m.—Vice-Admiral Sir Archibald Day, K.B.E., C.B., D.S.O.: "The International Geophysical Year".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Prof. P. M. S. Blackett, F.R.S.: "Rock Magnetism as Evidence of Continental Drift".

Tuesday, March 11

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Scientific Papers.

Institution of the Rubber Industry, London Section (at the National College of Rubber Technology, Holloway, London, N.7), at 5.30 p.m.—Mr. E. Hornby: "Modern Methods of Tyre Building and Vulcanizing". 7 p.m.—Research Lecturers and Demonstrations.

Tuesday, March 11—Wednesday, March 12

Society of Chemical Industry, Corrosion Group (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 9.30 a.m. daily—Symposium on "The Protection of Motor Vehicles from Corrosion".

Tuesday, March 11—Thursday, March 13

Oil and Colour Chemists' Association, London Section (in the Royal Horticultural Society's New Hall, Greycoat and Elverton Streets, London, S.W.1)—Tenth Technical Exhibition.*

Wednesday, March 12

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. N. W. Pirie, F.R.S.: "World Hunger as a Biochemical Problem" (Frankland Armstrong Memorial Lecture).

Palæontological Association (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 4.45 p.m.—Prof. O. M. B. Bulman, F.R.S.: "The Sequence of Graptolite Faunas" (First Annual Address).

Royal Institution, Library Circle (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Dr. H. D. Anthony: "Scientific Books of the 18th Century and the Emergence of Modern Science".

Institute of Welding (at 54 Princes Gate, Exhibition Road, London, S.W.7), at 6 p.m.—Prof. Sir Alfred Pugsley, F.R.S.: "The Influence of Welding on Structural Design".

Society of Chemical Industry, Food Group (joint meeting with the Microbiology Group, at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Meeting on "The Prevention of Microbial Spoilage in Fruit".

Radar and Electronics Association (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 7.30 p.m.—Prof. A. C. B. Lovell, O.B.E., F.R.S.: "The Jodrell Bank Radio-telescope in Action".

Thursday, March 13

Royal Society (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m.—Discussion on "The Physiology and Biochemistry of Lactation".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. T. G. Tutin and Dr. V. H. Heywood: "The Flora Europaea Project"; Dr. J. Ramsbottom, O.B.E.: "P. A. Micheli's *Nova Plantarum Genera*, 1729".

Institution of Electrical Engineers, Utilization Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. D. L. Smart and Mr. J. J. L. Weaver: "The Use of Steel-Tank Mercury-Arc Inverters for Generating Medium Frequencies for Induction Heating".

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Kurt Mothes (Deutsche Akademie der Wissenschaften zu Berlin): "Physiology of Alkaloids".* (First of two Special University Lectures in Pharmacy. Further lecture on March 14.)

Royal Institute of Chemistry, London Section (joint meeting with the West Ham College of Technology Chemical Society, at the West Ham College of Technology, Romford Road, London, E.15), at 7 p.m.—Mr. I. Goodman: "The Chemistry of Synthetic Fibres".

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. Dr. W. Klemm: "Metalloids and Their Compounds with the Alkali Metals" (Centenary Lecture).

Friday, March 14

Society for Water Treatment and Examination (at the Royal Society of Health, 90 Buckingham Palace Road, London, S.W.1), at 9.30 a.m.—Annual General Meeting, followed by Scientific Papers.

Royal Institute of British Architects (in the Jarvis Hall, R.I.B.A., 66 Portland Place, London, W.1), at 2.15 p.m.—Symposium on "The Design of Teaching Laboratories in Universities and Colleges of Advanced Technology".

British Glaciological Society (at the Geography School, 341 Bristol Road, Birmingham), at 5.30 p.m.—Mr. W. H. Ward: "The Ice Caps and Glaciers of Baffin Island".

Institute of Physics, Non-Destructive Testing Group (at 47 Belgrave Square, London, S.W.1), at 6 p.m.—Meeting on "X-Ray Microscopy". Prof. R. W. K. Honeycombe: "Surfaces Reflection Techniques"; Mr. P. Duncomb: "Electron Probe Methods".

Society of Chemicals Industry, Fine Chemicals Group (joint meeting with the London Section, at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. E. S. Hedges and Dr. G. J. M. Van der Kerk: "Research on Organotin Compounds and their Technological Applications".

Royal Photographic Society (at 16 Princes Gate, London, S.W.7), at 7 p.m.—Mr. S. W. Simmons: "Kinematograph Instrumentation".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. H. S. W. Massey, F.R.S.: "Artificial Satellites".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer (with a degree in science or agriculture and an interest in dairy chemistry) in Chemistry—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (March 13).

Assistant, Grade B, for Anatomy, Physiology and some Biology; an Assistant, Grade B, for Chemistry and Science; and an Assistant, Grade A, for General Laboratory Techniques and Science—The Secretary, Paddington Technical College, Saltram Crescent, London, W.9 (March 14).

Assistant Librarian (Chartered Librarian) in the Dairy Science Library—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 58/4 (March 15).

Lecturer in Organic Chemistry—The Principal, Nottingham and District Technical College, Shakespeare Street, Nottingham (March 15).

Lecturer (Grade II) in Pure Mathematics—The Registrar, The University, Bristol (March 17).

Scientist (with a good honours degree or equivalent in chemistry, chemical engineering or metallurgy and a number of years experience in a responsible position in industrial research, development or production operations, and preferably experience in uranium or ceramics), at Springfields Laboratory, Salwick, Preston, Lancashire, to lead a section which is principally concerned with the experimental manufacture of ceramic fuels—The Recruitment Officer, United Kingdom Atomic Energy Authority, I.G.H.Q., Risley, Warrington, Lancashire, quoting Ref. 2289 (March 17).

Head (with good academic and teaching qualifications and preferably industrial experience) of the Mathematics Department—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (March 20).

Assistant Curator (Ethnology) (with a good honours degree or diploma and preferably museum experience) at Horniman Museum, London, S.E.23—The Education Officer (EO/Estab.2/F), The County Hall, London, S.E.1 (March 21).

Junior Lecturer in Physical Chemistry—The Registrar, Trinity College, Dublin (March 22).

Assistant Lecturer and Demonstrator in Zoology—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8 (March 24).

Assistant Lecturer (with qualifications in petrology) in Geology; and an Assistant Lecturer (with qualifications in pure mathematics) in Mathematics—The Registrar, The University, Hull (March 28).

Assistant Lecturer or Lecturer in Pure Mathematics—The Registrar, University College, Singleton Park, Swansea (March 29).

Experimental Officers (with a degree in horticulture or botany or equivalent) in the Pomology Section, for (*a*) experiments on propagation of fruit plants, and (*b*) field experiments on small fruits—The Secretary, East Malling Research Station, near Maidstone, Kent (March 31).

Keeper (with a university degree in botany or zoology or the Diploma of the Museums Association, and previous museum experience) of the Department of Biology in the Leicester Museums—The Director, Museums and Art Gallery, New Walk, Leicester (March 31).

Lecturer in Psychology at the University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, March 31).

Post-Doctoral Fellow in Chemistry, for work on thermodynamic and relaxation behaviour of polyblycol-solvent systems—Dr. B. E. Conway, Department of Chemistry, University of Ottawa, Ottawa, Canada (March 31).

Research Fellow in the Chemistry Department, for fundamental work on compounds potentially useful in the paint industry—The Professor of Chemistry, The University, Hull (March 31).

Lecturer (with a degree in agriculture and a specific interest in animal husbandry generally and poultry in particular) at Gwebi Agricultural College (Ministry of Agriculture), Salisbury, Southern Rhodesia, for duties which will include lecturing and giving practical instruction to diploma students in certain aspects of animal husbandry, including anatomy, physiology and in poultry husbandry—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (April 1).

Lecturer/Senior Lecturer (preferably with a principal interest in morphological, physiological or chemical cytology) in Histology and Embryology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 5).

Lecturer (with an honours degree in engineering or physics and experience in vacuum tube and transistor circuits) in Electrical Engineering at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 5).

RESEARCH OFFICER (qualified zoologist with experience of fisheries research) IN THE FISHERIES RESEARCH UNIT within the Department of Biology, University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, April 8).

UNIVERSITY STUDENTS AND FELLOWS, for experimental or theoretical research in nuclear and elementary particle physics—The Professor of Natural Philosophy, The University, Glasgow, W.2 (April 12).

SENIOR LECTURER (with a degree in science with geology as a major subject, and experience in modern mineralogical techniques) IN GEOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

TURNER and NEWALL RESEARCH FELLOWS IN ENGINEERING, INORGANIC CHEMISTRY, PHYSICS and allied subjects—The Registrar, The University, Manchester 13 (April 30).

PRINCIPAL (graduate of a university in the British Commonwealth, a wide experience of agricultural teaching or advisory work, experience of administration and a sound knowledge of commercial agriculture, and preferably under 45 years of age) OF THE ROYAL AGRICULTURAL COLLEGE—Joint Clerks to the Governors, Royal Agricultural College, 7 Dollar Street, Cirencester, Glos (May 1).

SENIOR TECHNICIAN or TECHNICIAN IN THE DEPARTMENT OF CHEMISTRY, University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 2).

ASSISTANT CHEMIST (male or female, with training in agricultural chemistry, and preferably postgraduate experience), to carry out investigations into matters concerning turf maintenance—The Secretary, The Sports Turf Research Institute, Bingley, Yorkshire.

CHIEF PLANT PHYSIOLOGIST in the Division of Plant Industry, Department of Agriculture and Stock, Brisbane, Australia—Agent-General for Queensland, 409 Strand, London, W.C.2.

ENGINEERS AND PHYSICISTS (with an honours degree), for work in Sheffield on problems of metal plasticity, lubrication, heat transfer, and their application to the manufacture of wrought steel products—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "M.W.2".

LECTURER, ASSISTANT PROFESSOR, POSTDOCTORATE FELLOW, and RESEARCH ASSISTANT IN THE DEPARTMENT OF PHYSICS—Head of the Department of Physics, University of British Columbia, Vancouver, B.C., Canada.

LECTURER IN MATHEMATICS, to teach pure and applied mathematics to degree standard—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

LECTURERS (with special qualifications in (*a*) organic chemistry or (*b*) physical chemistry) IN CHEMISTRY—The Secretary, Royal College of Science and Technology, Glasgow.

PHYSICIST (with at least an M.Sc. degree or equivalent)—Dr. E. Wilson, Superintendent, General Hospital, St. John's, Newfoundland, Canada.

PHYSICISTS, Experimental Officer or Assistant Experimental Officer grade, to work in collaboration with scientists on research in the following: (*a*) properties of solids under high stress and high rates of strain; (*b*) physics of detonation process and propagation of intense shock waves; (*c*) development of transient spectrographic techniques and application to study of high temperature gas shocks; and (*d*) experimental hydromagnetics—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. C/1463/34.

SCIENTIFIC ASSISTANT (ENTOMOLOGY) to assist in field work on controlling *Culicoides* in Scotland—Dr. D. S. Kettle, Midge Control Unit, Zoology Department, West Mains Road, Edinburgh.

SCIENTIFIC ASSISTANT (with a good science degree, a reading knowledge of two European languages (preferably other than French or German), ability to write good English, and preferably a knowledge of soil science and plant physiology), for work in a scientific information service involving abstracting and indexing—The Director, Commonwealth Bureau of Soils, Rothamsted Experimental Station, Harpenden, Herts.

SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER CHEMIST (with a first- or second-class honours degree in chemistry or equivalent) IN THE INSECTICIDE SECTION of the Pest Infestation Laboratory, D.S.I.R., Slough, Bucks, for work on contact insecticides for the control of stored-product insects—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.165/8A.

SENIOR TECHNICIAN (with considerable experience in histological and photographic techniques, together with experience in the general work of an anatomy department) IN THE ANATOMY DEPARTMENT—The Secretary, Guy's Hospital Medical School, London Bridge, S.E.1, quoting Ref. STA.

TECHNICIAN (preferably with experience in biochemical or microbiological techniques) to assist in research in the Biochemistry Laboratories—The Secretary, Institute of Dental Surgery (University of London), Eastman Dental Hospital, Gray's Inn Road, London, W.C.1.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Eton College Natural History Society. Twelfth Report, 1955–1957. Pp. 52. (Eton: Eton College Natural History Society, 1957.) 2*s.* 6*d.* [1612

Annual Report of the National Oceanographic Council, 1956–57. Pp. v+34. (Cambridge: At the University Press, 1957.) 5*s.* net. [1612

Federation of British Industries. The Training of Designers for Industry: Furniture, Pottery, Printing and Textiles. (A Report of a One-day Conference between Industrialists and Educationalists, London, 1957.) Pp. vii+50. (London: Federation of British Industries, 1957.) 3*s.* 6*d.* [1612

Scottish Marine Biological Association. Annual Report, 1956–57. Pp. ii+34. (Millport, Isle of Cumbrae: Scottish Marine Biological Association, 1957.) 4*s.* [1612

Government Administration in Wales: Text of a letter addressed by the Prime Minister to the Chairman of the Council for Wales and Monmouthshire. Pp. 7. (Cmnd. 334.) (London: H.M. Stationery Office, 1957.) 6*d.* net. [1612

Building Research Station Digest, No. 104 (November, 1957): Miscellany. Pp. 5. (London: H.M. Stationery Office, 1957.) 3*d.* [1612

Coal Tar Research Association. *Review of Coal Tar Technology*, Vol. 9, Part 1 (January–June, 1957.) Pp. 97. (Gomersal, Leeds: Coal Tar Research Association, 1957.) 10*s.* [1612

Other Countries

Carnegie Institution of Washington. Report of the President. Pp. 33. (Reprinted from *Carnegie Institution of Washington Year Book*, 56, for the year 1956–57.) (Washington, D.C.: Carnegie Institution of Washington, 1957.) [1612

Institut National pour l'Étude Agronomique du Congo Belge. Au Service de l'Agriculture Congolaise. Quatrième edition. Pp. 156. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1957.) [1612

United States Department of the Interior: Geological Survey. Bulletin 1019-G: Bibliography of Titanium Deposits of the World. By Robert Lawthers and Helen R. Mark. Pp. iii+543–608. 25 cents. Bulletin 1030-M: Description of Indicator Plants and Methods of Botanical Prospecting for Uranium Deposits on the Colorado Plateau. By Helen L. Cannon. Pp. iv+399–516. 50 cents. Bulletin 1042-K: Dismal Swamp Placer Deposit, Elmore County, Idaho. By Frank C. Armstrong. Pp. iii+383–392+plate 18. 15 cents. Bulletin 1059-C: Selected Annotated Bibliography of the Geology of the Sandstone-type Uranium Deposits of the United States. By Robert E. Melin. Pp. iii+59–176. 35 cents. Bulletin 1074-A: Mineralogic Classification of Uranium-Vanadium Deposits of the Colorado Plateau. By Theodore Botinelly and Alice D. Weeks. Pp. iii+5+plate 1. 40 cents. Water-Supply Paper 1320-B: Floods of May–June 1953 in Missouri River Basin in Montana. Prepared under the direction of J. V. B. Wells. Pp. vii+69–153+plates 3 and 4. 1 dollar. Water-Supply Paper 1377: Geology and Ground-Water Resources of Goshen County, Wyoming. By J. R. Rapp, F. N. Visher and R. T. Littleton. Pp. vi+145+4 plates. 1.75 dollars. Water-Supply Paper 1414: Water Resources of the Neuse River Basin, North Carolina. By G. A. Billingsley, R. E. Fish and R. G. Schipf. Pp. vii+89+3 plates. 35 cents. Water-Supply Paper 1418: Geology and Ground Water, Heart Mountain and Chapman Bench Divisions, Shoshone Irrigation Project, Wyoming. By Frank A. Swenson. Pp. iv+55+7 plates. n.p. Water-Supply Paper 1421: Geology and Ground-Water Resources of Outagamie County, Wisconsin. By E. F. LeRoux. Pp. iv+57. 1 dollar. (Washington, D.C.: Government Printing Office, 1957.) [1612

Conseil Permanent International pour l'Exploration de la Mer, Charlottenlund-Slot, Danemark. Fiches d'Identification du Zooplancton, Nos. 61–70. Rédigé par J. H. Fraser et G. Thorson. Pp. 54. (Copenhague: Andr. Fred Høst et Fils, 1957.) 15 Kr. [1612

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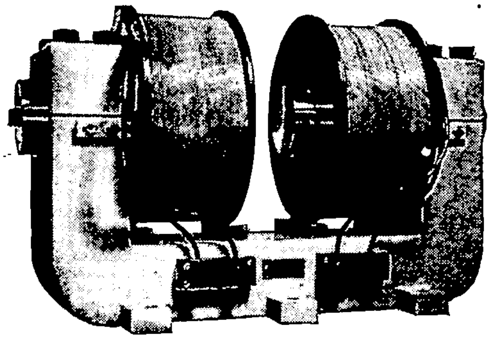

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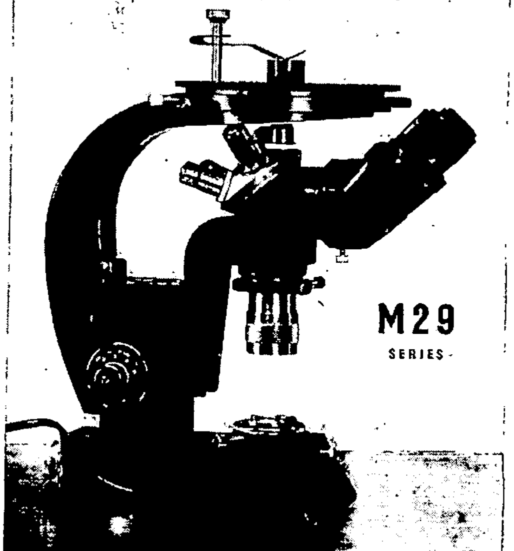

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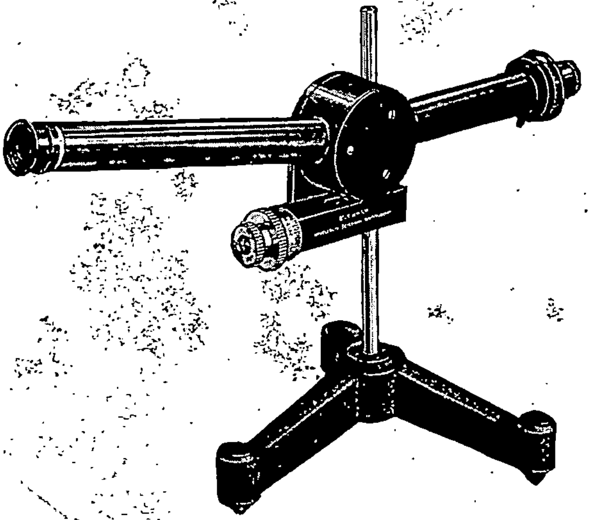

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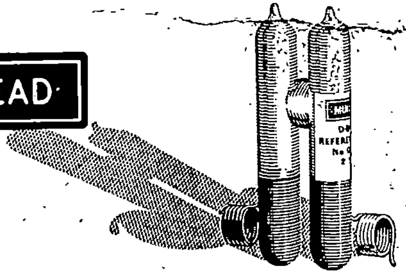

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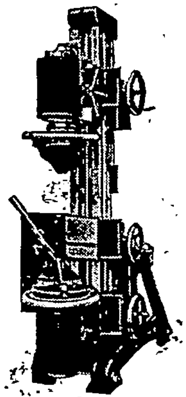

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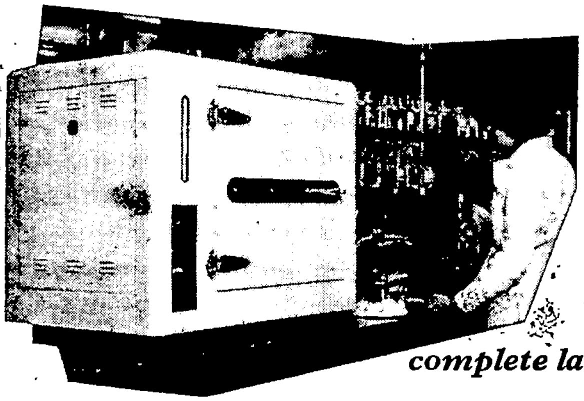

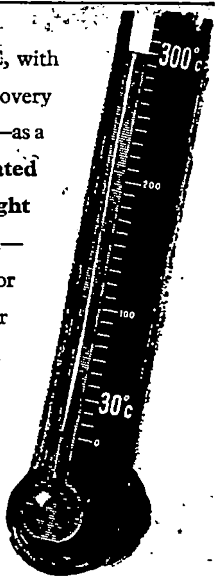

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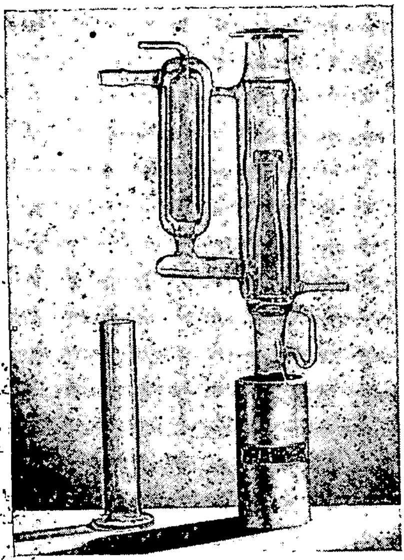

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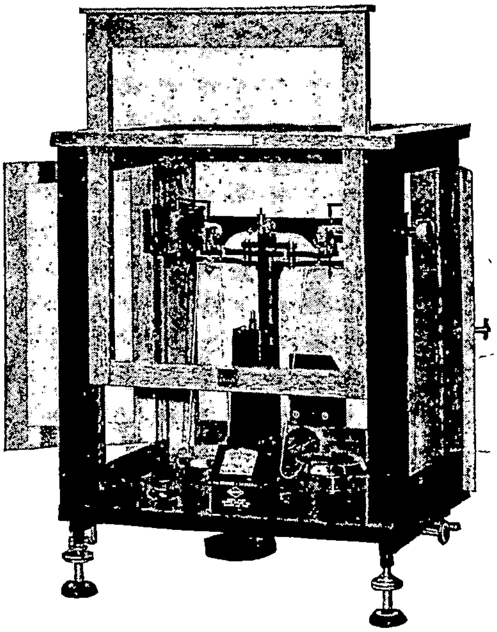

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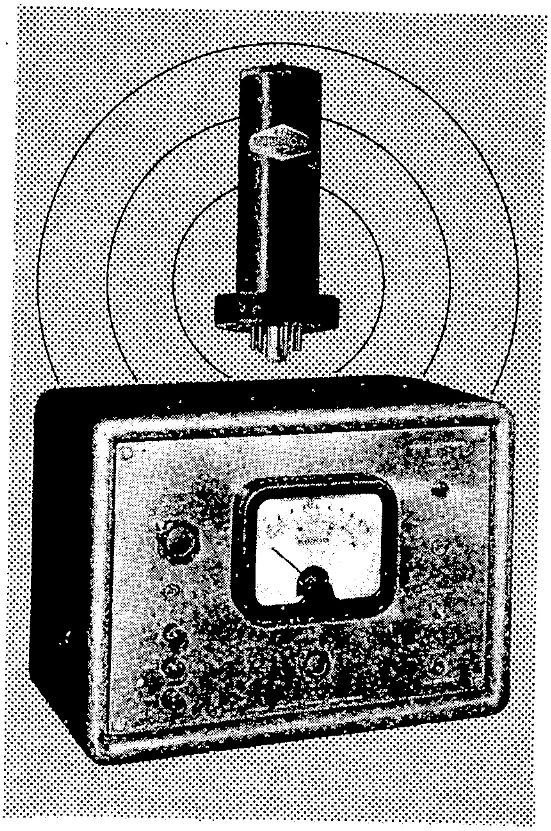

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THE COMPTROLLERSHIP OF THE PATENT OFFICE

"THAT a scientific office should have a scientific man at its head is a principle which seems obvious but needs to be constantly reasserted, because the administrative officials who influence such appointments are not always sympathetic towards the claims of science." These words are quoted from an editorial published in *Nature* thirty-three years ago, on February 27, 1925. It had become known that the Comptroller-General of the Patent Office was likely to retire and that an administrative officer, without legal or scientific qualifications, had been chosen to fill the vacancy when this should occur.

To-day the importance of applying scientific methods and results to public affairs is so generally accepted in industry and in many other fields that it has become a truism. Nobody would expect Imperial Chemical Industries, or the Atomic Energy Research Establishment at Harwell, or the National Physical Laboratory, to be under the direction of a man who had never worked in a laboratory. But fifty years ago the role of the scientist in administration was merely to supply information or advice to non-scientific administrators, who might or might not be capable of understanding it, and who certainly were ill-qualified to evaluate its significance in relation to policy. Even as late as 1925, however, it was necessary to refer, in the article quoted above, to a "tendency to regard a man of science as a mere adviser who is himself incapable of administrative work. Such an attitude is the more unjustifiable because of the fact that a scientific training is necessarily additional to some degree of education in the humanities, whereas a literary scholar may be quite ignorant of science; so that the former type of upbringing is the more likely to produce the breadth of outlook which is necessary in handling men and affairs". It was to further this point of view that the British Science Guild had been founded, and largely through its work the importance of according the scientist his proper place was acknowledged. Eventually, the British Science Guild, with its assets and functions, was absorbed into the British Association, and the latter began to pay increased attention to the social aspects of science.

But in 1925 the battle had not been won, and a deputation from the British Science Guild, led by Sir Richard Gregory, and including such men as Marconi, Sir Hugo Hirst and the first Lord Melchett, visited the President of the Board of Trade. The daily Press joined in, and after a strenuous battle common sense eventually triumphed. From that date until the beginning of this month, the Comptrollers of the Patent Office have been scientists with legal training and long experience of the intricacies of patent practice.

Meanwhile, the average invention has become immeasurably more technical than before, the rate of filing of complete specifications has increased by half, international negotiations relating to industrial property have become more intricate, the Second World War has left behind a number of problems demanding first-hand knowledge for their solution, and the competition of industry for the services of scientists has increased the need for handling the examining staff with understanding if they are not to be tempted to seek employment elsewhere. Yet successive Comptrollers have contrived to maintain, in the teeth of the most harassing difficulties, the services which the Patent Office renders to industry.

The qualifications needed by the Comptroller of the Patent Office arise partly from the fact that he has to handle a staff which is predominantly scientific and technical, and partly from the nature of the statutory duties laid upon him by the Patents Acts. As regard the first point, "it would be unreasonable", to quote once more from the editorial referred to above, "to subordinate the Examining Staff to the control of a man who is not qualified, by a scientific training similar to theirs, to understand the outlook and mentality with which such a training is associated". That is even more true to-day, for the staff must be able to feel full confidence in its leader if it is to carry out with the necessary zest the gruelling task which it is particularly engaged upon at the present time, namely, that of reducing the long delay in the granting of patents without reducing the quality of the examination, with a consequent increase in litigation.

As regards the Comptroller's statutory duties: his court is a court of first instance for certain classes of patent litigation, and though he delegates some of this work to his immediate subordinates on the examining staff, it has been usual (except in certain instances where bad health intervened) for him to take the most important hearings in person, and in any event to guide his staff on legal points. Comptrollers have also attended international conferences on industrial property in person, and acted as chairman in at least one instance. It is important that they should do so, and that they should be able to deal with the representatives of other countries on a footing of equality in the range of knowledge which comes from a scientific and legal background, with a foreground of experience of the highly specialized subject-matter with which such conferences have to deal.

For the past two years, negotiations have been in progress in relation to patents within the European Free-Trade Area, and they are now entering upon an acute stage. British interests are likely to be at a disadvantage if Germany succeeds in her strenuous efforts to have the Patent Office of the Area established under her tutelage.

We have just stated that the Comptrollers of the Patent Office have had the requisite professional qualifications "until the beginning of this month". It is no secret that the Board of Trade has been faced with a difficult establishment problem in that it has a redundancy of senior administrative officers for whom it has to find suitable posts. Such a post has been provided by the retirement through ill-health of the Comptroller-General of the Patent Office, which by historical accident is a department of the Board of Trade, and an appointment has been made; this has been done by way of surprise, before the action taken in 1925 could be repeated. *Nature* is, of course, in no way concerned with personal considerations; but it is concerned when a vitally important principle, for which it has always fought and which has come to be generally accepted in industry and in government departments of modern origin, has been violated by means of a *fait accompli*. To ask that what has been done should now be undone is to ask a great deal; but, on the other hand, a great deal is owed to the nation by way of reparation by a government department which has acted in such a way at a time when technological progress has become a matter of the utmost urgency in relation to the national interest.

The head of the Patent Office, if he be not a scientist and a lawyer with long experience of patent practice, cannot be more than a figure-head for subordinates who do possess those qualifications, and a figure-head cannot hope to discharge the duties of the office in a way which will give satisfaction. The Patent Office is a vitally important feature of the industrial world, and of international significance particularly at the present time. The appointment of a mere figure-head cannot but do disservice to the national interest.

IONOSPHERIC RESEARCH

Annals of the International Geophysical Year

Vol. 3, Part 1. Pp. xix+168. Vol. 3, Parts 2, 3 and 4. Pp. 169–381. Subscription per volume: 120*s.*; 17 dollars. (London and New York: Pergamon Press, 1957.)

AT this stage in the progress of the International Geophysical Year, which covers the period July 1, 1957, to December 31, 1958, the detailed programmes of observations are well in hand in all parts of the world. The results of these observations are being collected in an internationally agreed form at a number of world data centres, so that they may be available for scientific workers everywhere. Various discussions of these results and their analysis will undoubtedly occur from time to time in the course of normal scientific publications. In order to ensure that a co-ordinated central record of the whole proceedings of the International Geophysical Year is available for both present and future readers and students, it was decided, at an early stage in the discussions of the Special International Committee (C.S.A.G.I.), to publish a connected series of Annals of the International Geophysical Year. These are published by the Pergamon Press, Ltd., under the general editorship of Sir Harold Spencer Jones, assisted by an advisory board comprising international experts in the various disciplines involved.

The first two volumes of the series will deal, respectively, with the history of the events leading up to the present International Geophysical Year, and with the proceedings of the Special International Committee and its associate bodies. Vol. 3 is, however, the first to be published since it was produced originally in the form of a series of radio instruction manuals for those engaged in the study of the ionosphere. With the aid of the component sections of this volume, the detailed technique for sounding the ionosphere and presenting the results has been standardized together with the associated terminology. They are, moreover, much more than booklets of instruction and guidance. In its present published form, this volume forms a notable contribution to the somewhat sparse number of available books dealing with the ionosphere and various other radio phenomena, such as atmospherics, associated with the atmosphere.

Vol. 3 is divided into four parts, of which the first, entitled "Ionospheric Vertical Soundings", has been compiled by J. W. Wright and R. W. Knecht (U.S. National Bureau of Standards) and K. Davies (Radio Physics Laboratory, Ottawa), and edited by W. J. G. Beynon and G. M. Brown (University College of Swansea). An introduction covering the programme of the International Geophysical Year is followed by a chapter dealing with ionospheric physics, outlining the main characteristics of the ionosphere which are studied by radio techniques. There follow short descriptions of the fourteen types of ionosondes at present available; and practical instructions are given for adjusting the equipment to obtain the best results. The next chapter, on "Interpretation of Ionograms", provides detailed guidance on the evaluation of the ionospheric parameters from the photographic records, the great variety of which is illustrated by some fifty excellent photographs. Chapter 6, on "Reduction of Ionograms", is equally helpful and well illustrated, and it should prove invaluable to a newcomer to this complicated technique. A short chapter on the assessment of the quality of the data and a very brief list of references are followed by six appendixes which deal with programmes, interchange of data and suggestions for research at stations.

Part 2 deals with "The Measurement of Ionospheric Absorption" and has been compiled by a number of authors with considerable experience in this field: W. R. Piggott (Radio Research Station, Slough), W. J. G. Beynon and G. M. Brown (University College of Swansea) and C. G. Little (Geophysical Institute, College, Alaska). An account is given of the general theory of the absorption of radio-waves in the ionosphere, and of two methods of measurement; namely, the pulse reflexion method using ionosonde technique, and the other, developed particularly by radio-astronomers, using radio-waves of extra-terrestrial origin. As in the preceding part, the subject of nomenclature and presentation of results is dealt with in appendixes.

The third part is entitled "The Measurement of Ionospheric Drifts" and comprises separate contributions by B. H. Briggs (Cambridge), L. G. H. Huxley (Adelaide) and J. S. Greenhow (Manchester). The separate chapters deal with the measurement of ionospheric drift velocities by simultaneous fading records on three receivers, by observations on meteor reflexions, and by some other techniques available to ionospheric physicists and radio astronomers.

The contents of Part 4 conform with its heading, "Miscellaneous Radio Measurements", but some of these are not immediately obvious as coming under the general title of Vol. 3, "The Ionosphere".

Nevertheless, the six contributions form a very appropriate ancillary part of the volume and are certainly directly related to portions of the programme of the International Geophysical Year under active study at the present time. These individual papers are entitled: "The Measurement of Atmospheric Radio Noise", by F. Horner (Radio Research Station, Slough); "Whistlers and Dawn Chorus", by M. G. Morgan (Dartmouth College, Hanover, U.S.A.); "Radio Reflections from Aurorae", by A. C. B. Lovell (Manchester), P. A. Forsyth (Saskatchewan) and L. Harang (Auroral Observatory, Tromsö); "Apparatus for Radio-Echo Meteor Survey", by A. C. B. Lovell; "Ionospheric Forward Scatter", by K. L. Bowles (U.S. National Bureau of Standards); and "Ionospheric Back Scatter", by A. M. Peterson (Stanford University). All these sections form well-illustrated reviews, each with selected references which should prove useful for further study.

The publication of this volume (in two sections) shows that the work of preparation for the International Geophysical Year has successfully stimulated the production of a most useful addition to the scientific literature on the detailed characteristics of the ionosphere and related physical phenomena.

R. L. Smith-Rose

ÅNGSTRÖM RADIATION AS PHENOMENON AND AS TOOL

Handbuch der Physik

Herausgegeben von S. Flügge. Band 30: Röntgenstrahlen. Pp. vii+384. Band 32: Strukturforschung. Pp. vii+663. (Berlin: Springer-Verlag, 1957.) 88 and 144 D.M., respectively.

These books, though edited, printed and published in Germany, are largely written in English. In Vol. 30 only the first chapter, on the production of X-rays, by W. Schaaffs, is in German. The remaining chapters deal with experimental methods of X-ray spectroscopy at ordinary wave-lengths, by A. E. Sandström; experimental methods of soft X-ray spectroscopy and the valence-band spectra of the light elements, by D. H. Tomboulian; X-ray microscopy, by P. Kirkpatrick and H. H. Pattee; and the continuous X-ray spectrum, by S. T. Stephenson. Vol. 32 contains French contributions also; the chapters are on experimental methods for determining crystal structures by X-rays (in French) by A. Guinier and G. von Eller; on the theoretical principles of structural research by X-rays, by J. Bouman; on the study of the structure of liquids and amorphous substances by means of the diffusion of X-rays (also in French), by G. Fournet; on size of particles and lattice defects, by W. W. Beeman, P. Kaesberg, J. W. Anderegg and M. B. Webb; on electron diffraction (in German), by H. Raether; and lastly on neutron diffraction and interference, by G. R. Ringo. It is the last two chapters that necessitate 'Ångström radiation' instead of 'X-radiation' in the title of this review.

The names of the authors guarantee the quality and accuracy of the various chapters. Vol. 30 contains references up to 1956, but much of it has a curiously old-fashioned ring, as if it could have been written in the thirties without much difference. (The chapters on soft X-ray spectra and X-ray microscopy are clear exceptions.) In the field of emission spectra of medium wave-lengths, however, there are signs of a revival of interest. Sandström, in summing up the experimental results, states "These two effects [asymmetry and overlapping] raise the question of the definition of the wave-length of a line with a finite width. Usually the wave-length of the peak intensity is preferred as it is the one detail most easily identified. However, the centre of gravity of the area below the intensity distribution curve could also be chosen. . . . No X-ray wave-lengths have been determined with an accuracy better than ± 0·002 XU, which value has to be considered the ultimate limit of accuracy, systematic errors excluded. Some narrow lines in the region of medium wave-lengths excepted, the absolute value of the error certainly exceeds ± 0·004 XU. Considering the systematic errors, as well, errors 10 times as big are to be expected". The differences between peak and centre-of-gravity wave-lengths, and systematic errors of 4×10^{-5} A., are big enough to be disturbing in the type of counter diffractometry now being developed, and it is to be hoped that the needs of crystallographers will stimulate the spectroscopists, who are presumably better equipped for the undertaking, to push the systematic error into the next decimal place, and to produce reliable line profiles extending several half-widths on both sides of the peak.

I am a crystallographer, and I turned with some relief from the phenomenon to its applications. Guinier and von Eller's description of experimental techniques is characteristically lucid. Bouman manages to give the theory of almost everything from symmetry elements to intensity statistics, not excluding lattice distortion, in 140 pages. Fournet's chapter on amorphous states and that of Beeman *et al.* on small particles and lattice defects carry particular aspects of the theory considerably further, and supplement the experimental techniques on low-angle scattering. The chapters on diffraction of material particles contain much to fascinate the conventional X-ray worker.

The German and the English sections are indexed in both German and English in the two volumes. The French sections in Vol. 32, however, are indexed only in French, a fact that does not seem to be stated clearly anywhere, and was discovered empirically. There are copious references to the original papers by means of footnotes, and each chapter ends with a general bibliography. The bibliographical coverage seems very thorough; only two papers which I sought were not found mentioned in the expected places. There are no author indexes, so it could not be checked whether they appeared elsewhere. Altogether, these two volumes will be indispensable for the spectroscopist and the crystallographer, and each will learn much from the volume intended for the other.

A. J. C. Wilson

RADIATION PHYSICS IN MEDICINE

Radiological Physics

By M. E. J. Young. Pp. x+365. (London: H. K. Lewis and Co., Ltd., 1957.) 42*s.* net.

Medical practitioners specializing in radiodiagnosis or radiotherapy require an understanding of certain aspects of radiation physics of a relatively advanced nature. There are few suitable text-books on the subject for doctors preparing for their professional examinations, and thus a new work directed to their needs is welcome, particularly when it is as well written and presented as the volume under review. It should, moreover, be of value to a wider circle of readers, including new entrants to the field of medical physics.

After introductory chapters, the production of X-rays including those in the megavoltage region is considered in some detail, and is followed by an account of naturally occurring radioactive sources. There is one chapter on the interaction of X- and γ-rays with matter, while two are devoted mainly to methods of measurement of ionizing radiation but include discussion of the principles of dosimetry. A chapter on the physical principles of diagnostic radiography is followed by an account of the chemical and biological effects of radiation. The therapeutic uses of X- and γ-radiation are covered in some detail with examples of treatment planning. The production and medical applications of artificial radioisotopes are next described, and the final chapter deals with radiation hazards and protection. Each of the main chapters has a list of references and a selection of appropriate examination questions.

In general, the clarity and conciseness of expression are noteworthy, but the value of the book to students would be enhanced by more frequent use of cross-reference. The author has made allowance for differences in the mathematics and physics background of his readers by the use of small print for more advanced explanation, although this practice has not been followed entirely consistently.

Some misprints have been noted, such as the repeated use of 'Ce^{137}' when 'Cs^{137}' is intended and '8 mA' for '3 mA' in the fluoroscopy conditions in Table 9.01. One or two ambiguous or even erroneous statements have been overlooked, for example that X-ray pulses from a betatron have an interval of $\frac{3}{4}$ cycle, and it is unfortunate that the calculation on p. 199 relating to foreign-body localization is incorrect. These criticisms, however, relate to minor defects in a text-book that can be warmly recommended.

G. W. Reed

OCCUPATIONAL DISEASES

The Diseases of Occupations

By Donald Hunter. Second enlarged and revised edition. Pp. xvii+1100+16 plates. (London: English Universities Press, Ltd., 1957.) 105*s*. net.

DR. DONALD HUNTER is one of our most talented medical teachers, and few who have listened to his words can have failed to be impressed by his wide knowledge in the field of occupational medicine.

He has given us the benefit of his knowledge in a remarkable text-book, which, in its first edition, has already become the standard work on this subject in the British Isles. I venture to suggest that it should be read by all consultants, who will find it not only extremely entertaining but also a revelation of the wide variety of ways in which occupation can affect health.

In this second edition, eleven new illustrations have been added, making a total of 447, and certain additions and corrections have been made in the text, but the general layout and arrangement of the sections remain unchanged. The total number of pages is now 1,100 compared with 1,046 in the first edition. There are comprehensive bibliographies at the end of each chapter.

Several additions have been made to the first four chapters concerned with the history of the subject. These include sections on metal workers in Greek, Roman and Teutonic mythology, a description of Alexander Gordon's views on the cause of puerperal fever, the status of the lower middle classes, and the hey-day of the Lancashire cotton industry. There is a most useful and much-needed section on the importance of vital statistics and epidemiology, including the work of Dr. John Snow on cholera. Unfortunately there is no account of the present-day use of morbidity statistics in industry. This is a pity since so much has been done in recent years, particularly by such organizations as the London Transport Executive. A description of the value of this type of work would have been a welcome addition. There is no adequate account of the extremely valuable Occupational Mortality Supplement 1931 and the Supplement for 1951, based on a 1 per cent sample. There is a critical review of the findings of the Sadler Committee to inquire into the working conditions of children in factories. Due credit has now been given to the Perkins family of Leeds and their early discoveries in the dyestuffs industry.

These items are mentioned to indicate the vast field which has been covered in the historical section of the book.

The Factories Act 1948 is discussed, but unfortunately there is no mention of the fact that the examining surgeon is now called the appointed factory doctor.

There are new sections on the National Insurance Industrial Injuries Act, the work of the National Coal Board Medical Services and an excellent description of the workings of the Disabled Persons Employment Act. The value of health education in industry is given its due emphasis. In all the sections on toxicology one marvels at the wide knowledge of industrial processes possessed by the author; the section on lead poisoning is particularly informative and full of fascination even for a lay person. Additional information has been given concerning vanadium poisoning in relation to petroleum and to boiler cleaning. There are a few slight additions to the section on manganese poisoning.

There is a new section on cadmium poisoning in man and in experimental animals. The section on thallium poisoning is completely new. There is an excellent account of hazards in the iron and steel industry and a description of the Iron and Steel Foundries Regulations 1953. The new section on sewer men gives a graphic account of the hazards of this dangerous job and the cheerful disposition of those employed in it.

There is an up-to-date account of a nuclear power station and the dangers associated with it. In the next edition the public-health hazards might be discussed in more detail. In a book which is so comprehensive and which covers such a wide field it is almost inevitable that some minor items should be omitted.

Everyone concerned with the health of workers should have access to this book. Although it is written by a consulting physician primarily for medical men, parts of it could be read with profit and interest by any intelligent layman. I regard the price of £5 5*s*. as reasonable, providing very good value for money.

W. Hobson

ARCTIC AND ANTARCTIC

Arctic Research

The Current Status of Research and Some Immediate Problems in the North American Arctic and Subarctic. Edited by Diana Rowley. (Special publication No. 2 of the Arctic Institute of North America. Reprinted from *Arctic*, Vol. 7, Nos. 3 and 4.) Pp. 261. (Montreal: Arctic Institute of North America, 1955.) 3.50 dollars.

Arctic Frontiers

United States Explorations in the Far North. By Dr. John Edwards Caswell. Pp. xv+232+16 plates. (Norman, Oklahoma: University of Oklahoma Press, 1956.) 3.75 dollars.

Men against the Frozen North

By Ritchie Calder. Pp. 279+15 plates. (London: George Allen and Unwin, Ltd.; Toronto: Thomas Nelson and Sons (Canada), Ltd., 1957.) 16*s.* net.

Spring on an Arctic Island

By Katharine Scherman. Pp. xvi+331+12 plates. (London: Victor Gollancz, Ltd., 1956.) 18*s.* net.

THE higher latitudes, both north and south, in these days receive an amount and style of attention which is not altogether in accord with reality. Vestigial glamour, lack of perspective, research progress, public ignorance and polar beauty, are among the attitudes which characterize, with varying degrees of helpfulness, the arctic literature of to-day. The present four volumes under review are diverse in worth, style, and subject, and all will find grateful readers. But those readers will be distinctly varied in type and taste, some learned, others ignorant but eager to read if the fare is, as some would say, served in the contemporary manner. The first of these four volumes is an important work.

"Arctic Research" is a truly important compilation and reference book. Its twenty-six chapters, each with its list of references, are about equally divided between the physical, the biological and the social sciences. There is a most impressive list of field research projects sponsored by the Arctic Institute since its foundation.

This work was not intended to provide a complete picture of arctic research, not even of North American arctic research, at this date. That would have been a goal impossible of attainment. Rather was the attempt to define the present state of knowledge in a selected variety of fields where individuals of prominence are available to perform the task. The introduction is by the late Dr. R. C. Wallace, the executive director of the Arctic Institute from 1951 until his death in 1955. Dr. Wallace played a great and vigorous part in the continuing growth of this energetic joint Canadian and United States organization. But the brunt of the work, in the production of the volume and the assembling of the authors, is due to Mrs. Diana Rowley, the editor. Her task cannot have been easy: the result is admirable.

The chapters are naturally of varying quality, but in general it is distinctly high. Excessive verbosity, that intellectual disease of North America, has been fairly well controlled, though we are still presented with 'population enumeration' for 'census' and similar word wasters. The lists of references are not overloaded; indeed, in a few instances further references to the scientific literature of Europe might have been helpful.

Photographs are quite properly not numerous. There are four striking pictures of the retreat of the North Dawes glacier in Alaska between 1889 and 1950, a total of 6,500 feet.

This admirable volume may well be compared with "Problems of Polar Research" issued as Special Publication No. 7 of the American Geographical Society in 1928. That earlier work had a long and useful life, and so will "Arctic Research".

"Arctic Frontiers" describes the period of United States arctic explorations from 1850 to Peary's return from the attainment of the North Pole very nearly fifty years ago. As the author says, "This is the narrative, not of isolated adventures, but of a movement". This is an interesting and useful introductory record of what was afoot and when. The reader may well feel that he is perusing the competent précis of an extensive narrative; and that seems indeed to be so, the background work being the same author's study of "The Utilization of the Scientific Reports of the United States Arctic Expeditions 1850–1909".

"Men against the Frozen North" is a successor to the same author's two similarly titled books where our species is set as an adversary of deserts and jungles. This is not the place for detail. The author travelled very widely over the northern parts of the American continent, the Arctic Archipelago and Arctic Ocean. He did so in a very short time, and he is a scientific journalist of enthusiasm, discernment and repute. He knows full well that a large fraction of the population must be tempted to read by devices such as the use of direct speech and minor jokes, and that then information can be inserted like the filling of a sandwich. As *The Times* commented upon the on-stage disrobement of a revue star, "if you like that sort of thing; it is extremely well done".

"Spring on an Arctic Island" is by a woman author who spent six weeks in 1954 on Bylot Island off Northern Baffin Island in 73° north latitude. This is a simple, personal tale, well told by one to whom all was happy novelty. "Above all we got to know some Eskimos." There are some attractive photographs. G. C. L. BERTRAM

POISONOUS PLANTS

The Toxic Plants of Western Australia

By C. A. Gardner and H. W. Bennetts. Pp. xxx+253+52 coloured plates. (Perth: West Australian Newspapers, Ltd., 1956.) £(A)2 10*s.*

THE rich and varied flora of Western Australia, which has so many affinities with the flora of the Cape in South Africa, is noted for the number of highly ornamental or beautiful plants that it contains. Unfortunately, it contains also a large number of species known to be poisonous. These have been the cause of loss and anxiety to stock-owners since the days of the earliest settlers. A great deal of knowledge regarding these harmful plants has been accumulated in recent years, thanks largely to the investigations of the two authors of this book. They have now produced, in a most scholarly fashion, what is the first comprehensive work on the poisonous plants of Western Australia. Both authors are eminent in their respective fields—botanical and veterinary—and together they have formed an ideal partnership for work of this kind. It is to be hoped that the toxic plants in other parts of the world, particularly the less-developed countries, will be similarly dealt with.

The book has purposely been written in a manner that will enable pastoralists and farmers to recognize symptoms of poisoning and to identify the plants that may be responsible. It is well illustrated with coloured plates and line drawings. Each species is treated separately and a detailed description of it provided. This is followed by information on toxicity, symptoms and post-mortem appearances. An appendix lists the toxic plants likely to be found in each of the sixteen districts of Western Australia. Other appendixes give lists of the cyanogenetic plants and those known to cause photosensitivity, dermatitis and hay fever. As quite a number of the species dealt with occur in other parts of the world the book is likely to be of value in other countries.

F. N. Howes

WHEAT IN AUSTRALIA

The Wheat Industry in Australia

By Dr. A. R. Callaghan and Dr. A. J. Millington. Pp. viii+486. (Sydney and London: Angus and Robertson, Ltd., 1956.) 63*s*.

WHEAT is by far the most important crop in Australian agriculture, and next to wool it is the most valuable product. Australian wheat accounts for about 5 per cent of the world output, but its international significance is greater than this figure suggests, because Australia is one of the four major wheat-exporting countries. The history of wheat cultivation in Australia provides an excellent example of agricultural evolution; starting from an exhausting mono-culture on virgin land after clearing and burning the native vegetation, it was improved by the introduction of fallows and fertilizers, especially superphosphate, and more recently by diversified cropping and alternation with leguminous pasture, in an attempt to achieve stability of yield and to prevent soil erosion. The extensive cultivation of wheat with a minimum of man-power was made possible by the invention of special implements and machines adapted to local conditions. These are a few of the reasons that justify the publication of "the first comprehensive account of the Australian wheat industry".

This book is certainly comprehensive. It starts with a history of the establishment of agriculture in Australia, and its development up to the present. Some introductory chapters describe the climate and soils of the wheat lands, and discuss soil structure, plant nutrition and the use of fertilizers in general terms. There are a useful summary of Australian work on the effect of fallow and of leguminous crops on soil nitrogen, and an account of 'dry-farming', the benefits of which are shown to be due to conservation of nitrogen, not water, and to weed control. Variations in husbandry on the different soil types of the wheat belt, and possible future developments in cropping systems are discussed. There is a short general description of the morphological changes during growth of a wheat plant, not specifically related to Australian varieties or conditions. Later chapters deal with the improvement of wheat varieties by selection and breeding, wheat diseases, and the implements and machines used in wheat growing. The rest of the book, about a quarter of it, is concerned with non-agricultural topics, such as storage and marketing of grain, its conversion into flour and bread, and the economics of world trade in wheat. Some of these seem scarcely appropriate for a volume of the "Australian Agricultural and Livestock Series". The most conspicuous omission is the lack of any consideration of the quantitative physiology of growth of wheat plants, and the ecology of wheat crops that form the basis on which the wheat industry is built.

The book is lavishly illustrated with nearly 300 photographs, diagrams and graphs, but many of them have so little relevance to the theme, and others so nearly duplicate each other (for example, Figs. 140, 141 and 154) that they could have been omitted with little loss, and possibly some reduction in cost. It is full of factual information, clearly presented and critically discussed, and generally succeeds in its declared intention of giving "an overall appreciation of the industry and its problems"; but it could have been shorter, more selective, and more readable if the authors had written for a more restricted audience, and had not tried to meet the requirements of "the farmer, the specialist, the student and the general reader" all within the same volume.

D. J. Watson

COMMON LANDS

The Common Lands of Hampshire

By Dr. L. Ellis Tavener. Pp. vii+123+8 plates+7 maps. (Winchester: Hampshire County Council, 1957.) 21*s*.

WHEN the Royal Commission on Common Land began its work two years ago, the lack of accurate information on the status and distribution of common land in England and Wales was at once apparent. The official estimate of about 2,000,000 acres (of which 500,000 may be in Wales) was based on a return made so long ago as 1873, together with some later information on larger areas suitable for war-time reclamation. Only one county, Cambridge, had made a survey of commons as part of its planning survey. To remedy its own position, the Hampshire County Council commissioned Dr. L. E. Tavener, senior lecturer in geography in the University of Southampton, to carry out a factual study of common land in that county—excluding the New Forest, of which adequate details exist.

The county has published his findings in this handsome volume. Whereas he was provided with a provisional list of 90 commons covering 12,000 acres, he actually found at least 133 commons totalling nearly 17,000 acres, not including innumerable village greens of less than five acres which have not been listed.

A tabular analysis and succinct descriptions of commons by administrative areas are accompanied by a chapter on their soils, and a comparison of the maps in the folder shows clearly the close association of commons with coarse, hungry soils of the London and Hampshire Tertiary basins, and the western end of the Weald. Tavener's pioneer study is of far more than local interest. A careful glossary, an attempt to determine what is a common, an indication of sources of information—notably the enclosure awards—combine to make this an indispensable guide to others who, it is hoped, will take up the systematic study in other counties.

L. Dudley Stamp

Guided Missiles in War and Peace

By Nels A. Parson, jun. Pp. xii+161. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1956.) 28*s.* net.

THIS introductory study, by a member of the United States Army Ordnance Corps, attempts to show the impact of guided missiles on military operations and to describe the technical characteristics of the main classes of missile. The subject is treated at a technical level suitable for non-specialists; nevertheless the book gives a useful account of the basic principles of missile propulsion, aerodynamics and guidance, with clear diagrammatic illustrations. There is a strong tendency to advance the guided missile as the solution to almost every military problem of the future, although the need for specially trained man-power to operate and maintain the associated complex equipment is emphasized. Great importance is attached to the use of submarine-launched atomic missiles and to the provision of medium-range ballistic missiles for use by army commanders. Although, at the time the book was written, the speculations it contains on satellites and space travel may have seemed naïve, the last chapter on 'missiles of peace' has a topical ring in the light of recent events.

In general the book is typical of the spate of publications on missiles which have emanated from the United States in the past few years. For the inquiring layman, as for the soldier, sailor or airman, it gives a readable introduction to the subject, with a number of interesting photographs of American missiles and a summary review of the likely tactical and strategic uses of guided missiles.

Non-Stable Stars

Edited by George H. Herbig. (Symposium No. 3 of the International Astronomical Union.) Pp. viii+200. (Cambridge: At the University Press, 1957.) 30*s.* net.

THIS volume contains the talks given at a symposium of the General Assembly of the International Astronomical Union held in 1955 at Dublin. It is concerned mainly with stars which for one reason or another are thought to be unstable, or near instability, especially T Tauri stars, flare stars, novae, Wolf-Rayet stars, and eclipsing binaries.

Among the more interesting contributions are those on T Tauri stars, peculiar objects to which A. H. Joy first directed attention in 1945. They are dwarf stars, irregularly variable, with late-type spectra but showing emission lines, and associated closely with interstellar matter. At first their peculiarities were attributed solely to collision with gas clouds, but the association between stars and gas is now thought to be more than fortuitous. The general opinion is that these stars are young and, indeed, that we may be witnessing some stage in their formation. Another important paper is that by M. F. Walker, giving evidence for extremely rapid light variations in old novae, especially DQ Her, better known perhaps as Nova Herculis 1934. A. McKellar and R. M. Petrie give some valuable measures of spectrum line changes during ingress and egress in 31 Cyg, where a *B*5 star is eclipsed by a super-giant *K* star. The results show irregular structure and movement in the *K* star's atmosphere, giving us a decidedly more complicated picture than is usually contemplated in theory.

Much attention is given to ejection of matter by one component of an eclipsing binary and interception by the other. The opinion appears to be growing that some such mechanism is often operative, with a significant and possibly rapid effect on the evolution of the component stars. Z. Kopal reports some computations, based on a very simple model, to deduce the actual trajectories for gas particles from one star to the other. One may hope to see more work of this kind.

But valuable and interesting though these and other papers in this book may be, I have been left with a rather depressing suspicion that in this subject we have too many complications and too few significant facts, too much hopeful speculation and perhaps not enough hard thinking. We need new measurement techniques, deliberately designed to answer specific questions, and not merely for the purposeless collection of more data with which to confuse ourselves; and we need fresh theoretical ideas, rigorously worked out. If this symposium stimulates such developments it will have justified itself.

R. O. REDMAN

The Origins of Modern Science, 1300–1800

By Prof. H. Butterfield. New edition, revised and enlarged. Pp. x+242. (London: G. Bell and Sons, Ltd., 1957.) 16*s.* net.

IN view of its intrinsic value and the many appreciative reviews of the first edition, including that in *Nature* (165, 333; 1950), it is very fitting that "The Origins of Modern Science", published in 1949 and reprinted in 1950 and 1951, should now appear in a revised and enlarged form. Referring to the lectures which he delivered for the History of Science Committee in Cambridge in 1948, Prof. H. Butterfield writes, "In this revised edition they appear now with some of their original errors removed, some judgments altered, and some changes which reflect the advance of knowledge in the intervening years".

Thus, although this book retains its general plan, its value is enhanced by the author's considered judgment, which finds expression in revision and expansion, here and there, of the various chapters. A summary of the importance of the 'theory of impetus'; an appreciation of the contribution to modern science of fifteenth-century art; a discussion of the notion, brought to a climax in the eighteenth century, of 'the Great Chain of Being', are examples. Not least in value are the suggestions for further reading, which have also been brought up to date.

This new edition is specially welcome in a world which is still in need of the historian's as well as the scientist's point of view.

H. D. ANTHONY

Pioneer of Sociology

The Life and Letters of Patrick Geddes. By Philip Mairet. Pp. xx+226. (London: Lund Humphries and Co., Ltd., 1957.) 21*s.* net.

TO convey a vivid and accurate impression of a personality so dynamic and many-sided as that of Patrick Geddes is no easy task, and though the thirty-odd letters Mr. Mairet allows himself in his two hundred or so pages appear to be well chosen and representative, they are scanty measure for the task. None the less, the book is well balanced and gives a clearer and more continuous picture of Geddes' whole life and work than Mr. Broadman's earlier book. In his final chapter Mr. Mairet attempts a brief but admirable appreciation of the significance of Geddes' work, and it is here in its exposition of the contribution which Geddes' work and thought has made to the problems of to-day that the great merit of this book is to be found. Not simply in town and country planning, in the community centre and in like fields of sociology, but on a host of educational issues such as the multi-racial university (as Sir William Holford notes in his foreword), the functions and work of a university, the fragmentation of knowledge, halls of residence and technical assistance, Geddes had stimulating and sensible ideas, the reference of which in the context of to-day is apparent from Mr. Mairet's exposition. It is the more unfortunate, therefore, that the book is robbed of its full value by the omission to supply those bibliographical details which would enable the reader when interest is aroused to turn to Geddes' own writings and study for himself the implications of his thought. The book is also marred by some careless writing, inaccuracies of description, for example of the Committee of Intellectual Co-operation, and the index is erratic and might well be more complete. R. Brightman

Tree Injuries

Their Causes and Their Prevention. By H. L. Edlin and M. Nimmo. Pp. v+167. (London and New York: Thames and Hudson, Ltd., 1956.) 21*s*. net.

THE post-war boom in horticultural societies has had its parallel in a marked revival of interest in arboriculture, and for this type of reader the book under review can be strongly recommended. It is eminently readable, the information provided is thoroughly reliable and, above all, the 125 photographs provided are fascinating. With the text these should provide a means of recognizing and explaining all the common, and some uncommon, forms of damage and abnormality likely to be seen about the country, and should also serve as a warning of the harm that may be caused inadvertently by man. Some people may find life the duller for the sensible answer given to the perennial question as to what damage is done to a tree by ivy, but they may perhaps find compensation in becoming knowledgeable about many more recondite problems. It may be pedantic to quarrel with the classification of old age, coppicing, spiral grain, etc., as 'injuries', particularly as the book would be much the poorer for their omission, but this leads to a misleading impression that 'prevention', as mentioned in the title, is not very adequately covered. In fact, such measures as are possible for the prevention of diseases and defects are given with commendable brevity and practical sense.

More than seventy types of 'injury' are described, and these are grouped conveniently according to causes, such as climate, man, mammals and birds, insects, climbing and parasitic plants, fungi and old age, with a chapter on deformities and curiosities. A useful bibliography of about forty articles and books is included. L. Chalk

Insect Life in the Tropics

By T. W. Kirkpatrick. Pp. xiv+311. (London and New York: Longmans, Green and Co., Ltd., 1957.) 35*s*. net.

THIS book may reasonably be likened to a small text-book on entomology in which particular point is made of selecting from tropical forms of insect-life examples to illustrate principles in insect biology and behaviour. The author draws largely from his own experiences and observations in East Africa, Trinidad, Egypt and the Sudan. It is written primarily for the layman but contains so much information about different sorts of insects that it is likely to be helpful and of interest to the entomologist curious about insects beyond his speciality. The opening chapter considers briefly the nature of climates in the tropics. Two further chapters deal with the essentials of insect structure (mainly external), with some special reference to sensory organs, and the classification of insects to the level of orders. This is done in sufficient detail to satisfy the layman's aspirations to approach his hobby scientifically. The remainder of the book presents its subject from a biological point of view. Thus, the chapters are on the way insects develop, reproductive mechanisms, food and feeding habits, locomotion, defence and protection, insect social communities and the architecture of insect nests and termitaria. The book is well illustrated with 146 line drawings and photographs, well produced, and of a convenient size for travel.

Heat and Thermodynamics

An Intermediate Textbook for Students of Physics, Chemistry, and Engineering. By Prof. Mark W. Zemansky. Fourth Edition. Pp. xi+484. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 56*s*. 6*d*.

AMONG the present glut of thermodynamical texts, Prof. M. W. Zemansky's book, in a refurbished edition, is still well among the best. It is, the author writes, aimed at physicists, chemists and engineers, but in fact it is most suited to the needs of physicists. It adheres rigidly to the classical approach, eschewing statistical mechanics and quantum theory, although certain facts have to be quoted from these subjects. This restriction does not prevent the author from discussing some of the most recent advances, notably in low-temperature physics. This topic, Zemansky's own speciality, occupies a new and extensive chapter which forms an excellent survey of the field but tends to spoil the balance of the book. Perhaps this will be redressed in a fifth edition with an equally long chapter on the increasingly fashionable problems of high-temperature plasma, undoubtedly of great thermodynamic interest. Ionized gas is studied briefly in the chapter on gas reactions. The concluding chapters on chemical thermodynamics and the phase rule, though very clear, are markedly more theoretical in approach than the physical chapters, which abound in experimental detail. The sections with relevance to engineering are probably the weakest, and the section on heat transfer is necessarily so brief as to be scarcely worth while. A greater emphasis on flow processes is desirable in a thermodynamical text-book for engineers.

The examples at the end of each chapter have been extended and improved. One's only criticism is that many are exercises in mathematics rather than applied physics.

Besides the discussion of low-temperature physics already mentioned, there are several new features in this edition. The faulty Kelvin treatment of the thermocouple has been superseded by the theory of coupled irreversible flows. The relation between information and entropy is touched on with tantalizing brevity. That the book should be so capable of continued development is testimony to the soundness of the original structure.

J. A. Shercliff

THE LONDON PLANETARIUM

By Dr. H. C. KING
Lecturer-in-Charge

H.R.H. the Duke of Edinburgh will be present at the initial lecture or presentation to be held at the new London Planetarium on March 19. After this inauguration the Planetarium will be opening its doors to the general public and offering as many as thirty-five presentations a week, each presentation lasting forty minutes.

The London Planetarium (Fig. 1) is the thirty-third Zeiss planetarium and the first large-scale project of its type in the British Commonwealth. The first was set up in 1924 on the roof of the Zeiss works at Jena, where in eighteen months some 80,000 visitors viewed the artificial heavens. The instrument was thereafter operated at the Deutsches Museum, Munich, and a second projector, later moved to the Haagsche Courant at The Hague, took its place. By 1928 Zeiss had installed twelve planetarium projectors at important sites in Germany and Austria. Rome had one in 1928 and Moscow followed suit in 1929: according to a recent report 20,000,000 visitors have so far visited the Moscow centre project. The first American planetarium, the Adler Planetarium, Chicago, was opened in May 1930. Its success was such that others appeared at Philadelphia (1933), Los Angeles and New York (1935), Pittsburgh (1939) and Chapel Hill, North Carolina (1949). During the 1930's Zeiss planetaria were also built at Stockholm, Milan, Osaka and Tokyo.

The instrument for London is one of a new series made at the Zeiss works at Oberkochen, Western Germany. As such, it is of the type recently assembled in São Paulo and Hamburg. Previously, only the brightest star, Sirius, had been reproduced by a special optical projector; but this system has now been extended and applied to all stars down to those of the second magnitude by the introduction of forty-two special projectors fitted to the main dumb-bell assembly (Fig. 2). Furthermore, the 32 star diapositives, which contain some 8,900 remaining stars and various nebulæ and star clusters, are no longer made of perforated copper foil but are produced by photo-chemical means on scratch-proof plates. New speeds of three and twelve minutes have been introduced into both the diurnal and annual movements, and the Moon projector has been improved to show a brighter Moon with characteristic maculæ.

The building can be likened to a large hollow mushroom having an outer skin of copper-covered concrete, and an inner dome of aluminium alloy. The domes both rest on a circular floor of reinforced concrete 24 in. thick, which in turn is supported by twelve columns. These columns are placed 11 ft. back from the perimeter and act as fulcra so that the mass of the concrete floor inside the circle of columns balances the cantilever plus the weight of the entire dome structure. The thrust downwards to the ground floor amounts to 145 tons per column, and this in turn is taken up by four piles to each column. The piles are 45 ft. long and have their tops 10 ft. below road-level.

The Metropolitan Railway runs along Marylebone Road at approximately 30 ft. from the edge of the building and the crown of the tunnel is some 6 ft. below road-level. Vibration from this source is so heavy that its effects can be heard in the present basement of Madame Tussaud's—some 150 ft. back. Moreover, the direction of the railway changes at the new building and curves away into Baker Street Station; as the trains slow down their wheels lock over to

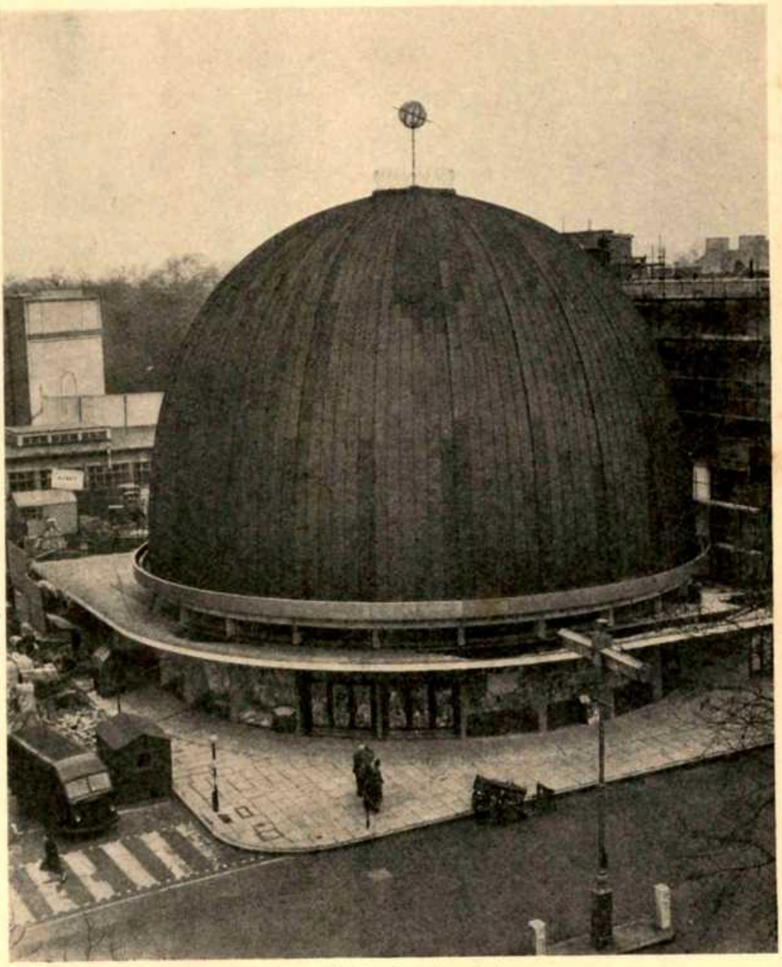

Fig. 1. The London Planetarium

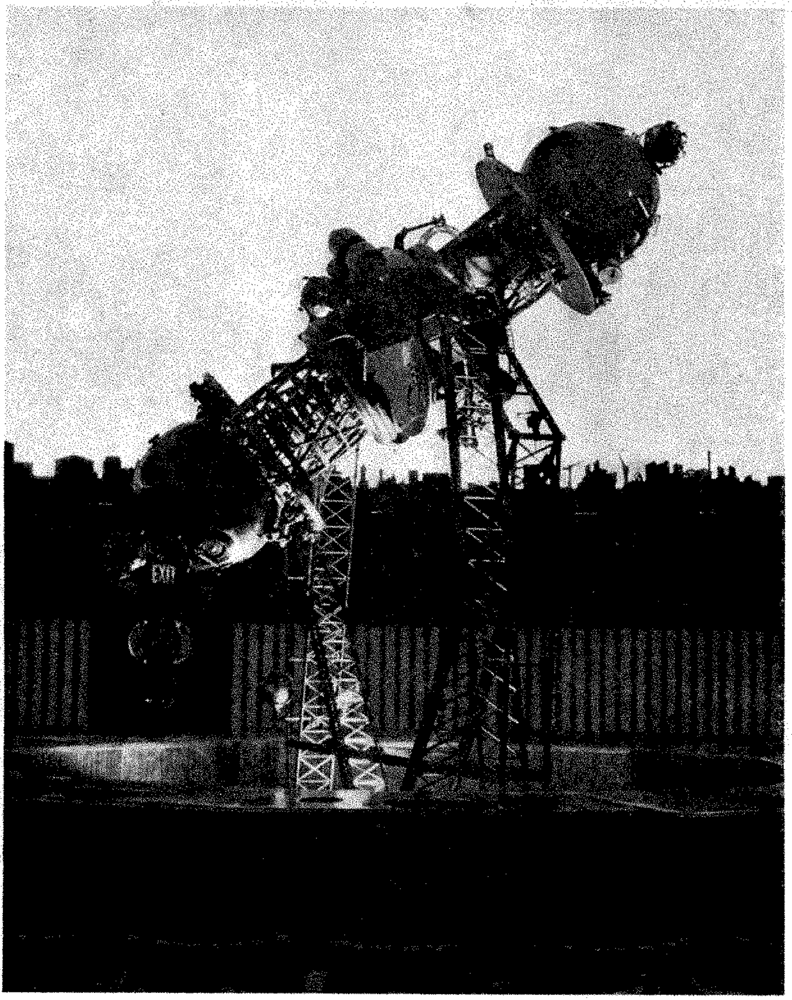

Fig. 2. The Zeiss dumb-bell projector

cause heavy reverberation. It was therefore decided that only weight would overcome ground vibration, and the engineers designed heavy concrete beams on a spider's web pattern. These beams connect up all the pile caps at 10 ft. below road surface and are topped off with an 18-in. thick concrete floor at ground-level. This scheme has proved highly successful. Not only is the floor of the auditorium free from transmitted vibration but also the sound of trains passing beneath is barely perceptible when the auditorium is empty.

In all other planetaria the central projector assembly is permanently mounted at the centre of the auditorium. At London, however, this assembly is carried by a vertical lift mechanism installed by Knight Construction, Ltd. When a lecture is not in progress, the instrument can be seen by the public in the brightly-lit foyer directly beneath the auditorium. In this 'down' position it is protected by a glass cage surround and a large overhead roller-blind. The sequence controls for the operation of the lift, lift blinds and lighting are at the lecturer's console near the northern face of the auditorium.

The auditorium has a seating capacity of 550 and can be given as many as eight changes of air every hour. Good optical projection makes it essential to enforce a 'No Smoking' ban and to filter the greater part of the incoming air. The projection dome, 67 ft. in diameter, is constructed of 16-gauge half-hard aluminium-alloy sheets formed with butt joints and screws to sixteen aluminium ribs. These ribs are held in position by two tubular tension rings and an upper aluminium saucer, and are bolted and insulated to a steel substructure at the bottom. To prevent echoes and reverberation, the sheets are perforated with holes 0·08 in. in diameter at a density of 20 per square inch and backed by a thick blanket of 'Rocksil'. These holes in no way prevent the audience from seeing even the smallest star images.

In most planetaria the blackness of the darkened projection dome can be relieved by a faint blue radiance provided by two special lamps fixed to the top members of the dumb-bell supports. In the London Planetarium this quite realistic auroral glow can be heightened by operating further lights concealed in the dais which surrounds the instrument, and by introducing blue and green 'effects lights' from behind the skyline. The effects lighting is carried out in three rings of cold-cathode tubes in red, green and blue (all concealed behind the plywood cut-out of the London skyline), and is controlled from the lecturer's console. The red lighting is used for special sunrise and sunset effects, and can be faded in or out together with or separate from the blue and green lights.

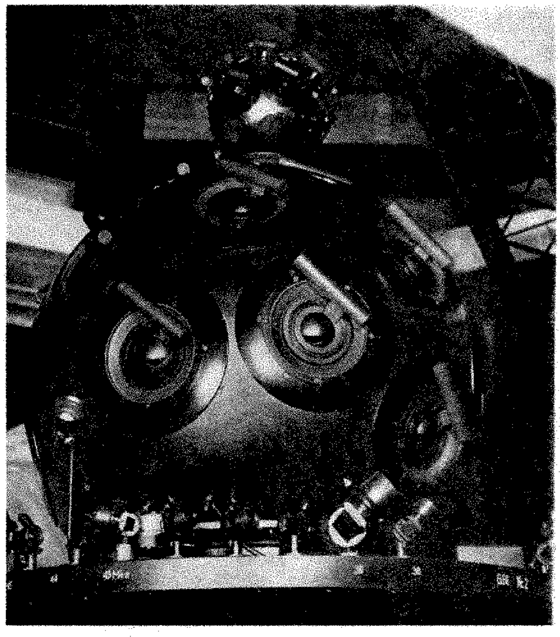

Fig. 3. Southern star globe and small globe for constellation names

Although the London Planetarium is owned by Madame Tussaud's, Ltd., it will operate as a separate entity from the Waxworks Exhibition. So far as the public is concerned, there will be no connexion between the two. It is also the first planetarium to be financed by and operated through private enterprise. As such, its presentations are designed to have the widest popular appeal and are not restricted to special times on just one or two days of the week.

The presentations will be at once entertaining and yet restricted to the facts and findings of astronomy. Each and every aspect of astronomy that the Zeiss equipment can cover will be treated with integrity and in proper context and sequence. The public, as B. J. Bok has remarked, will soon lose interest in presentations of scientific results if the fundamentals of scientific honesty are not strictly observed. School parties will be specially catered for in the morning and early afternoon presentations. Lectures on more advanced aspects of astronomy and courses of lectures on the fundamentals of practical astronomy and astro-navigation will undoubtedly follow in due course. How soon the normal programme can be extended into these most attractive fields will depend largely on the demand. For a year, at least, and until all the necessary technical staff is appointed, the operation of the basic programme with its monthly changes will receive priority.

The Planetarium has its own bookstall, and in addition to souvenir-brochures and booklets will later publish star-guides and low-priced books on elementary astronomy. The foyer will also contain display material arranged to interest the public in the findings of modern astronomy. When the new office block at the rear of the site is completed, the Planetarium will be able to offer an information service on matters astronomical to Press and public alike. It will by then have its own library and reference room, and also the necessary staff to deal with the anticipated heavy correspondence.

THE BRITISH NUCLEAR ENERGY CONFERENCE

SYMPOSIUM ON NUCLEAR ENERGY

SEVERAL chemical engineering aspects of atomic energy were discussed at the British Nuclear Energy Conference Symposium on Nuclear Energy which was held on January 21 in London. The symposium was sponsored by the Institution of Chemical Engineers, and the topics ranged from the problems which are involved when a nuclear power station of the Calder Hall type is started up, to the computation of the performance of solvent extraction columns which are used in purification processes for partially burnt nuclear fuel.

Sir John Cockcroft, as chairman of the Conference, opened the symposium, after which the chair for the morning session was taken by Mr. A. S. White (Atomic Energy Research Establishment, Harwell). Mr. H. G. Davey (United Kingdom Atomic Energy Authority, Windscale) presented the first paper on the "Commissioning and Operation of 'A' Station, Calder Works". Only a short time was available for commissioning the first of the two reactors in 'A' Station, and experimental measurements were restricted to those which would provide essential data. These included making measurements to determine the critical size and to find the optimum number and disposition of control rods required in the fully loaded reactor. These data were substantially supplemented by a more detailed experimental programme during the commissioning of the second reactor.

A cylindrical loading pattern was used, and the critical mass found to be the equivalent of 406 channels as compared with the predicted 475 channels, the difference being almost within the estimated error. A value of $k_{\text{eff.}} = 1{\cdot}0547$ was derived from experimental measurements, compared with the design figure of 1·042. The 48 control rods were calibrated by taking advantage of the closed pressurized cooling circuit to maintain the reactor in a critical condition, by adjusting the air pressure within the pressure vessel.

To ensure successful operation of the plant, it was necessary to test the coolant gas flow-rates through individual fuel channels, the gas leakage, the blowers, the gas circuit and the burst cartridge detection gear. Mr. Davey went on to discuss the work-up to power on August 1, 1956, and the approach to the maximum cartridge temperature of 375° C. on August 27, when the first turbine set was synchronized and loaded up. The second set was commissioned a week later and an electrical load of about 28 MW. was achieved with a reactor heat output of 136 MW. Steady conditions were maintained during September and early October and the official opening by H.M. the Queen was held on October 17, 1956, with the same operating conditions. A deliberate shut-down took place on November 15 and various modifications were made. Afterwards, near design conditions were obtained with an electrical output of 42 MW. at a heat output of 180 MW., with a maximum cartridge temperature of 408° C. The power output was eventually increased to 200 MW. heat in late August 1957. Mr. Davey gave sufficient information to demonstrate that Calder 'A' Station was not difficult to commission and, in fact, most of the teething troubles arose on the more conventional items of equipment.

In his paper on the "Development of the Butex Process for the Industrial Separation of Plutonium from Nuclear Reactor Fuels", Mr. C. M. Nicholls (Harwell) described the work which had been done in the Chalk River Laboratories prior to building the Windscale plant. Development of the Butex (diethylene glycol dibutyl ether) process, which was begun by a chemical team, was continued until proved by pilot-plant operation. The preferred process is one in which the fission products are eliminated by an early stage in a stream which is practically free from dissolved salts. Column studies were carried out, using uranyl nitrate, to study mechanical design details of solvent extraction columns, to provide information on the extraction performance of columns and to check the flow-sheet so far as possible. Some of these studies were repeated, using uranyl nitrate solutions containing trace quantities of plutonium.

The design of the radioactive pilot plant was largely governed by: (*a*) the limitations imposed by the radioactive and toxic nature of the materials handled; (*b*) the novelty of the process; (*c*) the need for versatility in the plant; (*d*) the urgency of the situation; and (*e*) the limited staff and laboratory facilities and restricted space. Mr. Nicholls discussed the effects of these conditions and outlined the form of the plant and flow-sheets. Typical extraction results were given, but it was stressed that the main object of the operations was not to obtain the best overall plant performance but to study the extraction at each stage of the process and to obtain results which could give information for the design of a production plant. The development of production-scale equipment was undertaken by a team from Imperial Chemical Industries, Ltd. The value of the help and consideration given to the United Kingdom team by the Canadians at Chalk River was emphasized by Mr. Nicholls.

In discussing this paper, Mr. Davey described the process development as a remarkable piece of work and emphasized the similarity of both plant and flow-sheets with the present Windscale plant. The salt-free highly radioactive effluent was a feature of great importance, since it enabled the volume of the highly radioactive stream to be reduced 40–50-fold by evaporation before storage. The use of simple types of column had contributed to trouble-free operation, and Mr. Davey said that he was not so enthusiastic about suggested departures to other types of equipment which may lead to more efficient extraction but also to more trouble in operation.

Dr. E. Lofthouse (Imperial Chemical Industries, Widnes), as a member of the Imperial Chemical Industries team which had assisted in the development of the Butex process, pointed out the importance of finding, at Chalk River, that the plutonium extraction was at least as efficient as that of uranium, and this greatly aided the scaling-up work.

"Fission Product Disposal" was discussed by K. Saddington (Windscale). As an inevitable consequence of the operation of nuclear reactors, significant amounts of fission products are formed. The problem of the disposal of unwanted radioactive products will increase with increasing utilization of nuclear power. The problem is finally solved only by complete natural radioactive decay, but this process will take hundreds of years. The alternative methods of tackling the intermediate problem are: (*a*) complete containment (safe storage); and (*b*) dispersion in such a way that, by natural or other causes, the waste is greatly diluted. At Windscale, the highly active waste is concentrated by evaporation prior to storage. Evaporation raises issues of nitric acid removal, and destruction by the addition of formaldehyde may be used as well as steam or vacuum evaporation. The separation of specific fission products from this waste may provide useful radiation sources (cæsium-137 and strontium-90), but the residual solution must still be stored for lengthy periods, since it also contains long-lived alpha-emitting isotopes. Both American and British developments in dealing with highly active effluents were described. They included cation exchange on montmorillonite clays and fused salt calcination.

Medium active liquors may be treated by alumina floc adsorption (as at Windscale) or by alternative coprecipitation processes. After flocculation with alumina, 92–95 per cent of the total β–γ activity and 98 per cent of the trace plutonium are removed. The filtrate is monitored and discharged to sea. American practices include direct ground disposal using the ion-exchange properties of the latter. The small geographical area and dense population of Great Britain probably exclude such methods in this country. Low-active effluent may be discharged directly, or discharge may follow chemical pretreatment. The problem is the same in all cases, to discharge the liquors at such a rate and to a pattern which is defined so as to safeguard the public health and convenience in the widest sense.

Dr. E. Glueckauf (Harwell) discussed alternative methods of nitric acid destruction or removal such as electro-deionization methods. He described work being done at Harwell to fix fission products in the form of insoluble glasses from which the activity could not be released. Mr. Grover (Harwell) mentioned that pilot-plant work was being done in the Chemical Engineering Division at Harwell to convert fission products to glasses.

Sir Hugh Beaver was chairman of the afternoon session. The first paper, on "Nuclear Criticality in Chemical Plants", was preceded by a film entitled "Criticality". This described aspects of process plant criticality in terms which could be understood by plant personnel having little scientific training. Dr. A. H. Gillieson (United Kingdom Atomic Energy Authority, Risley) then presented the paper by himself and Mr. Nicholls. A criticality accident with fissile materials could lead to hazards to plant operators and damage to the plant. Dr. Gillieson briefly reviewed the relevant neutron physics and discussed methods for the safe design of geometrically simple, isolated solution systems. This can be achieved by limitation of the mass, volume or concentration of fissile material in solution or, preferably, by selection of the shape of plant. Geometrically complex systems and the influence on safety of choice of process and plant operation were briefly discussed.

A welcome speaker was Monsieur R. Galley (Commissariat à l'Energie Atomique, Paris), who read his paper on the "Marcoule Plutonium Plant". M. Galley gave a well-illustrated account of the plant, which is based on a tributyl phosphate extraction process. He included interesting details of plant construction, operation, analytical facilities and control, and allied problems of effluent disposal, etc.

"Fuel Processing in Homogeneous Aqueous Reactors", by Mr. I. Wells (Harwell) and Dr. E. Lofthouse, was presented by Mr. Wells. He summarized the relevant features of this type of reactor and discussed the special processing problems involved. It is necessary to keep to a minimum the wasteful absorption of neutrons in order that more fissile material is produced than is burnt (that is, for 'breeding' to be possible). This, and the need for chemical and radiation stability, limits the number of chemical compounds suitable as fissile and fertile materials. Mr. Wells described gas–liquid processing to remove volatile fission products, and solid–liquid separations by cyclones to remove precipitated fission product compounds. Alternative methods of chemical processing include solvent extraction and uranium peroxide precipitation. Mr. Wells concluded that it will be some time before such reactors are applied commercially, since many problems still have to be overcome, for example, the containment of fluids, the handling of slurries and the maintenance of equipment in high-radiation fields.

The final paper in the symposium, on the "Computation of the Performance of a Multicomponent Solvent Extraction System" by Dr. J. T. Wood (Risley) and Mr. J. A. Williams (Windscale), was read by Mr. Williams. He showed how established methods of graphical calculation for immiscible phases may be applied to a complex multicomponent solvent extraction system such as the first extractor of a tributyl phosphate process for irradiated uranium. Partition coefficients for the main components were presented and Mr. Williams demonstrated their use in the calculation of extractor performance. Typical results were illustrated, and the choice of operating conditions, as determined by the behaviour of individual components, was discussed. In conclusion, Mr. Williams pointed out that while the broad outlines of a process can be calculated by the means described it must be emphasized that a reliable prediction of performance can only be made when all the partition data required are available. In some cases (for example, plutonium and ruthenium) it may be necessary to consider kinetic as well as partition effects, and it is more satisfactory to obtain detailed knowledge by experiment under conditions closely approximating, with respect to time of residence and flow ratios, to those of the plant.

F. S. Martin

RUDOLF DIESEL, 1858-1913

By E. J. HOLMGREN

At present the world is passing through a great phase of scientific discovery that commenced with the end of the Second World War. Mankind has seen such periodic surges of scientific achievement before, at which times remarkable discoveries and developments take place that have profound effects upon the subsequent achievements of man. Just such an upsurge occurred in the closing decades of the nineteenth century and the opening years of the twentieth—years which we associate with such names as Parsons, Nobel, Edison, Fleming and many others. It was an age of great scientific pride and perhaps one of the most notable advances (and certainly one that has in recent years seen spectacular changes) was the advent of the compression-ignition engine as a prime mover with its notable promoter, Rudolf Diesel.

Diesel was born in Paris on March 18, 1858, of Bavarian parents. He spent most of his early years in that city, but on the outbreak of the Franco-Prussian War his family's fortunes were ruined and he was sent to England to school in 1870. Later that year he was sent to Augsburg, where he studied at the Technical School, and in 1880 he graduated from the Technical University with record marks. His one ambition was to become an engineer, and after graduating he worked for Prof. von Linde on the development of machinery for liquefying air.

This was the era in which the reciprocating steam engine reached its greatest development ; the steam turbine had yet to appear. Diesel, however, as he worked both in the university and with von Linde, was not satisfied with the steam engine. Not only was it inefficient but also the cost per unit of power was much higher for the smaller than for the larger engines, so that it was an economical proposition only in the larger units.

During his undergraduate years Diesel had first become interested in the Carnot cycle of the theoretically perfect steam engine. He realized that this cycle must be applied in some way to provide a prime mover which did away with the faults of the steam engine. At first he designed an engine to run on ammonia gas in a manner similar to that of the steam engine, but while this was not satisfactory, mainly because of leakage of the gas, it demonstrated that a small economical engine was a possibility.

As a result of his experiments with the ammonia engine, Diesel came to four conclusions : (1) the idea of an engine on the pattern of a steam engine had to be discarded ; (2) combustion of the fuel must be in the cylinder of the engine and not in a boiler ; (3) air must be used as a working medium instead of steam ; (4) high compression is necessary in order that the Carnot cycle be realized. It should be noted in passing that the concept of the compression-ignition engine was not new. In 1896 Charles Arkroyd Stuart had taken out his first patent, and had conceived the idea of fuel injection with compressed air, using a hot bulb as the means of ignition. Diesel dispensed with the hot bulb altogether. Later, Arkroyd Stuart applied for a patent covering automatic injection.

Prior to this time gas engines working on the four-stroke Otto cycle were the only internal combustion engines, and they all employed low compression ratios. With Diesel's engine, high compression was to be a necessity : it was to produce heat so that when the fuel (at first powdered coal was envisaged) was introduced, combustion would take place ; this could be controlled. No air–oil mixture could be introduced or a premature explosion would result.

In 1893, with financial backing from Krupp's and the Augsburg–Nuremburg Engine Works, Diesel constructed his first engine. This was a single-cylinder machine with an external crosshead, working on the four-stroke cycle. The cylinder was not water-jacketed. The engine was driven by external power and when the fuel oil was introduced there was an explosion and the indicator was shattered. The engine, though a failure, served to demonstrate that compression could ignite fuel oil. In a second engine, Diesel introduced certain modifications such as a higher cam-shaft and a water-cooled cylinder jacket. This engine ran for only a minute. The third and fourth engines, built in 1897 and 1898, respectively, were more successful : the latter, although it was only a single-cylinder machine, developed 20–25 h.p.

The success of these experiments, which had been carried on at the Augsburg Engine Works since 1894, with the subsequent triumph of the engine as a workable machine, caused a world-wide sensation. Diesel engines began to be constructed in all parts of the world under licence, for Diesel himself still possessed the patents. Unfortunately, at the turn of the century a number of minor mishaps on one or two machines caused Diesel considerable embarrassment and some financial reverse, during which he sold many of his patents; only later did he realize his mistake.

After 1901 a number of refinements were introduced. Machines of several cylinders were built; trunk pistons were introduced. The four-stroke cycle remained supreme and the oil was injected with the aid of compressed air, that is to say, a mixture of oil and air was introduced at the top of the compression stroke, for which purpose the engine had to be equipped with an air pump. Diesel himself saw the advantages of airless injection, and also of the two-stroke cycle which was peculiarly suitable for his engine. Its advent was delayed for two decades following his initial success because no manufacturer could build a workable fuel-injection pump capable of withstanding the high pressures involved. It was airless injection that made possible the success of the Diesel engine as we know it to-day, particularly in respect to the smaller sizes. Ironically enough, the small-size Diesel engine was not realized as quickly as Diesel had hoped, partly because of the introduction and success of the electric motor.

In 1912, Diesel visited the United States and addressed the American Society of Mechanical Engineers. At this time he was broken both in health and financially, and his death a year later, although mysterious, is generally attributed to suicide.

Diesel's invention can be regarded as comparable in importance to that of the steam engine. It is interesting to note that Diesel foresaw that his engine would eventually change the railways. However, at the time of its introduction the steam locomotive reigned supreme and another twenty-five years had to pass before the railways took any serious interest in Diesel locomotives. Diesel visualized his engine driving locomotives through a mechanical drive rather than through the intermediary of an electric generator and motor. Mechanical transmission was to come into its own, however, in rail cars and small switching engines.

The story of the Diesel engine in construction equipment, marine applications and road transport is well known. The success of the Diesel engine in the First World War in submarines and in the marine world in general gave it an assured place as a prime mover. In road transport, it is interesting to note that Diesel himself designed a road truck but later withdrew it. The early success of the petrol engine in Canada and the United States overshadowed the smaller Diesel engine, which, however, achieved some popularity in Europe. In Germany and Britain Diesel aero-engines made their appearance before the Second World War and were very successful, but gave way to the gas turbine when it appeared.

PROGRESS OF SPUTNIK 2 (1957β)

By D. G. KING-HELE

Royal Aircraft Establishment, Farnborough

SPUTNIK 2 has now been circling the Earth for more than four months, and sufficient observations have been received and analysed to allow a preliminary report on its progress to be made.

Fig. 1 shows how its period of revolution has altered during this time. A marked change in the slope of the curve is apparent between December 20 and January 5, and there are several smaller fluctuations in slope, which are not visible on the scale of Fig. 1. Until mid-December the rate of decrease of period remained fairly constant at about 3·0 sec. a day. There followed a sharp rise to about 4·0 sec. a day in early January. During January the rate fluctuated between 4·4 and 3·9 sec. a day; then in

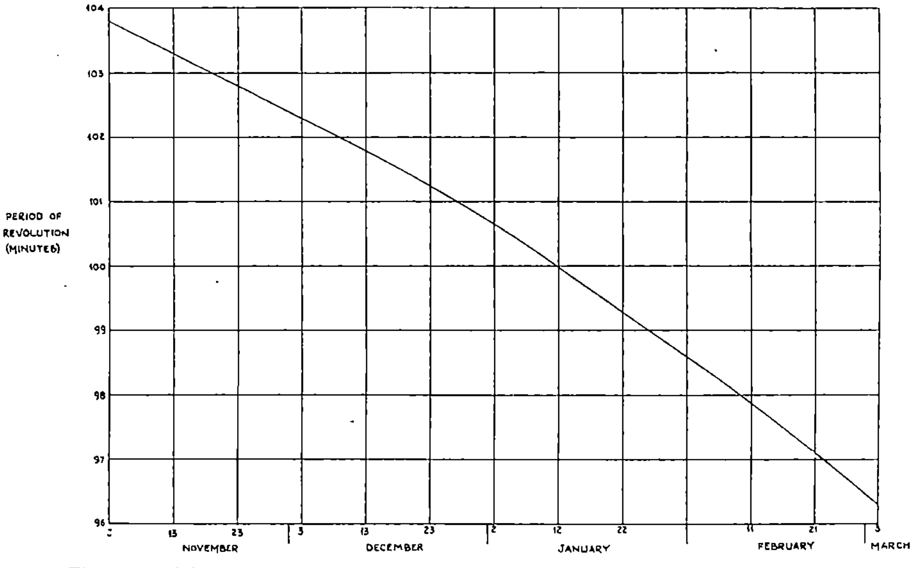

Fig. 1. Variation of the (nodal) period of Sputnik 2 between November 1957 and March 1958

Table 1. Orbital Data for Sputnik 2

Date	November 9, 1957	December 3, 1957	January 22, 1958	March 2, 1958
Time, G.M.T.	05.23 hr.	07.28 hr.	19.23 hr.	16.00 hr.
Orbital period (min.)	103·49 ± 0·05	102·289 ± 0·001	99·206 ± 0·001	96·33 ± 0·01
Semi-major axis (nautical miles)	3,940·2 ± 1·3	3,909·72 ± 0·06	3,830·77 ± 0·06	3,756·5 ± 0·3
Eccentricity	0·0973 ± 0·0004	0·0904 ± 0·0003	0·0728 ± 0·0005	0·055*
Angle from apex to perigee	– 33° ± 1°	– 41·9° ± 0·2°	– 63·19° ± 0·06°	– 83°*

Inclination of orbital plane to equator: 65·29° ± 0·03°.

The rate of rotation of the orbital plane about the Earth's axis was 2·69 ± 0·01 degrees/day at 00.00 hr. on December 1, 1957, and 2·88 ± 0·01 degrees/day at 00.00 hr. on January 20, 1958.

* Accuracy uncertain.

February there was a further rise, from 3·9 to more than 5 sec. a day, followed by a fall to about 4·5 sec. a day. These fluctuations are believed to be genuine and not due to observational error. They imply fluctuations in the effective drag on the satellite, and their interpretation should provide much scope for ingenuity. There have also been striking fluctuations in the apparent brightness of the satellite, often with a period of the order of one minute, and these have generally been attributed to its rotation.

The fluctuations in drag have made it difficult to predict the movements of the satellite accurately, and any estimates of life-time are subject to considerable error. At present the most likely date for the final descent through the atmosphere appears to be April 15; but if the drag were to change abruptly by 20 per cent, as it has done in the past, this date could be in error by up to 10 days.

When Sputnik 2 began its career the orbit had an eccentricity of about 0·1 and the height varied between a minimum of 120 nautical miles and a maximum of 900 nautical miles (1 nautical mile = 6,080 ft.). The satellite was at perigee when going north at a latitude of about 51° N. By the beginning of March 1958, the eccentricity had fallen to about 0·056 and the height varied between 110 and 530 nautical miles. Meanwhile perigee shifted slowly backwards along the orbit, and by the beginning of March had nearly reached the equator. The inclination of the orbital plane to the equator has remained virtually constant, as was expected from theory.

Fig. 1 and the orbital data given in Table 1 are derived partly from the many independent observations on which the prediction service for Sputnik 2 relies, and partly from observations made by kinetheodolite stations of the Royal Aircraft Establishment. I would like to thank all those concerned in the observations and analysis for the help they have given, often in the dark hours before dawn.

NEWS and VIEWS

Royal Society of Edinburgh: New Fellows

At the ordinary meeting of the Royal Society of Edinburgh, held on March 3, the following were elected Fellows of the Society: Prof. H. A. Brück, Astronomer Royal for Scotland and professor of astronomy in the University of Edinburgh; Dr. W. K. Burton, lecturer in natural philosophy, University of Glasgow; Mr. W. McL. Dewar, headmaster, George Heriot's School, Edinburgh; Mr. W. E. J. Farvis, head of the Postgraduate School in Electronics and Radio and senior lecturer, Department of Engineering, University of Edinburgh; Dr. D. Finlayson, research superintendent, British Celanese, Ltd.; Dr. A. R. Hill, lecturer in agricultural zoology, University of Glasgow; Dr. D. K. McE. Kevan, lecturer in agricultural zoology and head of the zoology section, School of Agriculture, University of Nottingham, recently appointed to the chair of entomology, McGill University; Dr. I. R. W. Lominski, senior lecturer in bacteriology, University of Glasgow; Dr. A. McDiarmid, principal scientific officer (veterinary science), Agricultural Research Council Field Station; Dr. Sheila Macintyre, lecturer in mathematics, University of Aberdeen; Prof. D. McKie, professor in the history and philosophy of science in the University of London; Mr. J. P. Maule, director, Commonwealth Bureau of Animal Breeding and Genetics; Dr. A. Meiklejohn, senior lecturer in industrial health in the University of Glasgow; Prof. R. Meredith, professor of textile technology, Royal College of Science and Technology, Glasgow; Dr. Mary J. McD. Noble, principal scientific officer (plant pathologist), Department of Agriculture for Scotland; Dr. D. V. Osborne, lecturer in natural philosophy, University of St. Andrews; Dr. R. Osborne, principal scientific officer, Poultry Research Centre, Agricultural Research Council; Dr. R. V. Rajam, director, Department of Venereal Diseases, Government General Hospital, Madras; Prof. R. A. Raphael, regius professor of chemistry in the University of Glasgow; Prof. I. N. Sneddon, Simson professor of mathematics in the University of Glasgow; Prof. F. S. Spring, Freeland professor in the Royal College of Science and Technology, Glasgow; Mr. J. N. Toothill, general manager, Ferranti, Ltd., Edinburgh; Dr. C. D. Waterston, assistant keeper in charge of the Department of Geology, Royal Scottish Museum; Prof. A. Williams, professor of geology in The Queen's University, Belfast; Prof. M. F. A. Woodruff, professor of surgical science, University of Edinburgh.

NATO Science Committee

The following national representatives on the North Atlantic Treaty Organization Science Committee have recently been nominated: Prof. C. Alexopoulos (Greece); Prof. F. Giordani, professor of general chemistry in the University of Naples (Italy); Prof. R. F. Mayer, vice-rector of Lisbon Technical University (Portugal); Prof. I. I. Rabi, professor of physics in Columbia University (United States); Prof. P. B. Rehberg, University of Copenhagen (Denmark); Prof. S. Rosseland, professor of astrophysics in the University of Oslo (Norway); Prof. A. Rucker, rector of the Munich Technical High School (Germany); Prof. S. J. Sizoo, professor of chemistry in the University of Amsterdam (Holland); Sir Solly Zuckerman, Sands Cox professor of anatomy in the University of Birmingham (United Kingdom); Dr. E. W. R. Steacie, president of the National Research Council of Canada (Canada).

Astronomy at Cambridge: Sir Harold Jeffreys, F.R.S.

Sir Harold Jeffreys, who is to retire from the Plumian professorship of astronomy and experimental philosophy in the University of Cambridge in October, is best known for his work on physics of the Earth and in particular for his discussion of seismological observations and the deduction of the times of travel for earthquake waves. While this work on earthquakes was for many years the centre of his interest, there is scarcely any branch of science connected with the physics of the Earth to which he has not contributed, his work on its thermal history, on stresses in the crust and on tidal friction being particularly well known. The three editions of his book, "The Earth", have for thirty years been the best-known exposition of the application of physics and mathematics to our planet. In the course of his work on earthquake waves, Jeffreys met severe statistical difficulties arising from the failure of the observations to conform to the Gaussian law of errors. This led him to make an extensive study of the basis of the theory of probability and to write a stimulating and entertaining book on the subject. As was to be expected, this led to a vigorous controversy with the guardians of statistical orthodoxy. Jeffreys has also written several books on mathematical topics, including the widely known "Mathematical Methods", which is a joint work with Lady Jeffreys. Since he was appointed to the Plumian professorship in 1946, Jeffreys has devoted his attention mainly to the relation between the Earth's internal structure and astronomical quantities; in particular, he has studied the effect of the Earth's fluid core on nutation.

Prof. F. Hoyle, F.R.S.

Mr. Fred Hoyle, who has been elected to succeed Sir Harold Jeffreys as Plumian professor of astronomy and experimental philosophy, is well known through his many substantial contributions to modern theoretical astrophysics. After an early start in quantum theory, Mr. Hoyle, in collaboration with Dr. R. A. Lyttleton, began to turn his attention to theoretical astrophysics shortly before the Second World War. His outstanding gift of physical intuition has enabled him to appreciate the vital factors in astrophysical situations that are far from terrestrial experience. In this way he has been able to make far-reaching contributions to the theories of stellar structure and evolution, of galactic evolution, of star formation, and of cosmology. Mr. Hoyle has kept in close contact with the outstanding observational astronomers who are associated with the Mount Wilson and Palomar Observatories, and has spent a good deal of his time with them in Pasadena. In this way his theoretical work is backed by an up-to-the-minute knowledge of the latest observational results. The great depth of his understanding has made Mr. Hoyle an outstanding popular writer and broadcaster on astronomical and other topics. He has in the past added great distinction to astronomy in Cambridge as Fellow of St. John's College and lecturer in mathematics, and will continue to do so now in his professorial position.

U.S. National Astronomical Observatory: Dr. A. B. Meinel

Dr. Aden B. Meinel has been appointed director of the proposed new U.S. National Astronomical Observatory by the National Science Foundation in conjunction with the Association of Universities for Research in Astronomy, Inc., which is under contract to the Foundation for the establishment and operation of the observatory at a site to be selected in Arizona (see *Nature* of January 25, p. 236). Dr. Meinel received his Ph.D. in astronomy from the University of California in 1949. He joined the Department of Astrophysics of the University of Chicago in 1950, where he was appointed associate professor. In 1953 he was made associate director of the Yerkes and McDonald Observatories. Dr. Meinel's published work, in addition to optical design, spectroscopy of night airglow and aurora borealis, has included the identification of new band systems in the spectra of OH and N_2, detection of extraterrestrial protons in the aurora, and reproduction of the auroral spectrum in the laboratory by the use of accelerated particles. He has received the Lomb Prize of the Optical Society of America and the Helen Warner award of the American Astronomical Society in 1954.

Dr. Meinel has been associated with the project for the new observatory almost since its inception. He has served as full-time executive secretary to the *ad hoc* advisory panel of astronomers set up to make recommendations on a suitable site. Early in the spring of 1955 he began field work for the selection of possible sites in the south-western area. Assisted by H. A. Abt, Dr. Meinel made a comprehensive examination of the entire region bounded by the Rio Grande on the east, by latitude 36° on the north, and the geographical limits of the United States on the south and west. All available high-altitude rocket photographs were carefully examined. The two scientists flew thousands of miles in a small plane and travelled great distances by car in the course of examining every possible site. Dr. Meinel will continue to direct work on the new observatory from his present field office in Phoenix, Arizona, until a site has been selected.

Social Medicine at Aberdeen: Prof. E. M. Backett

Dr. E. Maurice Backett, who has recently been appointed professor of social medicine in the University of Aberdeen, is forty-two. He graduated in medicine at the Westminster Hospital (University of London) and holds an honours degree in psychology, a diploma in public health, and is a member of the Royal College of Physicians. During the Second World War he served in the R.A.F. (Science Branch). After qualification, he became a Nuffield Fellow in Social Medicine and carried out some work for the Medical Research Council. He was appointed a lecturer in The Queen's University, Belfast, and a senior lecturer at Guy's Hospital Medical School and the London School of Hygiene and Tropical Medicine, jointly. In this post he has been able to develop his interests in undergraduate teaching and also to carry out various investigations, especially in the organization of medical services; quality of medical care; morbidity studies in general practice; social factors in the distribution of polio virus; medical care of deaf mutes; epidemiology of road accidents; and coronary disease in doctors.

Graham Kerr Memorial

A committee has been formed to promote a fund for a memorial to the late Sir John Graham Kerr, who occupied the regius chair of zoology in the University of Glasgow from 1902 until 1935. Lord Boyd Orr, chancellor of the University, has agreed to preside over the committee composed of the following friends and colleagues: Viscountess Davidson, Dr. Muriel Robertson, Sister Monica Taylor, Dr. G. S. Carter, Dr. H. B. Cott, Sir James Gray, Dr. Edward Hindle, Dr. R. A. Staig and Prof. C. M. Yonge. The form of the memorial will depend on the amount collected; but it is hoped that it will provide for the erection of a plaque and the endowment of an annual prize in zoology. Contributions should be sent as soon as possible to the Hon. Secretary and Treasurer, Miss A. E. Miller, Department of Zoology, The University, Glasgow, W.2.

Sir William Siemens Exhibition

A small exhibition presenting the life and work of Sir William Siemens was opened at the Science Museum, South Kensington, on March 10. Prepared in collaboration with Siemens Edison Swan, Ltd., it is based upon exhibits collected together for display at the Central Hall, Westminster, on the occasion of the Siemens Bros. Centenary Lecture on March 5. Charles William Siemens was an outstanding figure in the industrial development of the nineteenth century, combining scientific insight and technical ability with an unusual degree of commercial acumen. He was an acknowledged pioneer of the electrical industry, both on the telegraph and supply sides; and his application of his regenerative furnace to metallurgy made him a leader also of the steel-manufacturing industry The exhibition traces his career and achievements in a chronological sequence. The early years, up to his election to the Royal Society, are represented by exhibits relating to his inventions during that period, and to the beginnings of his work with submarine cables. His later work is represented by exhibits dealing with the practice of steel manufacture and with the development of the electrical industry, including his work on the self-excited generator.

Directory of Societies for Natural History and Cognate Studies

The Council of the British Association for the Advancement of Science has decided, at the invitation and with the financial assistance of the Carnegie United Kingdom Trust, to undertake the publication of a new edition of the "Directory of Natural History Societies", which was first published in 1948 by the Amateur Entomologists' Society. The "Directory" will cover archæological, astronomical, biological, botanical, geographical, geological, meteorological and zoological societies—both national and local amateur bodies—and any other cognate societies which the Advisory Committee may feel should be included. More than three thousand questionnaires have so far been distributed, and it is hoped that any clubs or societies coming within the above terms of reference that have not yet received one will write to the editor, Dr. Averil Lysaght, c/o Bird Room, British Museum (Natural History), Cromwell Road, London, S.W.7.

Scientific and Technical Man-power in Britain

Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, replied on behalf of the Lord President of the Council to questions in the House of Commons on February 25 on the sections on research and development in the annual report for 1956–57 of the Advisory Council for Scientific Policy. He said that the Government is playing its part by approving the expansion programme for universities and technical colleges. It is for industry to take full advantage of the skill made available for civil research by the limitation of the defence programme. The Advisory Council is now studying in greater detail the methods of financing research at universities, including the provision of supporting staff. There is no sign at all of serious redundancy. Professional scientific and engineering institutions have offered to co-operate with the Committee on Scientific Man-power in carrying out an annual review of their membership, and in addition it has now been decided to undertake, towards the end of 1958, a further survey of the number of scientists and engineers in Great Britain, similar in scope to that made in 1955. He did not think there is anything to substantiate the suggestion that industry does not keep in close touch with new research in Britain and elsewhere.

Smoke Abatement

Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, replying on behalf of the Lord President of the Council to a question in the House of Commons on March 4 regarding research on the measurement and reduction of smoke from industrial chimneys, said that the Fuel Research Station of the Department of Scientific and Industrial Research had developed two types of instrument to simplify the measurement of smoke. One is intended to show a stoker in the boiler house, and the other a smoke inspector outside, when smoke darker than the legal limit is being produced. The Research Station has also developed smoke-eliminating devices for industrial hand-fired boilers, adoption of which would offer a saving of more than 1 million tons of coal a year.

Emergency Supplies of Water

In moving the second reading of the Water Bill in the House of Lords on February 27, the Minister without Portfolio, Lord Mancroft, said that the measure, which was designed to give permanent powers for maintaining public water supplies in serious droughts, would enable us to dispense with Defence Regulation 50*A*, under which orders had been made allowing water undertakings to draw water from emergency sources, and Defence Regulation 56, which had been used to relax restrictions and obligations resting on water undertakings. In the past few years a dozen or more water undertakings have been amalgamated and other discussions are proceeding. Although there are still nearly 1,000 such undertakings, he did not agree that nationalization is the best way to make them efficient; nearly 700 are actively considering amalgamation or re-grouping, and more than £240 million had been spent since the War on water supplies in Britain. Lord Mancroft said that the Bill broadly followed the lines of the Water Supplies (Emergency Shortage Orders) Act of 1934, Clause 1 allowing the Minister of Housing and Local Government or the Secretary of State for Scotland, if either is satisfied that a shortage of water supplies exists or is threatened because of an exceptional drought, to make orders authorizing undertakings to draw water from a source not normally used and to vary restrictions or obligations resting on the undertakings as to the amount of water that may be pumped from a river or the amount of compensating water to be discharged from their reservoirs. The Ministers are required to consider the interests of all concerned with the conservation or use of the water for agriculture, fisheries, industry, navigation, etc. Comparatively little potable water is used by the Atomic Energy Authority.

Committee for Biological Acoustics

In 1956 an International Committee for Biological Acoustics was set up at a conference in the United States to act as a focus for research on human and animal acoustics. The growing interest in this field in Great Britain has created a demand for a national committee, which has now come into being. Its constitution is as follows: *Chairman*, Prof. R. J. Pumphrey, Department of Zoology, University of Liverpool (who is also the British representative on the International Committee); *Secretary*, Dr. P. T. Haskell, Anti-Locust Research Centre, London; *Members*, Dr. E. C. Cherry, Department of Electrical Engineering, and Mr. D. Leston, Department of Zoology, Imperial College of Science and Technology, London; Dr. F. C. Fraser, Department of Zoology and Dr. D. R. Ragge, Department of Entomology, British Museum (Natural History); Dr. L. Harrison-Matthews, Zoological Society of London; Dr. J. W. S. Pringle, and Dr. W. H. Thorpe, Department of Zoology, University of Cambridge.

The committee hopes to arrange meetings on biological acoustics in collaboration with established biological societies, will maintain close liaison with the International Committee, and is also investigating the possibility of setting up a British collection of recorded animal sounds. A necessary first step will be to ascertain the present extent of interest in and the range of research on biological acoustics in Britain, and it is proposed to compile a list of all those interested in the field. Anyone interested in any aspect of human or animal acoustics should send his name and address, with brief comments on his research and field of interest, to Dr. P. T. Haskell, Anti-Locust Research Centre, 1 Princes Gate, London, S.W.7.

The Egyptian Journal of Geology

In these days when the output of scientific literature challenges the ability of the worker in even the most specialized fields to keep himself informed about current research, news of the publication of yet another scientific journal must sometimes be received with mixed feelings. This will not, however, prevent geologists from wishing success to the Geological Society of Egypt, which in 1957 published the first number of the *Egyptian Journal of Geology*, which is to be produced in future twice-yearly. Egypt is a country of considerable mineral wealth and with many features of geological interest; the new *Journal* will provide a useful forum for her geologists, and it is good that the results of their work should be made readily available to the scientific world at large. In the current issue, three of the four articles are concerned with specifically Egyptian problems of stratigraphy, micropalæontology, and mineral resources; the fourth deals with the more general subject of the serial character of igneous rocks. The articles are printed in English with Arabic summaries in this issue, but the editors invite contributions written in any language employing Latin or Arabic characters. An otherwise excellent format is marred by the adoption of a tall, narrow type-face which gives an impression of elegance but is trying to read. The *Journal* is published at Tager Building, Elhami Street, Kasr El Doubara, Cairo, and costs 50 P.T. (10*s*.).

Current Research on Orthoptera

The number of workers now engaged in research on Orthoptera is large and the field of work is very extensive, often resulting in unnecessary duplication of work and in restriction of exchange of ideas. A questionnaire was sent out by the Anti-Locust Research Centre, London, in 1956 to institutions and scientists all over the world known to be engaged in research on Orthoptera, asking them to provide information on the subjects of their research. Of 250 questionnaires sent out, 215 were returned by workers in thirty-seven different countries. As a result, a list of workers and their addresses, indicating the nature of their current work, has been issued by the Anti-Locust Research Centre, under the title "Current Research on Orthoptera", for circulation among all those known to be engaged in research on Orthoptera. The fields of research covered have been divided into seven sections (the figures in brackets showing the number of projects listed in each case) as follows: taxonomy and faunistics (51); anatomy and morphology (26); physiology (biochemistry and metabolism) (37); physiology (nervous system and sense organs) (21); behaviour (46); ecology, biogeography and general biology (76); and pest control (35). When a scientist is engaged in research related to more than one section, separate cross-indexed entries have been made, so that any one section contains a complete list of all known workers in that field. The arrangement within each section is alphabetical. All those listed will receive "Current Research on Orthoptera", further numbers of which will be issued as new or revised entries accumulate. All inquiries and any information for inclusion in the list should be addressed to the Anti-Locust Research Centre, 1 Princes Gate, London, S.W.7.

Swedish Forest Research

Scots pine (*Pinus silvestris*) and Norway spruce (*Picea abies*) form the chief commercial species of the Swedish forests and source of annual revenue obtained from them; it is to be expected, therefore, that these species should be considerably studied in the Forest Research Institute at Stockholm. In the report of the Forest Research Institute of Sweden (Vol. 46. Pp. 572. Stockholm: Statens Skogsforskningsinstitut, 1957) two interesting papers are printed: "Germination Analyses by the X-ray Method of *Picea abies*" and "Seed Development of *Picea abies* and *Pinus silvestris*". The X-ray experiments on the spruce here described are a continuation of work previously carried out at the Institute. The method of predicting the germinative properties of a seed from its X-ray photograph is based on the close correlation between these properties and the morphological characteristics of the seed's embryo and endosperm. The seed was harvested with great care, mostly from northern localities where the less developed seed types are found more frequently. The paper gives full details of the methods employed, with photographs. In the second paper, on the seed development of the two species, the aim of the investigation was to establish the time of fertilization and to follow embryo development during summer and early autumn. The material was collected from trees growing in the vicinity of Stockholm. The report gives data on the time between pollination, fertilization and other interesting facts. It is illustrated with good photographs.

Carlsberg–Wellcome Travelling Research Fellowships, 1958–59

THE directors of the Carlsberg Foundation, in Copenhagen, and the Wellcome Trustees, in London, instituted in 1957 a system of Carlsberg–Wellcome Travelling Research Fellowships, with the object of encouraging friendly co-operation, on an exchange basis, between Danish and British research workers in any branch of the natural sciences which has a bearing upon human and animal medicine. One Fellowship annually is awarded to a candidate from the United Kingdom for a year's work in Denmark and one annually to a Danish candidate for a year's work in the United Kingdom. The stipend may range from £800 to £1,200 per annum (or the equivalent sums in Danish kroner) for whole-time research. Travelling and some incidental expenses are provided in addition. It is intended to make the second two appointments in respect of the academic year beginning September 1958. Inquiries from candidates in the United Kingdom should be addressed to the Scientific Secretary of the Wellcome Trust, 52 Queen Anne Street, London, W.1, from whom further particulars can be obtained. There is no form of application, but candidates should submit a full *curriculum vitae*, together with details of their research proposals and a supporting letter from a senior scientist who is familiar with their work. Completed applications must be submitted before April 30.

Physical Society Handbook of Scientific Instruments and Apparatus

THE annual exhibition of scientific instruments and apparatus of the Physical Society, to be held in the Halls of the Royal Horticultural Society, London, during March 24–27 (see *Nature* of March 8, p. 673) is an established feature of the scientific year in London. The "Handbook of Scientific Instruments and Apparatus, 1958 Exhibition", published in connexion with the exhibition (pp. xvi+284+pp. 84 advertisements. London: The Physical Society, 1958. 6*s*. net), is not only a detailed catalogue of, and guide to, the exhibits, but also a valuable work of reference on recent developments in the design of physical apparatus, providing, moreover, convenient lists of British manufacturers, and of recent scientific and technical books. The "Handbook" is arranged in numerical order of stands at the exhibition and includes a brief description of every item. There are comprehensive indexes both of exhibitors and of all subjects exhibited, and the large section devoted to advertising is in itself a valuable collection of useful information.

Physics in Schools

A JOINT Easter conference of the Education Group and the South Western Branch of the Institute of Physics on "Physics in Schools" is to be held in the H. H. Wills Physics Laboratory of the University of Bristol during April 9–11. The conference will be opened by Sir Philip Morris and addressed by: Mr. A. D. C. Peterson (director of education, City of Oxford) on general education and physics in the sixth form; Mr. D. W. Scott (University of Bristol) on teaching physics in middle and upper forms of grammar schools; Mrs. C. E. Arregger (Hilger and Watts, Ltd.) on the problem of recruiting women as physicists; Mr. W. Llowarch (Institute of Education, London) on the role of practical work in the education of a physicist; Prof. C. H. Dobinson (Reading) on the General Certificate of Education examinations at Ordinary and Advanced levels for future physicists; Prof. G. K. T. Conn (Exeter) on the transition from school to university; and by Dr. J. Topping (principal of Brunel College of Technology, London) on the education of physicists in technical colleges. The conference is open to all who are interested, and accommodation will be available in Wills Hall. Further details and forms of application to attend can be obtained from the Institute of Physics, 47 Belgrave Square, London, S.W.1.

Announcements

THE annual Conference of Science for Peace will be held on March 22 at the Mahatma Gandhi Hall, Fitzroy Square, London, at 2 p.m. Speakers will include Prof. S. C. Harland, Dr. R. L. M. Synge and Dr. E. H. S. Burhop.

SIR HANS KREBS, Whitley professor of biochemistry in the University of Oxford, has been awarded the Gold Medal of the Association for the Advancement of Natural, Medical and Surgical Sciences, Amsterdam, for outstanding scientific achievement. This Medal was instituted in 1840, and the first awards in 1865 were to medical men; later recipients have included Lorentz, van der Waals, Kamerlingh Onnes, Einstein and Sir Henry Dale.

THE Mechanical Engineering Research Laboratory of the Department of Scientific and Industrial Research, East Kilbride, Glasgow, is to hold open days on June 4 and 5. Applications for invitations on either day from representatives of any organization with engineering interests should be sent to the Director.

THE Cornell Summer Laboratory Course in Techniques and Applications of the Electron Microscope for senior workers in the biological and medical sciences is to be given during June 16–July 3 and is being supported by a grant from the National Science Foundation. The course, which is primarily for scientists using the electron microscope in their research work, is under the direction of Prof. B. M. Siegel, to whom all inquiries should be addressed at Rockefeller Hall, Cornell University, Ithaca, New York.

THE scope of the annual Conference on Conservation of Nature in south-east England, which is to be held in the Zoological Society, Regent's Park, London, N.W.1, on April 12, has been extended to include all societies in south-eastern England whether they are members of the South-Eastern Union of Scientific Societies or not. The chair will be taken by the Earl of Cranbrook, and the following addresses will be given: "The Invertebrate Fauna of Chalk Country and its Conservation", by John Sankey; "The Vertebrates of Frensham Ponds and Romney Marsh", by Maxwell Knight; "Possible Nature Reserves in Kent, Sussex and Surrey from a Botanical Ecologist's Viewpoint", by Dr. Francis Rose; and "Conservation in Hertfordshire", by Dr. J. T. Dony. A symposium on the contribution of naturalists' trusts to Nature conservation will also be held. Further details can be obtained from the secretary of the South-Eastern Union of Scientific Societies, Mr. F. Edwards, 53 The Drive, Shoreham-by-Sea, Sussex.

AGEING AND EMPLOYMENT

THERE are many general statements and assumptions about the employment of older workers in industry, but few facts to support those assumptions. An inquiry* carried out by F. Le Gros Clark into the effects of ageing on 251 manual workers in the furniture industry provides information which will, therefore, not only be useful for employers in that industry, but also in other kinds of manufacturing industry.

Most domestic furniture is produced in large factories, which are tending to increase in size and are achieving greater efficiency mainly through the detailed planning and simplification of a large number of successive hand-and-machine operations. Many of the men employed are no longer craftsmen in the traditional sense of that word; they have each been trained on the job to carry out a limited range of operations. Since comparatively few of the men in the mechanized furniture industry are all-round craftsmen, their chances in later life depend partly upon their own adaptability as operatives or labourers, and partly upon the degree of ingenuity and forbearance shown by shop supervisors and foremen in fitting the job to the man.

In consultation with shop supervisors and others, Le Gros Clark examined the industrial and medical records of 251 men whose ages ranged from 55 to 76; they all worked in large factories. They were still employed or had, in a few cases, recently retired. Men were not compulsorily retired at a certain age.

Of the seventy-three men aged from 60 to 64, sixteen had been transferred permanently to jobs of a light character; practically all of them were labourers. Ten other men were only able to remain at or 'near' their normal jobs after some concessions and adjustments had been made. The remaining forty-seven men were still working in the ways to which they had been accustomed for some years past.

An ailing or ageing labourer may be less easy to accommodate than an operative in the same physical condition. He has frequently to be found light labouring work; and that is usually a matter of searching for a job that he can be trusted to carry out at his own pace. The jobs that were found had to be free from the characteristics that had disqualified the labourer from his normal work.

On the other hand, the ten men, for whom some allowances on the job had clearly been made, were mostly operatives. They had not been transferred from their normal departments and some pains had been taken to adjust the work to their physical capacities. The adjustments made often followed on a medical recommendation. A cabinet-maker, for example, had, until the age of 59, been assembling heavy wardrobes; after a hernia operation he had been transferred to light drawer assembly, where he could still, at 63 years, maintain a good pace of output. There was clear evidence of the firm's flexibility in handling older men once deterioration in their health had been checked and their physical condition fairly well stabilized.

Of the forty-seven men still on their normal jobs, Le Gros Clark believed that about one in four were not maintaining the level of output which they had once been capable; these men, too, would have needed some tolerance on the part of their supervisors. At a liberal estimate it appeared that about three in ten of the men in their early sixties were permanently incapacitated for full normal duty; in the case of several others some allowances had to be made.

There was little evidence that men were retiring or even contemplating retirement at the age of 65. Forty-two of the men between the ages of 65 and 69 were traceable from the records. Their patterns of employment were much the same as for those in their early sixties, except that larger numbers of them had to do some light or modified form of work. Sixteen out of these forty-two men (all but one were labourers) had been transferred to light jobs, or else had left their employer in so poor a physical condition that they could scarcely have undertaken any but the lightest work. No long-service employee among them had been discharged on an employer's initiative. Five of the sixteen men were bronchitic; the rest had records of arthritis, hypertension and cardiac debility. When an elderly man had no serious ailment of this nature, it was usually possible to maintain him on his customary work with minor concessions. Another twelve of the forty-two men, mostly operatives, had been provided with work of a distinctly modified kind.

Sixteen men in the records were aged 70 and over. Ten of these had little indication of sickness in their records. This is a common experience throughout industry; such old workers are doubtless in many industries no more than the constitutionally sound survivors of a diminishing generation. Their age had been allowed for in the ordering of their work. In no case was a man in his seventies in full production on what once had been his accustomed job. Each was employed now on very modified or easy-going operations or on tasks of a distinctly light character. Probably not one of these elderly men would have been physically capable of much further work when he did at last retire.

The inquiry clearly showed that some older men in the industry (though not necessarily in other industries) have often to give up their full normal work at about 60. Thenceforth, they only remain employable in furniture production to the extent to which readjustments and transfers can be arranged for their benefit on the shop floor.

In mechanized production of domestic furniture the overall tempo, though it does not necessarily force the pace of a man's individual movements, has to be maintained at a high level. This could easily discriminate against an employee who is ailing or slowing down. By the time they reach their mid-sixties, between one and two out of every five of the men would probably have had to be moved to light operations or to light labouring jobs. By the time they were in the seventies the proportion would be much higher. Similar figures are common in other industries.

In furniture production the continued employability of ageing men depends on two factors. How far are shop supervisors able to break down and reorganize operations in the interests of ageing or ailing men? And what reserves of skill and adaptability have the ageing men themselves? In an industry of this kind it becomes difficult to employ an elderly operative or labourer in the production line, unless he has reserves of adaptability to fall back on. This often depended upon whether these partly skilled men have acquired sufficient craft experience to make them still employable at their age. The craft background of many of the older men has given them assurance of employment. Though a good many of them may have been employed for most of their lives on repetitive and machine work, their early training with hand tools would have sufficed to fit them for transferring at some stage to the finishing shop, repairs or jig-making, according to their degree of skill.

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* Ageing on the Factory Floor. By F. Le Gros Clark. (Studies of Ageing within the Conditions of Modern Industry.) Pp. 36. (London: The Nuffield Foundation, 1957.)

Against this, where operatives now in their middle lives have not been trained in craftsmanship but only for machine and assembly operations, in later years they may prove somewhat of a problem. Not only will there probably be large numbers of them; they will lack the craft training that would have made them adaptable old employees.

Of the furniture industry as a whole, Le Gros Clark suggests that it will still continue to experiment with new techniques and with new and more efficient factory organization. That, inevitably, means concentration and division of labour; and in a factory where the timing of a large number of successive and converging operations is of paramount importance, it becomes difficult to allow too many operatives to fall too far below a standard level of output. A factory that has incurred heavy overhead charges in the employment of technical and other experts will have streamlined production processes to such an extent that it has to maintain a labour force that is physically capable of the effort and continuity needed. In other words, it has less flexibility than had an old-time workshop in employing its own ailing or ageing operatives.

FUEL CONSUMPTION AND RESOURCES

ONE of the four main purposes of the Clean Air Act is to prohibit in Britain the emission of dark smoke from chimneys, and on February 6 the Minister of Housing and Local Government, Mr. H. Brooke, announced that from June 1 emission of such smoke will be liable to incur a fine of up to £100. This will apply to factories, shops, offices and the funnels of ships and railway engines as well as to domestic chimneys, and from that date all new furnaces installed for burning pulverized fuel, or more than one ton an hour of other solid fuels, must be equipped with grit- and dust-arresting plant approved by the local authority.

These regulations will be applied through statutory instrument No. 167 (*C*2) of 1958, which was laid before Parliament on February 6 and appoints June 1 as the day for the operation of all those provisions of the Clean Air Act which were not brought into force by statutory instrument No. 2022 (*C*19) of 1956. It would seem, however, that much still remains to be done in the way of educating both the public and the local authorities on the importance and benefits of smoke control. In replying to a question in a broadcast discussion the following evening, a group of speakers, which included a member of Parliament, showed a regrettable lack of public responsibility and even ignorance of the fact that domestic fires rarely emit dark smoke as defined in the Act—"as dark as, or darker than, shade two on the Ringelmann chart".

Some reference was made to the importance of smoke abatement in a debate in the House of Lords on February 5. Lord Macdonald of Gwaenysgor, who opened the debate, referred to the importance of the most efficient use of coal and the need for adequate independent scientific advice: he was concerned that this should be available to the Minister of Fuel and Power. Lord Stonehaven, who stressed the value of the National Industrial Fuel Efficiency Service, referred to the savings to be achieved by scrapping the obsolete and inefficient Lancashire boilers still in use, the importance of adequate instrumentation and of competent stokers. Lord de L'Isle insisted that adequate provision for storing fuel is essential if fuel is to be handled economically for central heating systems. Lord Teviot and Lord Hall both referred to the contribution of science to the efficient use of fuel and power resources, but the major interest of the debate centred in the review of these resources which Lord Mills, the Minister of Power, gave in his reply.

Lord Mills suggested that we are approaching a turning-point in that field. Coal is still the foundation of British fuel economy, but while its consumption has increased by 10 per cent since 1948, that of oil has increased by 91 per cent. There is also a tendency for an increasing proportion of fuel to be consumed in refined forms: since 1948, coke consumption has increased by 15 per cent, gas by 27 per cent and electricity by 99 per cent, so that they now account for 40 per cent or more of inland consumption, compared with 25 per cent before the War. Taking all fuels together, 60 per cent is consumed by industry, 13 per cent by transport and 27 per cent by the domestic consumer. Half our coal supplies go to making fuel or energy, 18 per cent to the domestic consumer, 6 per cent to transport and 26 per cent to industry and commerce, which consumed 60 per cent of electricity supply and more than half that of gas.

Lord Mills said that planning must be based on the assumption that the inland demand for coal will continue to grow, but more slowly than that of other primary fuels. Its direct use by the railways and householders will decrease, but there may be large increases in the demand for coal by coke ovens. As regards small coal, stocks amount to 6 million tons, mainly from deep mines, although two-thirds of open-cast coal is in that form, compared with half of the deep-mined coal. Demand for oil is likely to continue, but the power station oil-conversion programme has been reduced by one-third, to the equivalent of 6 million tons of coal. The advent of nuclear power as a third fuel, however, has brought us to the turning point. Nevertheless, nuclear power at present represents very big demands on capital resources and the Minister thought it is entirely right to retard the programme slightly, making up the difference by conventional power stations.

In reply to questions about ZETA, Lord Mills said that while the production of a thermonuclear reaction under controlled conditions has been demonstrated as a practical possibility, the stage reached is comparable with that attained in 1938 when it was first demonstrated that if the atom could be split energy would thereby be released. It took eighteen years to produce the Calder Hall station, which was the prototype of the nuclear power programme, and the problems associated with the controlled release of thermonuclear power are certainly no less formidable. The Government will ensure that full account is taken of all the potentialities opened up by the genius of our scientists and technologists but, even on the most optimistic assumption, it is scarcely conceivable that the present programme for nuclear power will need modification because of these further developments. Lord Mills also suggested that the availability of nuclear power and the removal of the pressure of demand for coal will enable the coal industry to be more selective in its output, both in terms of cost of production and of the kinds of coal produced. He agreed as to the importance of efficiency in consumption and professed himself satisfied with the arrangements for scientific advice. He is setting up a committee to consider improving co-operation between the Area Electricity and Gas Boards, and a pilot plant for underground gasification is under construction.

LIBRARIES

EAST met West at the one-day conference of the Scottish Branch of Aslib in the Scottish Central Library, Edinburgh, on February 7. Five speakers representing overseas countries, but all working in Great Britain, gave papers on different aspects of library and information work in Britain and in their own countries.

Miss Margaret Haferd, Librarian of the U.S. Information Service Library in London, spoke of the different useful services that her establishment could offer by way of information on work in America, and technical books.

The principal speaker of the meeting was Dr. J. C. Malloch, of the Scientific Liaison Office of the National Research Council of Canada. His paper was on "Technical Information in the Modern World". He pointed out how science and technology affect every aspect of daily life, food, clothing, and travel. Even the classicist often does not realize the absurdity of voicing his scorn of science on television and reads Thucydides more easily because a technologist has developed a better printer's ink.

Dr. Malloch suggested that to get the type of general education that is needed, schools and teachers must have available the basic technical information in the right form. He criticized the old dull text teaching Boyle's law, the valency of oxygen or the bones of a frog to students, many of whom will never need this information. He suggested it should be replaced by material which would convey the fascination of scientific discovery and a realization that it really means something to every individual, whatever walk of life they might choose. This is a challenge that cannot be ignored if science is to have the intelligent public support necessary to its development and proper use.

He next spoke about abstracting services, and the tremendous expansion of scientific work in the past twenty years, much of which never appeared in standard journals, and how it had materially altered the situation. While chemists and physicists were served by abstract journals, biologists were badly off. By their own figures, the coverage of *Biological Abstracts* is only about 40 per cent and the publications of the Commonwealth Agricultural Bureaux cover only special fields, generally selectively. The industrial fields of applied science and engineering are virtually without abstracting services. We are now realizing the vast amount of important scientific and technical information that is available in the U.S.S.R., its satellites and China which is scarcely touched by most of the abstracting services and only available with difficulty in any form.

Scientists need help and this is a suitable task for information services, but one which must be carried out by methods agreeable to the working scientists. Many research organizations now make use of public relations or press officers whose duty it is to make known the activities of the laboratories and to present the results to the general public in an understandable form. Discoveries of science only become of immediate importance to mankind when they are available for the general benefit. As a result of nearly fifteen years of experience Dr. Malloch believes that the personal approach of field-officers throughout the country is the best method of disseminating information to factories and industry. Dr. Malloch suggested the motto of a public relations officer of the National Research Council in Canada might well be adopted: "No sooner done than said".

Dr. Malloch then went on to describe in detail the work of the National Research Council of Canada. Its library is the major scientific library of Canada and is operated as a national service. It maintains an index of all the translations made of scientific papers in Canada and co-operates with the Commonwealth Index of Translations.

The afternoon session was devoted to papers on library work in their own countries by three ladies at present working in Edinburgh and Aberdeen libraries. Miss L. Somme, of Hammerfest, Norway, at present in Edinburgh, gave the picture of the growth of libraries in her country since the Second World War. Interest in reading had begun during the war when there was little else to do. Now each county had a main district library and attempts were being made to cover outlying districts by mobile libraries by road and sea. The purchasing and binding of books are carried out by the State. Librarians have a three-year course and, as there is a great lack of librarians, positions are easy to obtain.

Miss T. Visser from Utrecht said that in Holland, owing to religious beliefs, it was quite common to find in any one town three public libraries, one neutral, one Roman Catholic and one Calvinistic, each getting State grants. All, however, are members of the Central Association of Public Libraries, which is responsible for the training and placing of librarians. Special libraries were late in commencing and are now organized by the Netherlands Institute for Documentation and Organization of Libraries. A very useful tool for Dutch librarians is the Union List of Periodicals held in the 166 libraries in the Netherlands maintained by the Royal Library at the Hague.

Miss De Silva, at present in Aberdeen, spoke of the differences between the libraries in Ceylon, Kenya and the United Kingdom. She pointed out that the two eastern countries were backward and not well equipped. Both countries were similar in basing their libraries upon British methods and Ceylon was the more advanced. There are three libraries in Kenya, the Macmillan Library for Europeans, one for Africans only and one general. J. R. K. PIRIE

EXOTIC FOREST TREES IN GREAT BRITAIN

IT is held that Great Britain contains a larger number of exotic trees than any other country, some of which have been well known for a long time. These have adapted themselves to soils and climate so well that they are regarded as indigenous species. This abundance conceals our poverty of native trees, especially conifers, among which the only natives are the Scots pine, the yew and the juniper, the latter little more than a straggling bush. Among broad-leaved trees the difference is not so great, but even in this group familiar trees such as the sycamore, the horse chestnut and the plane have been introduced in historic times. The sycamore is notable for its rapid growth in youth, for the lovely tree produced and its great fertility, young seedlings springing profusely from the seed shed in most years.

The Forestry Commission has recently published Bulletin No. 30 on "Exotic Trees in Great Britain", prepared by Messrs. James Macdonald, R. F. Wood, M. V. Edwards and J. R. Aldhous for the British Commonwealth Conference held last July in Australia and New Zealand (H.M. Stationery Office, 1957). The Scots pine formed forests in the Highlands of Scotland, but the Norway spruce, now so common in Britain, was absent. The beech was native only in the south of England and absent from the deciduous forest dominated by oak in the rest of the country. This is in marked contrast with France, where the great oak and beech forests are the glory of that country. Part 1 deals with general considerations affecting exotic forest trees in Great Britain; Part 2 exotic coniferous trees; and Part 3 exotic broad-leaved trees in Great Britain.

The poverty of the tree flora of the British Isles is attributed partly to geographical situation and partly to recent geological history. The introduction of exotic species was at first due to individuals who brought them in for æsthetic purposes on their estates. More recently, commercial motives have increased the rate of introduction of some species such as the sitka spruce and Douglas fir from North America and the Japanese larch. The European larch came in much earlier and was planted on private estates, but the Norway spruce and the silver fir were imported during the past two centuries.

The sitka spruce has been largely used in the twentieth century by the Forestry Commission in planting the new forests of Britain, as have the Japanese larch and the Corsican pine. Thirty-eight genera of conifers and twenty-two genera of broad-leaved trees have been introduced into Britain.

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

REPORT FOR 1956

THE second annual report of the European Organization for Nuclear Research (CERN), covering the period to the end of 1956*, is—as Prof. C. J. Bakker, the director-general of the Organization, remarks in his brief introduction—a straightforward account of development during the year, which indicates that rapid progress has been made in accordance with the plan outlined in the previous annual report (*Nature*, **178**, 902; 1956). However, several years of intensive scientific and technical work still lie ahead before Europe's great joint laboratory for advanced nuclear research can begin to operate fully. Except for the high-frequency system the synchro-cyclotron was practically completed; it was expected to come into operation during 1957. The buildings for the proton synchrotron were also nearly finished and orders for most of the components of the accelerator have been placed. The many illustrations and photographs given in the annual report show clearly the remarkable progress made in the construction of these two large accelerators and their associated buildings, and much detail of the layout and characteristics of the machines is also given in the two sections of the report devoted specially to them.

The purpose of the two-week symposium on high-energy accelerators and pion physics, organized by CERN and held in Geneva during June 1956, was to gather physicists from all over the world and thus enable the Organization to start playing the part for which it was intended as an international centre of advanced studies. 319 scientists from twenty-two countries, including some fifty American and an equal number of Russian scientists, attended. Most of the papers presented had been pre-printed either in English or French and were circulated before the conference. The discussions were recorded, and the proceedings were afterwards published in full in two volumes (see *Nature*, **179**, 283; 1957). It is proposed to hold a similar symposium in 1958. During the first week the principles and methods used in the construction of high-energy accelerators were discussed, and during the second week particle-detecting equipment and high-energy nuclear experimental research with special reference to pion physics. The section of the annual report describing the symposium includes a summary of the main contributions and of the new advances in research discussed, and a list of the titles of the papers which were presented by members of the staff of the Organization is given in an appendix.

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* Second Annual Report of the European Organization for Nuclear Research (CERN), 1956. Pp. vi+71 (19 plates). (Geneva: European Organization for Nuclear Research, 1957.)

No major change in the internal structure of the Organization took place during 1956. Theoretical work was carried out both under the direct control of Prof. Bakker at Geneva on cosmic rays and in the Theoretical Study Division at Copenhagen ; the other five Divisions consisted of the Proton Synchrotron, Synchro-Cyclotron, Scientific and Technical Services, Site and Buildings, and Administration. The number of the staff increased from 260 to 396, and in addition there were eight half-time workers, fourteen consultants and twenty-two Fellows. Thirty-one scientific articles were published and a very large number of lectures and colloquia, all of which are listed in the annual report, were arranged.

In the field of equipment the set of two cloud chambers was successfully completed by the Scientific and Technical Services Division and will be used for experiments on K-mesons. The Division has been studying the techniques of production and handling of liquid hydrogen and liquid helium for low-temperature work, and a liquid-hydrogen plant with a capacity of 20–40 litres/hr. is being built. An experimental liquid-hydrogen bubble chamber, 10 cm. in diameter, and later a larger chamber, 30 cm. in diameter, are to be constructed. Following Harwell and Saclay, and with a view of establishing interchangeable methods and means of computation with these two establishments, the Organization has ordered a 'Mercury' electronic computer, and an experienced mathematician-physicist has been recruited to direct the Computer Section of the Division. In addition, two engineers of the Division spent four months with the electronic groups at Harwell and Saclay.

EMBRYOLOGY OF POGONOPHORA AND CLASSIFICATIONS OF ANIMALS

By DR. S. M. MANTON, F.R.S.
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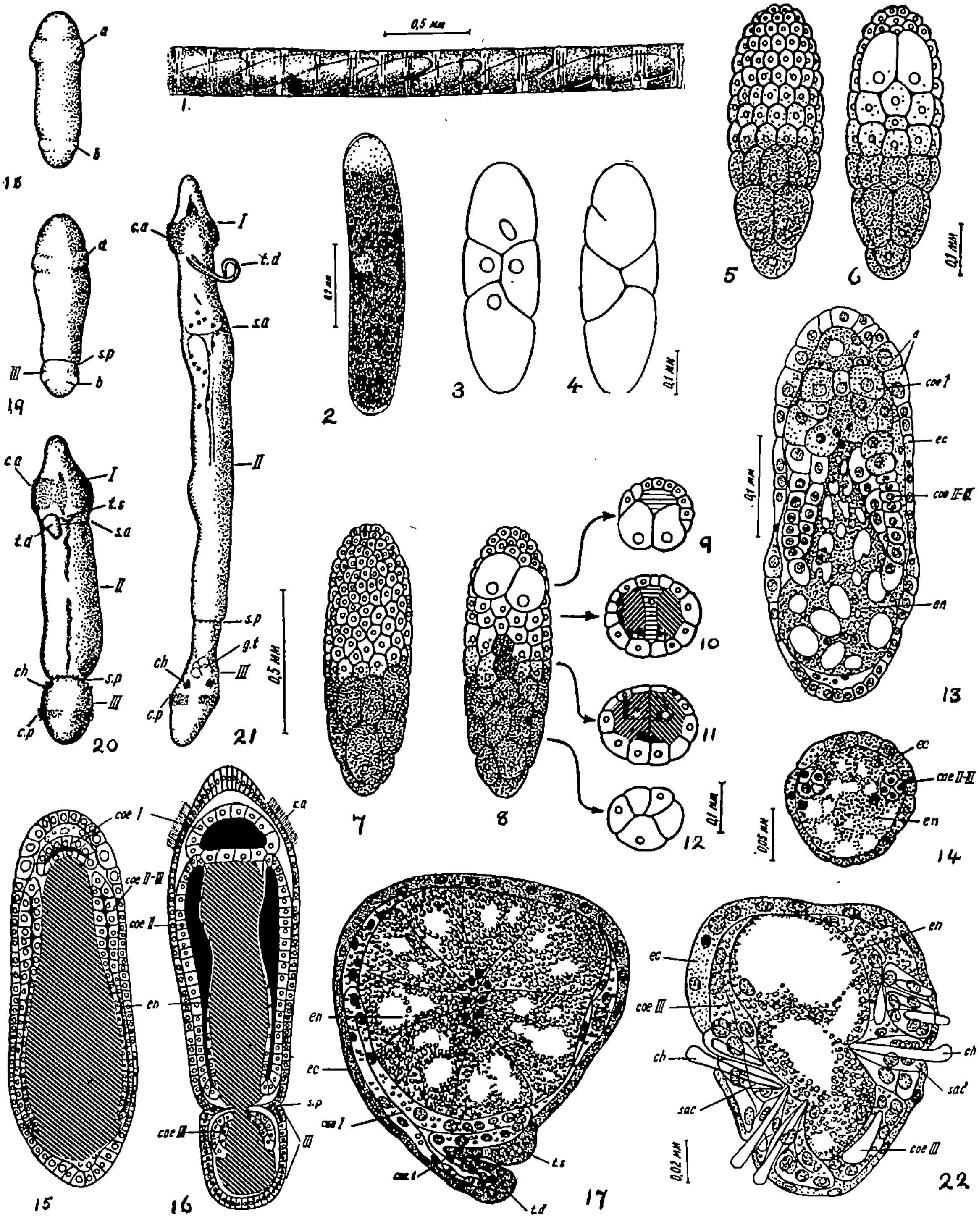
THE past twenty years have considerably widened zoological conceptions concerning the types of animals which are phylogenetically associated with the echinoderm-chordate stem. Kozlowski[1] (1938, 1947) dissolved the matrix from certain graptolites and cleared them, so demonstrating a similarity in budding and tube structure to *Rhabdopleura*, thus suggesting a protochordate rather than a coelenterate affinity for this great group of fossil animals (see also Bulman[2]). At that time much had been found out concerning evolution within the graptolites, but no clear evidence had been obtained as to the grade of organization of their soft parts, so that their systematic position was obscure. The class Pogonophora was described in 1937 by Johansson[3]. But it was the anatomical work of Ivanov in the University of Leningrad[4], on two orders of Pogonophora, collected from deep water in the north-west Pacific, which provided a sufficiency of detail both to demonstrate their place in the animal kingdom near to the Enteropneusta, and to show the extraordinary occurrence of extracellular digestion and absence of a gut in a non-parasitic triploblastic animal.

Recently, Ivanov[5] has given embryological details of a certain number of developmental stages of Pogonophora from the Okhotsk Sea, the preservation of which has been sufficiently good for sectioning. He stresses the incompleteness of the series and imperfections of fixation ; but his results are of such interest that a summary is given below, together with reproductions of some of the figures. Reference must be made to the original publication in Russian for further details.

About 32 batches of eggs, mainly of *Siboglinum caulleryi*, have been studied. The eggs in each batch, up to 42 in number, lie in a row inside the parental tube distal to the head of the mother (Fig. 1), where they undergo most of their development. No free-swimming larvæ are formed. The bilaterally symmetrical egg, much elongated in *Siboglinum*, is heavily yolked ; the nucleus (Fig. 2) lies nearest to the concave side of the egg. The darker distal pole of the egg gives rise to the anterior end, and the more yolky proximal pole to the posterior end of the young adult. Fertilization is presumed to take place in the tube. The nucleus migrates to the distal end of the egg, and after fertilization returns to the middle region ; the egg then becomes invested by a soft vitelline membrane. Development within each clutch is synchronous.

Cleavage is total, unequal and appears to be 'determinate'. There is no trace of either the spiral or typically radial type of cleavage, and the unique pattern appears to be anything but primitive. The egg shortens and divides diagonally, and unequal cleavages beyond the 4-celled stage are not synchronous (Figs. 3 and 4). Bilateral symmetry is marked at the 80–85 celled stage, large cells lie at the posterior end and on the convex side, and two very large cells are situated towards the anterior end on this side (Figs. 5 and 6, same embryo).

By the 130- to 140-celled stage internal cells are established, presumably by delamination or by overgrowth. Three large endodermal cells, one extending in front of the other two, fill most of the interior of the embryo, and contain the bulk of the yolk (ruled in three different directions in Figs. 9–11). Two surface cells rich in yolk lie in the middle of the convex side (dark in Fig. 8). In addition, two small groups of cells, presumed to be mesenchyme, are situated as shown in Fig. 10. The posterior outer cells are rich in yolk, and the large pair of anterior cells (Figs. 8 and 9, same embryo) remain unchanged for a while ; their fate is unknown. This stage represents a gastrula, but a blastopore is not formed.



Figs. 1–16 and 18–21, egg and embryos of *Siboglinum caulleryi*; Figs. 17 and 22, sections of *Oligobrachia dogieli*; Figs. 3 and 4, concave and convex sides, respectively, of same embryo; Figs. 5 and 6, concave and convex sides, respectively, of same embryo; Figs. 7 and 8, concave and convex sides, respectively, of same embryo; Figs. 9–12, T.S. of embryo at the levels indicated by arrows; Figs. 13 and 14, L.S. and T.S., respectively, of embryo younger than Fig. 18; Fig. 15, diagrammatic L.S. of slightly younger stage than Fig. 18; Fig. 16, diagrammatic L.S. of same stage as Fig. 19

The next available stage (Fig. 13) shows the establishment of the coelom, by a method very similar to that seen in the enteropneust *Dolichoglossus pusillus*. An inner yolky endodermal mass of cells is continuous with a median anterior enterocoelic pouch (*coel.* 1, Fig. 13), and from it paired tubular outgrowths form the common rudiments of the second and third pairs of coelomic pouches (*coel.* II–III, Figs. 13, 14 and 15). Later, the second and third pouches separate as shown (Fig. 16). A transitory minute endodermal cavity is formed anteriorly (*en.*, Fig. 17) but elsewhere the endodermal cells remain irregular in a solid mass.

Externally the embryo of *Siboglinum* develops two girdles of short dense cilia, the anterior one (*c.a.*) round the future protosoma (I) arising from two rows of ectodermal cells (*a*), and the hinder one (*c.p.*) round the developing metasoma (III) arising from only one row (Figs. 13–16, 18–21). A furrow (*s.p.*) then separates the meta- from the mesosoma (Figs. 16 and 19), followed by elongation of the mesosoma (II, Fig. 20), and another furrow (*s.a.*) appears between the proto- and meso-soma; internal septa develop at these furrows. The rudiment of the single adult tentacle (*t.d.*) protrudes on the ventral right side of the prosoma; a transitory small fellow one (*t.s.*) develops no further in *Siboglinum* (Figs. 17 and 20). In *Oligobrachia* pairs of tentacles develop progressively on either side of the initial ventral pair, on the postero-ventral arms of a U-shaped tentacle base, a process continuing throughout life. Diverticula of the median first coelomic sac pass into the tentacles (*coel.* 1, *coel. t.*, Fig. 17). Part of the dorsal surface of the mesosoma becomes ciliated. Mesosoma, metasoma and tentacle then elongate (Fig. 20), and perhaps the embryo leaves the parental tube shortly after this stage, moving by muscles of the body wall. The ciliated girdles are lost, and the ectoderm, rich in gland cells (*g.t.*, Fig. 21), may be ready to secrete a new tube for the young animal. No mouth or anus develops, and the endoderm disappears as its yolk content becomes used up.

Muscles of the body-wall develop from the coelomic mesoderm below the ectoderm. Several groups of ectodermal cells secrete provisional chitinous setae (*ch.*) on the metasoma, one seta from each group of cells (*sac.*, Figs. 20, 21, 22). The distal ends of the setæ finally project through the ectoderm, but no conspicuous muscles move these setæ, although some fine ectodermal fibrils to their inner ends may be seen.

Few details are available of the ontogeny of the nervous, vascular or genital systems, but the remarkable features just described amply confirm the existence of enteropneust resemblances. The Pogonophora clearly share with *Dolichoglossus kowalevskyi* and *D. pusillus*: (1) a suppression of pelagic larvæ owing to an abundance of yolk sufficient to maintain a long embryonic development, the provisional girdles of cilia and dorsal mesosomatic tract of cilia of the pogonophoran embryo representing those of the tornaria larva; (2) the anterior median and paired second and third coelomic pouches arising in a similar manner; (3) an early division of the body into three regions, the metasoma being small when first differentiated, and elongating later to form the greater part of the adult body, as occurs also in *Amphioxus*. These features place the Pogonophora squarely among the echinoderm–pterobranchiate–protochordate–chordate group of animals, and no question remains of annelic affinity. Their status as an independent phylum is dictated by: (1) the absence of adult alimentary canal, mouth and anus; (2) the presence of tentacles on the prosoma and not on the mesosoma as in *Cephalodiscus*; (3) the distribution and type of coelomoducts; (4) the positions of the brain and heart (see Ivanov, 1955[4]). The provisional setæ on the metasoma of Pogonophora show no exact similarity in either development or associations with those of annelid parapodia. Setæ are also found in Brachiopoda, and here as well as in Pogonophora have doubtless been convergently acquired. The bilateral symmetry of the egg of *Siboglinum*, the cleavage pattern, and the utilization of the endoderm to carry the embryonic food supply only, indicate the highly specialized nature of the Pogonophora, and the single adult tentacle of *Siboglinum* is clearly a secondary specialization within the group.

Dr. A. V. Ivanov is to be congratulated on achieving such important results from difficult material obtainable only from abyssal waters, and it is to be hoped that future expeditions organized by the Institute of Oceanography of the U.S.S.R. will yield further material which may fill the gaps in Ivanov's series of developmental stages.

Jägersten[6] has described one developmental stage (three specimens) from the tube of an undetermined species of *Siboglinum* collected from Norwegian waters. This stage possesses external ciliation and a yolky cavity-less endoderm as in *S. caulleryi* (Figs. 18–20); no tentacles are present but an anterior furrow is shown. Ivanov's fuller account indicates that this stage is in fact an embryo, and not a larva about to leave the tube, or an asexually produced bud. Jägersten's embryo possesses more provisional setæ than *S. caulleryi* and he notes their differences from setæ of annelids.

Ivanov and his countrymen use the term 'Deuterostomia' to designate that section of the animal kingdom frequently referred to in Great Britain as the echinoderm–chordate stem. We need some other terms to replace the outworn Protostomia and Deuterostomia. The anus may have an association with the blastopore in typical echinoderms, protochordates and vertebrates; but so has it in some quite unrelated invertebrates, and the spirally cleaving invertebrates and the arthropods are not all protostomial. The recognition of relationships within these two great assemblages of animals is universally accepted, although it does not rest on the fate of the blastopore. Closely related animals can be quite different in the fate of the blastopore and origin of mouth and anus[7]. Hyman's[8] definitions of these assemblages, Protostomia, "the groups with determinate cleavage, and mesoderm originating from definite cells or bands", and Deuterostomia, "the groups with indeterminate cleavage and mesoderm and coelom arising as entodermal sacs", also do not fit the facts; the occurrence of 'determinate' cleavage alone can be found in very different form in unrelated groups, such as ascidians, annelids, Pogonophora and molluscs, and mesoderm and coelom formation can scarcely be summarized adequately in these words.

The life-history of Pogonophora shows a clear relict of a tornaria type of dipleura larva which has become embryonic. The cilia are no longer locomotory, and must circulate water to some extent between closely packed embryos before they leave the parent. We cannot agree with Hyman in assigning an ancestral status to the dipleura larva for the whole echinoderm-chordate group of animals. Garstang[9], de Beer[10] and others have discussed the fallacy of regarding larval forms as representing ancestral adults. The tornaria characters appearing in the pogonophoran embryo can only represent the larval features of the ancestors of this group.

As more information on the little-known phyla becomes available it is perhaps remarkable to find so many groups related to echinoderms and vertebrates using the protection of either floating or fixed tubes or tests (Graptolites, Pterobranchia, Pogonophora, Tunicata), or evading competition by burrowing into the substratum (Enteropneuta, Cephalochordata) or retiring to abyssal waters (Pterobranchia, Pogonophora). It appears to have been the evolution of mobile personal armour and effective locomotory mechanisms which have enabled vertebrates and echinoderms to succeed in all manner of open and competitive environments.

[1] Kozlowski, R., *Ann. Mus. Zool. Polonici*, **13**, 183 (1938); *Biol. Rev.*, **22**, 93 (1947).

[2] Bulman, O. M. B., "Monograph on the Caradoc (Balclatchie) Graptolites from Limestone in Laggan Burn, Ayrshire", 1 (Palæont. Soc., 1944).

[3] Johansson, K., *Zool. Anz.*, **117**, 23 (1937).

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FLUORESCENCE OF THE TOXIN OF *CLOSTRIDIUM BOTULINUM* AND ITS RELATION TO TOXICITY

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THE toxins of *Clostridium botulinum* have been studied extensively in recent years, but no special chemical groups or unusual structural characteristics have been demonstrated to account for their extraordinary biological potency[1,2]. We have recently observed that *botulinum* toxin is fluorescent when activated by a specific wave-length in the ultra-violet, and the intensity of the fluorescence is related to the toxicity. Since chemical modification or preparative procedures which diminish the fluorescence also diminish the toxicity, this fluorescent property of the toxin makes possible a new chemical approach to the study of the toxic portion of the molecule. Furthermore, the fluorescence of the toxin can serve as the basis for a physical, *in vitro* method for measuring the toxicity of a preparation.

Type *C* toxin was prepared and purified by methods previously described[3,4]. The final preparation contained 2 × 10^7 minimum lethal dose mgm. nitrogen assayed by intraperitoneal injection in 20-gm. white mice. Measurements of survival time of 20-gm. white mice injected intravenously with 0·1 ml. of serial dilution of toxin were made. An unusually interesting correlation became evident when it was demonstrated that the logarithm of the minimum lethal dose administered showed a nearly linear relationship to the time of survival (Fig. 1). This was used as a standard toxicity curve. Fluorescent measurements were made in the 'Aminco–Bowman' spectrophotofluorometer and calibrated for wave-length and intensity by a standard quinine solution[5]. For this instrument, maxima of activation and fluorescence for the toxin occurred at 287 mμ and 350 mμ, respectively. The fluorescent intensity measured in arbitrary units is linear for toxin concentration below 45 μgm. of protein per ml. (1·4 × 10^5 minimum lethal dose). Above this concentration, fluorescent quenching occurs. Except where otherwise indicated, the toxin was dissolved in phosphate buffer (*p*H 6·8, μ 0·15). For this and the other solvents used, correction for blank was negligible. Scattering, which occurs at incident wave-length, is sufficiently separated from the fluorescent maximum to be non-contributing. The fluorescent intensity values are reproducible within 5 per cent even for different preparations of the toxin.

Botulinum toxin retains toxicity at acid or moderately alkaline *p*H values but is rapidly detoxified above *p*H 10. Fluorescent intensity is also retained below *p*H 10, but at higher *p*H-values there is a marked decrease in fluorescence corresponding to the loss in toxicity (Fig. 2). Neither the fluorescence nor

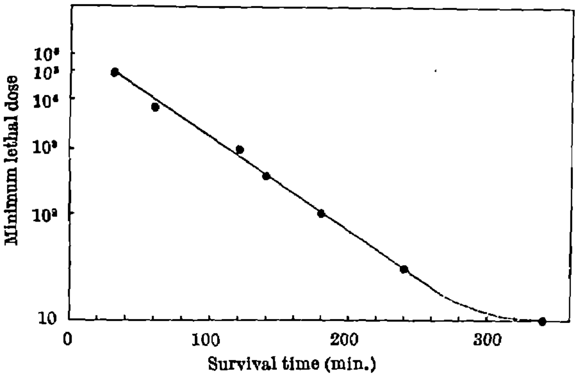

Fig. 1. The survival time of 20-gm. white mice after intravenous injection of dilutions of *Clostridium botulinum* toxin

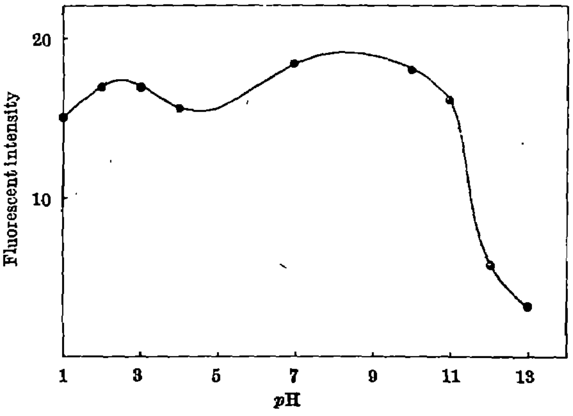

Fig. 2. Effect of *p*H on fluorescent intensity of *Clostridium botulinum* toxin

the toxicity is restored by prolonged dialysis against the original solvent in which the untreated toxin is fully potent. The significance of the smaller decrease in fluorescence near *p*H 5 is not yet clear, and *in vivo* measurements are not sufficiently sensitive to determine that a similar decrease occurs in the toxicity.

Although normal rabbit serum and specific rabbit antiserum (antitoxin) exhibit their own fluorescence, it was shown that the latter decreases the fluorescence of toxin while the former does not. In Fig. 3, the fluorescent intensity of dilutions of normal rabbit serum and specific rabbit antiserum alone are identical (curve *C*); curve *A* shows fluorescent intensity of dilutions of normal rabbit serum plus a constant amount of toxin, while curve *B* shows fluorescent intensity of dilutions of specific rabbit antiserum plus a constant amount of toxin. All samples were incubated at 4° C. for 18 hr. Curve *C* shows a simple increase of fluorescence as the concentration increases (in the non-quenching region). Curve *A* shows a simple additive effect of the fluorescence of the toxin plus the fluorescence of the normal rabbit serum. Curve *B* shows a progressive decrease in the toxin fluorescence as the concentration of specific rabbit serum is increased, suggesting that a combination of toxin and antitoxin has occurred. At the point of fluorescence extinction of the toxin, the toxicity was reduced from the initial value of 100,000 × minimum lethal dose to less than 10 × minimum lethal dose. The slow rate of this reaction is indicated by the fact that an incubation period is required since there is no diminution of toxin fluorescence immediately after the addition of rabbit antiserum.

Since metallic ions interact with active protein groups, a number of metal salts were tested for their effect on fluorescence. The toxin was mixed with dilute solutions (0·01–0·001 *M*) of copper sulphate, cadmium chloride, ferric and ferrous chlorides, chlorides of magnesium and mercury, and zinc sulphate. Of these, only ferric ion showed any effect on fluorescence or toxicity. This ion abolished the fluorescence at 10^{-3} *M* and produced significant depression of fluorescence at 10^{-7} *M*. The effect was immediate and showed no change with time. Ferric ion also depresses toxicity, but at higher concentrations (more than 0·005 *M*) (Fig. 4). The possibility that the reaction of the toxin with ferric ion in low concentrations is reversible and occurs *in vivo* has been considered. Preliminary experiments show that 'pre-loading' mice by intravenous injection of 0·3 ml. of 0·01 *M* ferric ion reduces the effectiveness of the toxin by more than 90 per cent.

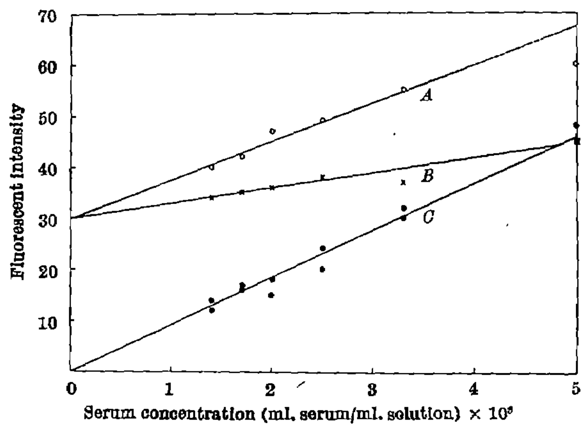

Fig. 3. The effect of antitoxin on the fluorescence of *Clostridium botulinum* toxin. ○, Fluorescent intensity of dilutions of normal rabbit serum alone; ●, specific rabbit antiserum alone (curve *C*). Fluorescent intensity of dilutions of normal rabbit serum plus constant amount of toxin (curve *A*). Fluorescent intensity of dilutions of specific rabbit antiserum plus the same amount of toxin used in curve *A* (curve *B*). Fluorescent intensity in arbitrary units; that of toxin alone = 32

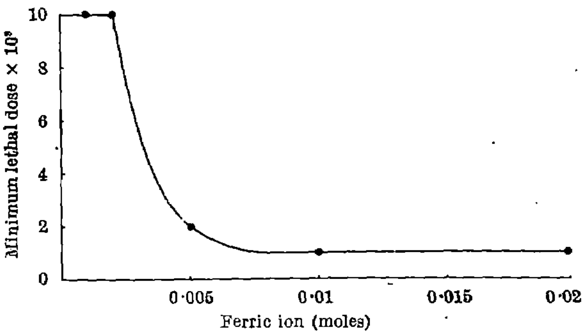

Fig. 4. The effect of ferric ion on the toxicity of *Clostridium botulinum* toxin

The dependence of fluorescence on toxicity was also demonstrated by two other means. *Cl. botulinum* when grown under certain conditions of subculture results in a progressive decrease in toxicity of the culture supernates, which is not due to a decrease in bacterial protein. The supernatants of these cultures subjected to our method of toxin purification yield material which appears similar to the substance obtained from fully toxigenic cultures, except that these preparations showed the above-mentioned decrease in toxicity with a corresponding decrease in fluorescence. The fluorescence in these supernatants was shown to decrease corresponding to the decrease in toxicity. Also, toxoid prepared by treatment of the toxin with 0·5 per cent formaldehyde showed no fluorescence.

Since the toxin is a protein and appears to contain no unusual chemical groups[3], the fluorescence is presumably due to the content of amino-acids which fluoresce in the region of the maxima observed, namely, tryptophan, phenylalanine and tyrosine. Purified serum albumin and bovine fibrinogen were also found to fluoresce in this region. The fluorescence intensity of the proteins, however, is much greater than can be accounted for by the sum of the fluorescence of these amino-acids measured alone under the same conditions and in the same concentrations in which they occur in the proteins. Hence, the spatial configuration of these amino-acids in the protein molecule, or of some other otherwise non-fluorescent amino-acids, is probably responsible for the fluorescence produced.

In these experiments with *botulinum* toxin, procedures which diminished the toxicity also diminished the fluorescence. This may indicate that alteration of the gross structure of the protein molecule destroys fluorescence and toxicity, and both these phenomena are properties of the intact molecule. It is more probable, however, that the relationship is more intimate and that some specific region of the molecule responsible for the toxicity is also responsible for the fluorescence.

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THE MESOPAUSE REGION OF THE IONOSPHERE

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A PULSE sounding apparatus, specially designed for the study of the lower ionosphere and capable of detecting reflexions the voltage coefficient of which exceeds 5×10^{-6}, has been maintained in operation near Christchurch, New Zealand (43° S.), since early 1955. Transmissions are made at a fixed frequency of 1·75 Mc./s. Initial results previously described[1] have now been largely confirmed. Extended observations suggest that there are some features of the ionosphere below 100 km. that deserve closer study in different latitudes. The most important of these features is the continuous existence of ionization throughout a range of heights commencing at a little above 80 km. and extending to about 100 km. Fig. 1 shows a plot of the lower boundary heights of reflexions from this region for four undisturbed days in the various seasons. The strength of the reflexions from this region varies through a range of about 70 db. Between 85 and 90 km., reflexions with a coefficient greater than 10^{-3} have been noted during day and night on many occasions. I have shown[2] that these partial reflexions detected at vertical incidence, together with those from lower heights, are the medium-frequency counterpart of the oblique scattering of very-high-frequency waves now utilized for communication purposes.

A characteristic of the reflexions near 85 km. is the formation of a sharp lower boundary, which may persist for several hours with little change in height. This discontinuity in ionization density usually continues during daylight hours despite the presence of reflexions immediately below it. The 1·75 Mc./s. observations indicate that the major change in ionization density below the *E*-region is more often near 85 km. than elsewhere. At night, the lowest height at which reflexions are detected is often close to 85 km. Initial observations suggested that the night boundary did not descend below 80 km., but later work has shown that ionization at night does remain to a much greater extent and at lower heights than has previously been reported. Fig. 2 shows a record taken at 0145 N.Z.S.T. on May 22, 1956, in which a distinct region at 73 km. is visible in addition to rapidly fading reflexions at 85 km. and sporadic-*E* at 105 km. The lower reflexions were present at heights between 73 km. and 75 km. at hourly intervals of observation throughout the night of May 21–22, with a reflexion coefficient which varied between 5×10^{-5} and 5×10^{-4}. Numerous examples, mostly in winter, are available of reflexions from as low as 75 km. The lowest recorded height at night occurred on May 27, 1957, at 0530 N.Z.S.T., that is to say, about eleven hours after sunset and two hours before sunrise, when weak reflexions from a height of 67 km. were noted during the 8 min. required for a routine observation of heights and strengths of reflexions. This particular event occurred during a 24-hr. period which was part of a group of winter days of high absorption, and during this period the lower boundary of the main reflecting region below the *E*-region did not rise above 78 km.

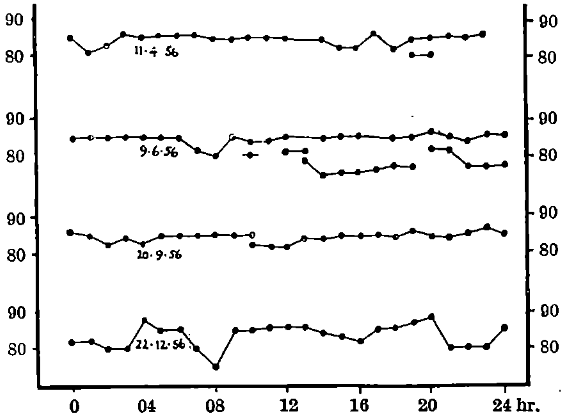

Fig. 1. Lower boundary heights of the mesopause layer at all seasons

Fig. 1 shows that the reflexion heights between 80 and 90 km. are largely independent of solar control. It is thus necessary to show how ionization of low recombination-rate may always be found, though in varying quantities, within limited heights below the *E*-region. A possible origin of this ionization is dust or debris, composed of elements of low ionization potentials such as are found spectroscopically in

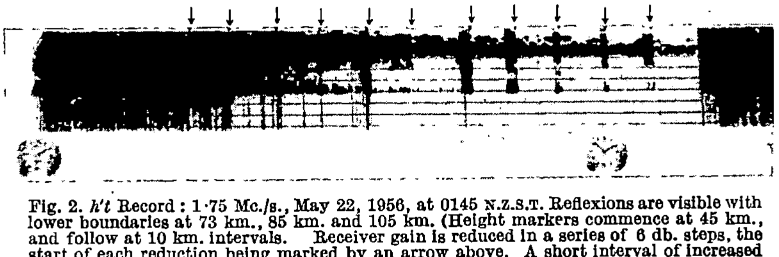

Fig. 2. *h't* Record: 1·75 Mc./s., May 22, 1956, at 0145 N.Z.S.T. Reflexions are visible with lower boundaries at 73 km., 85 km. and 105 km. (Height markers commence at 45 km., and follow at 10 km. intervals. Receiver gain is reduced in a series of 6 db. steps, the start of each reduction being marked by an arrow above. A short interval of increased gain precedes each reduction)

meteors. When photo-ionized, this material would recombine only by radiative processes. Observed electron densities appear to require concentrations of dust that are unlikely to be produced by ablation of meteors detected visually or by means of radar ; and hence an extra-terrestrial origin is supported. The existence of meteor atoms as a constituent of the *E*-region has been suggested by Nicolet[3].

The increase in concentration of this dust near 85 km., and the formation of a sharp lower boundary at this height, may be explained as follows. In the temperature inversion above the mesopause, vertical diffusion of dust will be slow, and certainly much less than any movement in horizontal directions. The concentration of dust will increase with decreasing height. In the mesodecline, vertical diffusion will occur at a much greater rate, so that any material which diffuses across the mesopause is likely to thin out rapidly. Hence maximum concentration will occur close to the mesopause (near 85 km.). Among my records are a number of features which are accounted for in qualitative fashion by the processes outlined. These include the formation of a sharp boundary, stratification of reflexions above 85 km., and a variable concentration of ionization from day to day at heights below 70 km. The optical scattering experiments of Bigg[4] support the existence of dust at the mesopause. Little is known of the incidence of dust on the Earth's atmosphere, and knowledge of horizontal transport within the atmosphere will be required before the radio method can give information as to its rate of arrival. Sufficient evidence is available to confirm its existence, and to show that physical rather than photo-chemical factors are responsible for the formation of a mesopause region of the ionosphere.

The enhancement of ionization at heights above 67 km. during winter days of high absorption has been demonstrated by me[1]. The low recombination-rate at night of this ionization, revealed by later work, raises the possibility that the extra constituent present during these periods may also be meteoric dust. If this proves to be the case, then the seasonal and latitude aspects of the high-absorption effect will require an explanation in terms of the upper-atmosphere circulation pattern. I believe that my records show some evidence that horizontal transport of the extra constituent may occur above the mesopause, but more work is required to confirm this view. At present, available information relating to atmospheric sodium[5], which shows a peak of radiation intensity near the mesopause, suggests that transport from the pole towards the equator is likely.

The suggestions advanced in this communication are being pursued, and results of a detailed analysis of a year's observations of the lower ionosphere will be presented at a later date.

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USE OF 'BROOD PATTERNS' IN RESEARCH ON CHEMICAL MUTAGENS

IN a recent article in *Nature*[1], Drs. O. G. and M. J. Fahmy have used a few brood patterns of mutation frequencies after treatment with certain sulphonates for building up far-reaching speculations on the action of these compounds. Since I have had many years of experience with this kind of approach to the study of chemical mutagenesis[2], may I be permitted to pronounce a warning against its incautious use. My points of criticism are too numerous and too technical to be discussed fully here ; they will be published *in extenso* elsewhere[3]. Here I only want to enumerate briefly the most important ones.

(*a*) There has been no proof that the methods used by Drs. Fahmy result in repeatable brood patterns in replicate experiments. On the contrary, the reference to these 'standardized' methods is to a paper[4] which illustrates strikingly the lack of uniformity in replicate experiments, and no modifications of the method have ever been reported.

(*b*) The claim that with the methods used "spermatogonia differentiate into mature sperm within a period of 15 days" is wholly unsubstantiated. It leaves out of account the influence which different kinds of chemical treatment may have on the rate of sperm release. An example that even one and the same chemical in different doses may produce different brood patterns is shown in Fig. 1 of Drs. Fahmy's article[1] : after treatment with the lower dose of methyl methanesulphonate, mutation-frequency dropped from 5·2 per cent in the third brood to 3·9 per cent in the fourth ; after treatment with the higher dose these two broods had the same frequency of lethals. Drs. Fahmy base their interpretation of brood patterns on an investigation[5] in which the brood pattern for triethylene melamine was interpreted by reference to the histological picture of the treated testis, a method which—unsupported by genetical tests[6]—leaves a wide margin of error. In any event, its results are applicable to triethylene melamine, and to that substance only ; they have no validity for other substances.

(*c*) There is no proof for the claim that after treatment with chloroethyl methane sulphonate (*CB* 1506) the fifth brood is drawn from the latest spermatogonia, "just before they started metamorphosing into spermatocytes". It is true that this brood had been drawn from treated spermatogonia, because it contained bunches of visible mutations. But there is no reason for believing that it was "the first brood" to do so ; for since the previous brood did not contain any visible mutations at all[7], it is hard to see how they could have formed bunches. In addition, the absence of bunches from limited sperm samples cannot be taken as proof that the treated cells had passed the spermatogonial stage ; for late spermatogonia give bunches of two, which can be detected only in very large-scale tests.

(*d*) The application of statistical methods to brood patterns has to be carried out with great care ;

differences between two points may appear to be significant in one experiment and insignificant in a replication. Much of the hypothesis concerning the action of *CB* 1506 is based on a difference between eight lethals in the third brood and two in the fourth[7], a difference which by chance would occur once in about twenty experiments, and which on application of Yates's correction for small numbers becomes insignificant. The same paper[7] presents data from a second experiment with *CB* 1506, carried out on twice the scale with two-thirds the dose. Here the difference between mutation-rates in the third and fourth broods is wholly negligible (χ^2 less than 1). It seems risky indeed to erect a speculative building on such a shaky foundation. It is true that meanwhile Purdom[8] has published two or more brood pattern curves for *CB* 1506 which resemble the one presented by Drs. Fahmy[1] in their main features, although not in detail. In particular, both these curves show a slight and statistically insignificant drop ($\chi^2 = 1 \cdot 4$ and $0 \cdot 5$) from the third to the fourth brood. It is thus possible that such a drop, which rarely seems to reach the level of statistical significance, is indeed a feature of the brood pattern produced by *CB* 1506.

Since Purdom's data are not used by Drs. Fahmy[1], they are, however, not relevant to my criticism, which is directed against the *methods* of Drs. Fahmy, not against the possibility that some of their very insecurely based conclusions may, on further experimentation, turn out to have been inspired guesses. While, in my opinion, the interpretation of the brood pattern for *CB* 1506 gives too much weight to a scarcely significant difference, the opposite error may have been committed in regard to ethyl methane sulphonate. Here the drop in mutation frequency from the first to the second brood (ref. 1, curve *A*, Fig. 1) is disregarded as statistically not significant; but it might well be significant in repeated experiments. This would bring ethyl methane sulphonate into line with diepoxybutane for which, on the basis of one experiment, such a drop has been claimed as a distinguishing feature, and with triethylene melamine, for which a similar drop seems highly characteristic[5].

(*e*) The application of statistical methods to frequencies of visible mutations is even more misleading, because of the large personal factor involved in the scoring of these mutations. That even Drs. Fahmy are open to this criticism is illustrated strikingly by the fact that no visible mutations were reported among more than a hundred mutations in the first experiments with phenyl alanine mustard[10], a substance which afterwards has been stated to have "an extraordinary efficiency in the induction of visible point mutations", yielding regularly a ratio of three visible to ten lethal sex-linked mutations[11,12].

If one nevertheless insists on the use of statistical methods for experiments on visible mutations, account will have to be taken of heterogeneities within the samples to be compared. This has not been done for the noticeable—and statistically significant—drop in the ratio of visible to lethal mutations from the first to the fourth brood after the treatments listed in Table 1 (ref. 1). Moreover, the vast majority of mutations which have been produced by *CB* 1506 occur in germ cells which do not respond to the action of the other sulphonates; comparisons involving *CB* 1506 and one of these other substances are therefore comparisons not only of different mutagens, but also of different cell types. The importance of this distinction has recently been emphasized by Purdom[8], whose results show the important part played by germinal selection in influencing the relative frequencies of sex-linked visible and lethal mutations, when these are recovered from different stages of spermatogenesis.

(*f*) Drs. Fahmy[12] attribute the alleged differences in the visible/lethal ratios after different chemical treatments to the fact that certain 'morphogenesis loci' react specifically to certain chemicals. From a biological point of view this is exceedingly difficult to believe. The classification of mutations into visible and lethal ones is convenient, but it is neither strict nor biologically very meaningful. Every mutation is a visible one, if it is studied at the right time and by the right method. The only distinction is that lethals affect and kill the animal before emergence from the pupa, whereas 'visibles' affect the adult flies and often kill a proportion of them after or even before emergence.

(*g*) The speculations on the action of *CB* 1506 are open to the following objections: (1) The experimental basis is very slender (see above). (2) To postulate two different mutagens acting in series on two selectively sensitive stages is an uncalled-for complication. (3) In view of the known mutagenic activity of chloroethyl radicals, it seems unnecessary to postulate the formation of a chloroethyl amino-acid compound. In any event, the outcome of the proposed experiment with chloroethyl cysteine would be decisive only with very special assumptions which will be more fully discussed in *Z.i.A.V.*[3]. (4) Biological factors, such as differential penetration, selection, differences in rate and quality of metabolism, are wholly neglected. Experiments by Miss E. M. Sonbati and myself indicate that some of them influence the mutagenic action of *CB* 1506. (5) For reasons of scientific economy, the chosen interpretation of the brood pattern of *CB* 1506 should be adaptable also to an unrelated substance, 2-3-*bis*-ethylene amino-benzoquinone-1.4, which gives a similar brood pattern[13].

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In the study of chemical mutagenesis on *Drosophila*, quantitative consistency of genetic response largely depends on the method of administration of the compound under test. The indirect methods of administration, especially that of mixing the compound with the food of the larvæ, result in complete lack of mutagenic consistency both in relation to the dose effect and the brood-mutation pattern[1]. This is perhaps what led Auerbach[2] to contest the possible achievement of reasonable consistency of brood-mutation patterns with the direct method of administration of the mutagens as developed in our laboratory.

(1) *The injection technique and mutagenic consistency.* With our method, accurately measured volumes of a solution of the compound are injected (by a micrometer-syringe) directly around the testes of males of the same age and average weight. In these circumstances, it has been shown[3-5] that for some compounds there is a fairly accurate and consistent relationship between the physical dose injected and the mutation-rate recovered. When the fractionation of the progeny of the treated males is undertaken at the same set periods, reasonable consistency of the brood-mutation pattern does occur, particularly within narrow dose-ranges. This has now been repeatedly ascertained for several alkylating compounds (unpublished) and is quite obvious from the published data, especially with the alkyl-methanesulphonates. The two experiments with 2-chloroethyl methanesulphonate[6], as well as a third undertaken by the same method and in our laboratory by Purdom[7], are clearly very similar; also those for methyl methanesulphonate[8] are almost diagrammatically identical. More extensive and comparable data with the above and related compounds are available, but obviously could not be included in the brief notes so far published.

The conclusion that with our standard brood technique spermatogonia differentiate into mature sperm within *roughly* 15 days is based on more than one line of evidence. We have already referred to the histo-genetic results with 2 : 4 : 6-tri(ethyleneimino)-1 : 3 : 5-triazine[4], which showed that pre-meiotic germ cells (spermatocytes and spermatogonia) give sperm which is utilized starting from the fifth brood, 13–15 days after treatment. That this timing applies equally well to 2-chloroethyl methanesulphonate is indicated by the appearance of 'visible' clusters in the fifth brood. Furthermore, the 'N-mustard' derivatives of amino-acids induce mutations at fairly high rates in all stages of spermatogenesis. In several of our recent experiments with these compounds, 'visible' clusters first appeared in the fifth brood. We feel justified in concluding, therefore, that under our experimental conditions, sperm *mainly* derived from spermatogonia is utilized in the fifth brood (within 15 days), irrespective of the treatment. This possibly means that under mild doses of the alkylating agents, the speed of germ-line differentiation is not drastically disturbed.

(2) *The brood-mutation curve and chemical reactivity.* Auerbach[2] emphasizes the lack of statistical significance for the drop in mutation-rate from the third to the fourth brood under the effect of the lower dose of 2-chloroethyl methanesulphonate[6]. This, however, is not essential to the hypothesis[8] we were expounding, namely, whether the rise in mutation-rate as a function of time after treatment (due to the possible retention of a slow-reacting compound) does continue after the third brood. The regression coefficients of mutations on broods (over the first three broods) for the two experiments (Table 1, ref. 6) did not differ significantly from each other. A conjoint coefficient was, therefore, calculated which indicated an increase in lethal percentage of 1·68 each brood. On this basis, the expected mutation-rate at the fourth brood for the lower dose would be 5·1 per cent, as compared to the observed 2·3 per cent (for the sample of chromosomes tested, $\chi^2 = 8{\cdot}3$, deg. freedom = 1, $P = 0{\cdot}006$). This clearly indicates that the mutation-rate observed in the sperm of the fourth brood is *very significantly* lower than expected on the hypothesis that the cells from which it is recovered have received a longer time of treatment than those utilized in the third brood. As postulated[8], this is probably due to the destruction of the 'residual' chloroethyl ester by hydrolysis (and other physiological factors) within less than the period of four broods (less than 12 days). It follows, therefore, that the much higher mutation-rate in spermatogonia which are utilized later than the fourth brood cannot be a function of time. Supporting evidence comes from the results with the fluoroethyl ester[8], which also possesses a slow-reacting methanesulphonoxy group and yet it does *not* induce a high mutation-rate in spermatogonia.

(3) *'Visible' mutations.* Auerbach[2] interpreted the lack of reference to 'visibles' in our preliminary reports on the 'N-mustard' derivatives of phenylalanine as evidence that none of these mutations was observed. Actually, the ratio of visibles to lethals in *all* our experiments with this mustard was of the order of 3 : 10. In the interim reports she referred to, only the lethal rates were given, and nothing whatever was said about the 'visibles'.

The statement[2] as to the heterogeneity of the ratio of visibles to lethals in the separate broods with the treatments listed in Table 1 of ref. 8 is rather ambiguous, since these data belong to two different compounds. A contingency table test for the relative frequency of these mutations in broods 1–4 gave for the ethyl ester $\chi^2 = 1{\cdot}8$, deg. freedom = 3, $P = 0{\cdot}6$, and for the methyl ester $\chi^2 = 7{\cdot}05$, deg. freedom = 3, $P = 0{\cdot}07$, thus revealing no pronounced heterogeneity.

Auerbach[2] raises the question of the possible role of cell-stage and germinal selection on the ratio of visibles to lethals recovered from various germ cells. This point will be dealt with in detail in a future publication. Suffice to say, however, that for all the alkylating mutagens tested in our laboratory, the ratio of sex-linked visibles to lethals for the same compound does not differ significantly for the separate broods up to and including the sixth. This ratio, however, was sometimes disturbed in favour of the visibles (presumably by differential germinal selection against the lethals) for mutations induced in the *very early* spermatogonia, which are recovered in the seventh brood (19–21 days after treatment). These mutations, however, did not contribute sufficiently to the total mutation pool in any of our experiments to alter significantly the overall ratio characteristic of the various compounds.

The exact biological mechanisms responsible for the variation in the ratio of visibles to lethals under the effect of different mutagens is at present entirely unknown and is one of the problems receiving attention in our laboratory. It may be a manifestation of various degrees of damage to the same loci; but might well be due to selective action on different loci. The merits of each of these views will be dealt with elsewhere, but whichever view is preferred can scarcely affect our conclusion: that if mutagens induce different ratios of visibles to lethals in the same sample of treated chromosomes, their mode of mutagenic action is somehow different.

(4) *Mode of mutagenic action of 2-chloroethyl methanesulphonate.* Our interpretation[8] of the mode of mutagenic action of 2-chloroethyl methanesulphonate is based on the comparative study of the chemical reactivity and mutagenicity of the above compound and some closely related alkyl-methanesulphonates. The mutagenic criteria considered were gross trends and points of detail were only mentioned as complementary evidence. Our argument rests on the complete reversal of the mutagenic cell-stage response under the effect of 2-chloroethyl methanesulphonate as compared with that of other alkyl methanesulphonates including the ethyl ester (see Fig. 2, ref. 8). As clearly stated in our contribution[8], and has been shown experimentally[9], changes in the brood-mutation pattern do occur with some compounds, due to cells being killed by the treatment, variation in the speed of differentiation of the germline, or on altering the experimental procedure, particularly the brood period. These changes, however, are of a much lower order than the gross difference that differentiates the mutation pattern of the chloroethyl ester from that of other alkyl-methanesulphonates.

Auerbach[2] suggests that the differential mutagenicity of the chloroethyl ester may be a function of the chloroethyl group which, she maintains, is known to be mutagenic. However, the fact that the chloroethyl group in 'mustards' (S- and N-mustards) is mutagenic does not mean that it is always so, irrespective of the configuration of the rest of the molecule. The biological activity of the chloroethyl group in 'N-mustards' has been shown by Ross[10] to be due to the tendency of these compounds to produce 'electrophilic' carbonium ions which would be expected to react with the 'nucleophilic' centres in the cell—particularly those of nucleic acids. Ross also demonstrated that the above tendency could be measured *in vitro* by the rate of hydrolysis of the chlorine atom under mild conditions. Since with 2-chloroethyl methanesulphonate, the chlorine atom does not hydrolyse in water at 37° C., whereas the methanesulphonoxy group does, there can scarcely be any doubt that the potential alkylating ability of the chloroethyl ester initially starts at the methanesulphonoxy end, as is the case with the other alkyl-methanesulphonates. If, however, the product of the initial reaction could be such as to 'activate' the chlorine atom of the chloroethyl group, then another alkylating centre would have been secondarily produced. Hence the search for the secondary agent that could account for the atypical mutagenic properties of the chloroethyl ester.

As clearly admitted in our article[8], the suggested formation of a secondary mutagen under the effect of 2-chloroethyl methanesulphonate was only inferential, and our idea about its chemical nature was purely speculative, but experiments were designed for testing our hypotheses. The first series of experiments using S-chloroethyl cysteine (one of the possible metabolites) has now been undertaken. The brood-mutation pattern for this compound was found to be of essentially the same type as that for 2-chloroethyl methanesulphonate, though indicating far greater selectivity for the early germ cells (details to be published elsewhere). An injected concentration of S-chloroethyl cysteine as low as $0{\cdot}4 \times 10^{-3}$ molar induces a sex-linked recessive lethal-rate of 30 per cent in the most sensitive spermatogonia as compared to a maximum of only 1·6 per cent among the sperm and spermatid stages. Other amino-acid mustards that are likely to be produced *in vivo* through the effect of the chloroethyl ester (particularly in conjunction with cysteine metabolism) will be tested for mutagenicity. However, the results with S-chloroethyl cysteine suggest that our reasoning as to the mode of mutagenic action of 2-chloroethyl methanesulphonate was on the correct lines: that the high response of spermatogonia under its effect is probably due to the production *in vivo* of a secondary mutagen other than the sulphonate itself.

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THE editors of *Nature* have kindly given me leave to wind up this discussion with a few lines; they do not wish a continuation of technicalities, and I refer, therefore, for details of my criticism to my paper in *Z.i.A.V.* Here I only want to say this: although the reply by Drs. Fahmy seems to meet all my objections, it does in fact, on closer analysis, confirm that their methods and reasoning were, point for point, exactly as stated and criticized by me. Their reply contains no new references to published data; their insistence on the repeatability, in their experiments, of the relation between dose and effect is wholly irrelevant to the argument; the calculation in section 2 is based on too specious an argument to be taken seriously; finally, it is very difficult to understand why "an extraordinary efficiency in the production of visible mutations" by certain compounds should have been noted but not mentioned for a full year during which two lengthy interim reports came out, especially as this result was first made public in exactly the same kind of interim report. If the speculations on the action of *CB* 1506 have led to the discovery of a further interesting mutagen, they certainly have had heuristic value. It does not follow, however, that they were correct or even well founded. Two substances may well produce similar brood patterns without one being a metabolic descendant of the other (see the last section of my communication above). Moreover, it would not be the first time that an effective mutagen has been detected on the basis of a wrong or doubtful hypothesis.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

X-Ray Study of Laboratory-made Diamonds

LAST summer one of us was able, through the courtesy of the General Electric Co., of Schenectady, New York, to select a few of the diamonds made in the Company's Research Laboratories and to bring them to University College, London, for detailed X-ray examinations. These diamonds are mostly very small (less than ½ mm. linear) and are coloured (yellow, green, black) and good shapes are rare. Although some colourless diamonds have been made, there were none among our collection, nor did we have any of those of pure cubic form. The habits, which are exceedingly interesting, will be discussed in the more extended account of this work to be published later.

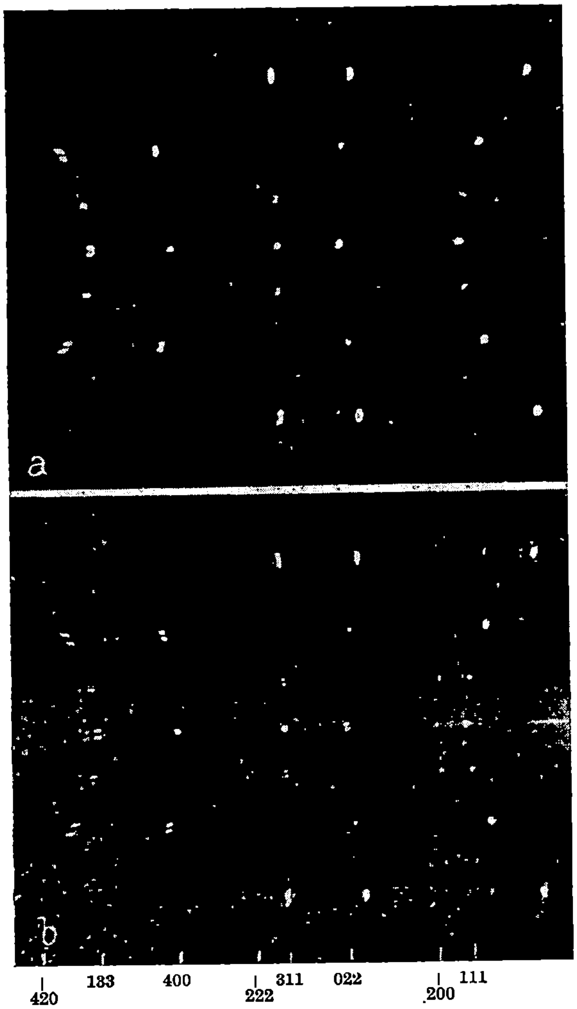

Fig. 1. (*a*) Twinned natural diamond. Rotation slightly mis-set from [01$\bar{1}$] for one individual: showing 111, 022, 311, 222 (very weak) 400, 133 reflexions. Copper *K* radiation, filtered. (*b*) Twinned laboratory-made diamond: same setting and radiation; showing, in addition to the above, the 'forbidden' 200 (medium) and 420 (very weak) reflexions, with very weak satellites to all others. Only the 200 spots are clearly visible on the reproduction

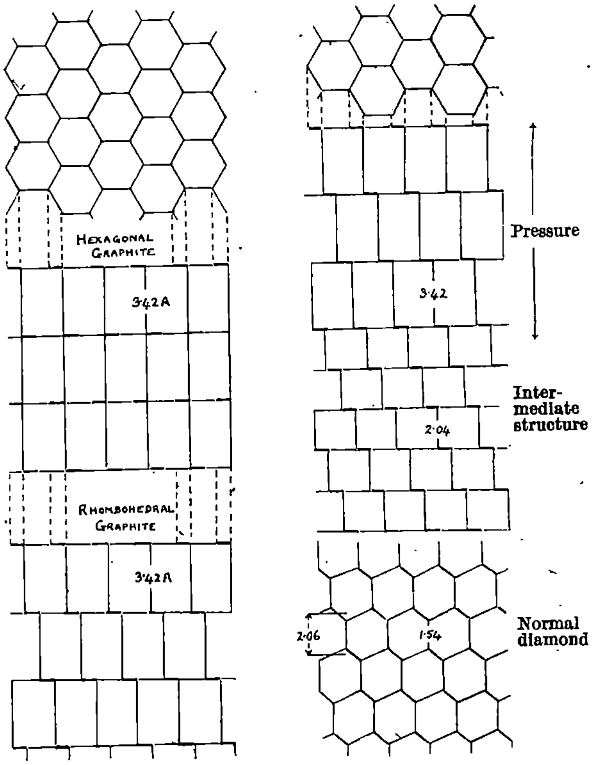

Fig. 2

Ten representative specimens have been studied so far. Laue photographs show that only two crystals are comparatively single and free from distortion; but five have given, using chromium, nickel, copper and molybdenum radiations, good rotation and/or Weissenberg photographs (about [001] and [01$\bar{1}$]) on which it is easy to distinguish spots due to the main specimen from those of its associated twin. In every case these laboratory-made diamonds show one outstanding diffraction feature, namely, the presence of a comparatively strong 200 reflexion, which is never shown by any natural diamond, whether of terrestrial or meteoritic origin, that we have studied. There are other 'forbidden' reflexions (h, k, l even and $h + k + l = 4n + 2$) present also, and nearly all the normal diamond reflexions show a faint satellite on the short-spacing side (Fig. 1).

All the low-order reflexions are sharp, but the 'forbidden' and 'satellite' spots are sometimes a little extended along arcs with θ constant, showing that they are given by a mosaic or conglomerate of slightly disorientated crystallites.

The explanation of the diffraction phenomena appears to be as follows. Each diamond consists of a matrix of normal diamond, of lattice constant 3·567 A., with carbon atoms at the usual positions:

$$000,\ 0\tfrac{1}{2}\tfrac{1}{2},\ \tfrac{1}{2}0\tfrac{1}{2},\ \tfrac{1}{2}\tfrac{1}{2}0\ +\ |000,\ \tfrac{1}{4}\tfrac{1}{4}\tfrac{1}{4}|$$

in each unit cell. Within this matrix there are islands of a different structure which is face-centred cubic with lattice constant 3·54 A. These islands lie closely parallel with the diamond matrix and must be at least 10,000 A. across to account for the sharpness of the reflexions, although some broadening of the 331 and 420 indicates possible distortion or strain.

A spectroscopic analysis of the diamonds, carried out in Messrs. Johnson Matthey's Research Laboratories, demonstrates the presence of some 0·2 per cent of nickel, with smaller quantities of other elements (Si, Al, Fe, Mn, Mg, Na, K, Ti, Ca, Cr, Cu, B). This points to a probable explanation of the subsidiary structure. β-Nickel has a face-centred cubic structure of lattice constant 3·52 A.; nickel carbide, a solid solution Ni_xC where $x \geqslant 4$, is face-centred cubic above 210° C. and has[1] the slightly higher parameter 3·54 A. A simple face-centred cubic structure would not account for the high intensity of 200 relative to other lines in the satellite structure. The addition of some impurity or solvent atoms could do so. A calculation shows that for incident nickel, copper $K\alpha$ or molybdenum radiation, even so small an amount of nickel as 0·2 per cent, concentrated in a few well-crystallized and parallel islands, would give reflexions of appreciable intensity, but that for chromium or copper $K\beta$ radiation they would be much reduced in intensity if the extent of each island is more than some 4×10^{-4} cm. linear. This reduction in intensity is found to occur.

Nickel does not normally appear as an impurity in natural diamonds. The closeness of its lattice constant to that of diamond would point to it, however, as a possible inducer of crystallization of carbon in the diamond form (much as β silver iodide can induce the precipitation of ice in clouds). The process of cooling from high temperatures and simultaneously expanding from high pressures could well leave islands of face-centred cubic nickel or Ni_xC or some other nickel compound in a state of strain; and the existence of orientation relationships (not necessarily complete parallelism) in a precipitated phase is typical, for example, of Widmanstätten patterns in iron-rich nickel–iron alloys in diamond-bearing meteorites. The presence of nickel in these laboratory-made diamonds recalls the Press release (February 15, 1955) by the Research Laboratory of the General Electric Co., in which it was stated that its scientists had "gained valuable help from nature, particularly from studies of diamonds found in Arizona meteorites". This will be discussed in our later paper.

The question still remains as to the actual mechanism of transformation from graphitic carbon (assuming this to be the initial substance) to diamond. This could in fact occur via an intermediate carbon structure, as shown in Fig. 2. This structure, if it has carbon atoms in the positions ($x \sim \frac{1}{24}$)

$$000,\ 0\tfrac{1}{2}\tfrac{1}{2},\ \tfrac{1}{2}0\tfrac{1}{2},\ \tfrac{1}{2}\tfrac{1}{2}0 + |\ \bar{x}\bar{x}\bar{x};\ \tfrac{1}{4}+x,\ \tfrac{1}{4}+x,\ \tfrac{1}{4}+x\ |$$

in a unit cell which is geometrically cubic, of side 3·54 A., but of rhombohedral symmetry only, would give reflexions in precisely the positions of the satellite spots. Apart from the variation of absorption factor with incident radiation, the occurrence of such an intermediate structure, in islands, each with its trigonal axis orientated parallel to one of the four diamond octahedral directions, could scarcely be distinguished from that of the nickel-rich islands we have postulated as the main cause of the satellite reflexions.

Nath[2] suggested in 1935 that the reverse transformation, diamond → graphite, might take place via rhombohedral graphite, but no experimental evidence of this has yet been found, even in heavily irradiated or heat-treated diamonds[3]. We should also emphasize that even the blackest of the laboratory-made diamonds examined showed no trace whatever of the strong 0002 reflexion typical of both hexagonal and rhombohedral graphites, or any other purely graphitic reflexion.

We would like to express our thanks to members of the research staff of the General Electric Company, Schenectady, who, within the limitations of United States security regulations, have given us every assistance in this investigation.

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Nuclear Quadrupole Resonance of Neutron-irradiated Sodium Chlorate

RECENTLY a method based on intensity measurements in pure quadrupole resonance has been developed and has proved itself useful for the study of solid solutions[1] and for the investigation of the damage induced in pure solid compounds by high-energy radiations such as gamma-rays[2].

The present work was undertaken in order to try to extend this method to the case of neutrons. With this in view, fused samples of sodium chlorate, which presents a favourable signal-to-noise ratio, were irradiated at 95° C. in the Belgian *BR*–1 reactor in which a high ratio of neutron to gamma energy is provided. A frequency-modulated super-regenerative detector was used and the spectra were automatically recorded after phase-sensitive detection of the signals.

The observations performed at 23° C. showed that the height of the line (located at 29·932 Mc./sec.) corresponding to chlorine-35 was decreased by about 25, 36 and 52 per cent for irradiations with doses of 2×10^{14}, 10^{15} and 2×10^{15} fast neutrons cm.$^{-2}$, respectively. We were unable to detect any significant shift in the line frequency and, as was found to occur with the gamma-rays[2], a plot of $\log I$ (irradiated sample) $-\log I_0$ (unirradiated sample) versus the dose gave a straight line. This shows that, despite a different type of effect, an exponential law still describes the intensity behaviour. It should be noticed that, within the range of doses used, no significant broadening of the line (measured by the separation between the peaks of the first derivative curve) was observed. For this reason, the intensity of the line was regarded as being satisfactorily represented by its height.

It may now be stated that the method here reported is also valuable for the study of damage induced by neutrons. Further research, including radio-resistance in terms of structure and recovery effects, is now in progress.

We are indebted to the Centre d'Etudes pour les applications de l'Energie Nucléaire for irradiation facilities.

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Flame Ionization Detector for Gas Chromatography

IT has been found that the electrical conductivity of a flame burning a mixture of hydrogen and nitrogen (in air) is very sensitively affected by the vapours of organic substances, and this effect can be used for detection purposes in gas chromatography.

In a simple form of the detector the carrier gas used was a mixture of approximately equal parts by volume of hydrogen and nitrogen and the issuing gas was burnt at a jet made from a 23-gauge hypodermic needle (cut square) which itself served as the positive pole for the conductance measurement. The negative pole consisted of a piece of 30-mesh brass gauze, about 1 cm. above the needle, and the current, driven by a battery of about 300 volts, passed through a 100,000-ohm resistor, across which a Leeds and Northrup 10-mV. potentiometric recorder was connected. The sensitivity of this arrangement to organic vapours was at least as good as reported for the best katharometers.

For the highest sensitivity yet obtained, a double triode 'long-tailed pair' impedance conversion circuit was used (voltage gain about × 2), with a reference jet (burning the same gas mixture) feeding one grid and the detection jet feeding the other. Circuit details are shown in Fig. 1.

The valve is an *E80CC* (Philips), heaters in series with a 12-volt accumulator. The output is filtered with an *RC* circuit with a time constant of about 5 sec. The combustion chamber and collector leads are completely shielded. The combustion chamber is supplied with filtered air since dust particles cause large disturbances.

With the jets connected to short partition columns, injection of 0·01 ml. of a solution of one part of diethyl ether in 10,000,000 of ethyl acetate (by liquid volume) gave an output of about 1 mV. for the ether peak, which was eluted during the passage of 100 ml. of carrier gas. This deflexion was about five times the background fluctuations, and the sensitivity (for twice background) was estimated at not less than 5×10^{-12} mole of diethyl ether, or 4×10^{-10} gm. The sensitivity at the point of detection was about one part in 400 million (by gas volume). From the daily variations in background, it is thought probable that the sensitivity is at present limited by the quality of the insulation and the stability of the grid resistors rather than by the stability of the flame outputs. (Much higher output could be obtained with higher grid resistances, provided background was not proportional.)

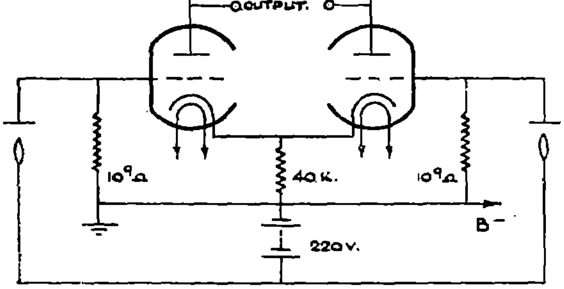

Fig. 1. Circuit of dual-jet detector

With the double-jet system fed with the same gas mixture to both columns, the base line is remarkably insensitive to nitrogen–hydrogen ratio, total flow-rate, vibration, ambient temperature or minor variations in the supply of filtered air. The air supply is passed straight into the bottom of the jet chamber without any device to suppress turbulence.

Other organic vapours so far tried give sensitive responses, including benzene, toluene, xylene, carbon tetrachloride and methylene chloride. Very little if any response is obtained with carbon dioxide.

Preliminary measurements and calculations based on Faraday's law, appear to indicate an ion yield of between one and ten ions per 10,000 molecules of ether, but further investigations, using electrometer valves with very low grid currents, are planned. It is hoped to publish the results at a later date.

A remarkable demonstration of the sensitivity of the apparatus (and of the difficulty of producing known concentrations of vapour by serial dilution) is given by charging an ordinary 2 ml. glass hypodermic syringe with ether vapour, pumping out completely about 100 times, and then injecting a syringeful of air. A peak of several millivolts is obtained, from ether desorbed from the glass.

The above detector was described at a discussion on gas chromatography held at Cambridge on October 4, 1957.

We thank Imperial Chemical Industries of Australia and New Zealand for permission to publish this communication, L. E. Polak, S. Lattimore and F. A. Walter for invaluable advice on the electronics, and V. E. Maier and W. J. Bryant for able assistance.

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Polarization of the Integrated Light of Comet Arend-Roland, 1956*h*

FROM a pair of photographs of the comet taken on the night of April 29–30, 1957, through a 'Polaroid' filter with the 50-cm. Zeiss triplet of the Mond Astrograph, percentage polarization in integrated light (spectral range, 4000–5900 A.) has been measured in the brightest part of the coma, and also at two locations in the tail 4 and 5 min. of arc respectively from the former position. The small scale of the photographs (6·85 min. of arc/mm.) prevented any attempt at a more detailed survey.

The correct position angle of the polarizing filter was determined visually by a preliminary observation of the comet, and the filter was rotated through 90° between the successive exposures, which were given separately on Kodak *O* 800 plates. It had been intended to give an exposure time of 2 hr. in each instance; but the presence of clouds limited the exposure through the 'crossed' filter to 1 hr. 20 min. The mean altitude of the comet was approximately 20°.

Both plates were microphotometered; and the photographic density measures at each of the three selected locations were reduced by the aid of magnitude–density curves, based on measurements of the trailed images of five field stars, namely, *H D*, 21291, 21389, 21447, 25291 and 25642. No corrections were applied to the observed magnitudes for differential atmospheric extinction.

The following values of percentage polarization were obtained: in the brightest part of the coma, 41 ± 5 per cent; in the inner tail, at a point 4 min. of arc from the coma, 51 ± 5 per cent, and at a point 5 min. of arc distant, 35 per cent, with the plane of polarization along the radius vector to the Sun.

Because of under-exposure, the total density in the image of the tail recorded through the 'crossed' analyser equalled the threshold (sky background) value at an angular distance of only 7 min. of arc from the bright, central region of the coma. Thus the probable error of the third measurement given above is uncertain and, in consequence, this result should have less weight than the other two.

The amount of polarization found in the head of the comet agrees well with the value of 45 per cent obtained on an unspecified date by Richter[1], who also used a polarizing filter. However, it is nearly 20 per cent higher than the maximum polarization found by Blackwell and Willstrop[2] in the continuous spectrum of the comet.

Richter (*loc cit.*) has reported that the comet's tail was also 45 per cent polarized out to a distance of 4° from the head. The present results suggest that this value may even be exceeded at the base of the tail near its junction with the coma.

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[2] *Mon. Not. Roy. Astro. Soc.*, 117, 590 (1957).

The α-β Transformation in Keratin

THE possibility of obtaining from X-ray diffraction results a quantitative estimate of the course of the α–β transformation as a keratin specimen is stretched is so important that attempts such as that of Bendit[1] are to be welcomed. I feel, however, that it is impossible to say the same about the proposal recently put forward by V. D. Gupta[2], who measures for specimens at various extensions the value of an index

$$\Omega = \frac{I_e - I_m}{I_e + I_m} \times 100$$

which he wishes to take as a measure of what he calls the "degree of order". So far as can be gathered from his somewhat ambiguous phraseology, the quantities I_m and I_e are the intensities of the meridional and equatorial diffraction spots, the former the group of reflexions with spacings near 5·1 A., and the latter the reflexions with spacings near 10 A. (common to the α- and β-photographs) and near 4·65 A. (characteristic of the β-photograph). If this interpretation of Gupta's intentions is correct, then changes in Ω are indications not so much of changes in the degree of order (whatever this might mean) as of changes in the β : α ratio. His conclusion that during stretching there is an initial rapid rise in the degree of order, with little further change at extensions greater than 40 per cent, should therefore be replaced by the almost trivial result (it was not so trivial 30 years ago) that the X-ray photograph at 40 per cent extension is more like that at 70 per cent extension than it is like that of unstretched fibres.

To talk about "degree of order" in a material like keratin, with its potentialities for changes of crystal structure, state of crystallite orientation, and crystallinity ratio, without making it quite clear whether some or all of these or some other unspecified characteristic of the material is involved, is, we consider, dangerous and misleading. If, for example, we agree to measure lack of order by the entropy, experiments on the elastic properties[3] indicate that in the initial stages of extension there is a *decrease* in the degree of order; I think that this is confirmed when the results of X-ray diffraction experiments are properly interpreted.

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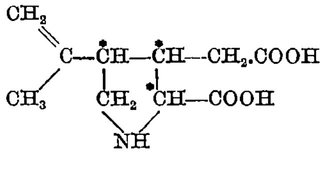
Structure of Kainic Acid and its Isomer, Allokainic Acid

IN 1953, Murakami, Takemoto and their collaborators[1] isolated the most active component of *Digenea simplex* Agardh which has been well known as an anthelmintic (vermifuge) for more than a thousand years. They named it kainic acid after 'Kaininso', the Japanese name of the mother alga. Kainic acid, $C_{10}H_{15}O_4N$, has an intense anthelmintic effect, about ten times that of santonin, without side-effects. In conjunction with chemical studies[2] to determine the structure of this interesting compound, we have carried out a structural determination by means of X-ray crystal analysis.

Following orthodox X-ray procedure the research was commenced with a salt containing zinc as a heavy atom. Zinc kainate crystallizes with two molecules of water in colourless prisms, which are orthorhombic. The space group was found to be $P2_12_12_1$, and the dimensions of the unit cell, containing four units of $C_{10}H_{13}O_4N$ Zn.2H_2O, were as follows: $a = 25·50$, $b = 6·93$, $c = 7·60$ A. By the trial-and-error method based on the presence of the heavy atom, electron-density projections along the *b*- and *c*-axes were derived, and the structure of kainic acid was found to be 2-carboxyl-3-carboxymethyl-4-*iso*propenylpyrrolidine, with the stereoconfiguration shown in the structural formula (asymmetric centres are marked by asterisks):



The structure of the molecule in the zinc salt is illustrated schematically in Fig. 1, where it is viewed along the *b*-axis.

In addition, we examined kainic acid itself. From water, kainic acid crystallizes with one water molecule, in colourless needles which are monoclinic. The dimensions of the unit cell were as follows: $a = 12·07$, $b = 5·86$, $c = 8·19$ A., $\beta = 94·7°$. The space group was $P2_1$, and the unit cell contained two units of $C_{10}H_{15}O_4N.H_2O$. By trial-and-error methods the electron-density projections along the three principal crystal axes were obtained, and the result was in

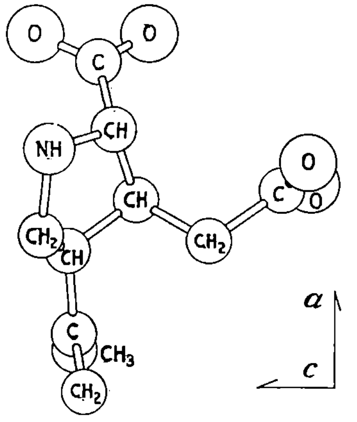


Fig. 1. The structure of the kainate anion

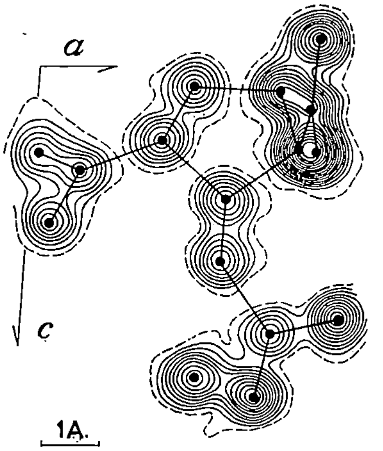


Fig. 2. The electron density of kainic acid monohydrate, projected on (010)

agreement with that for the zinc salt. The *b*-axis electron-density projection is shown in Fig. 2.

Furthermore, we analysed an isomer of kainic acid, allokainic acid, which is found also in *Digenea simplex* Agardh. It is weakly anthelmintic, if at all. Crystalline allokainic acid forms colourless prisms with no water of crystallization; the space group is $P2_12_12_1$, and the four units of $C_{10}H_{15}O_4N$ are contained in a cell of dimensions: $a = 26 \cdot 08$, $b = 5 \cdot 83$, $c = 6 \cdot 95$ A. The electron-density projections along the *b*- and *c*-axes were derived by the trial-and-error method. The stereochemical structure of the molecule is represented in Fig. 3, viewed along the *b*-axis. The structural relationship between the two isomers can be seen by comparison with Fig. 1. Accordingly, allokainic acid can be said to be a stereoisomer of kainic acid, differing merely in the configuration of one of its side-chains, namely, by reversal of the configuration at C_4 of the pyrrolidine ring. It is of interest that the anthelmintic effects of the two isomers are remarkably different from each other, due, apparently, to the dissimilar configurations of the *iso*propenyl side-chain.

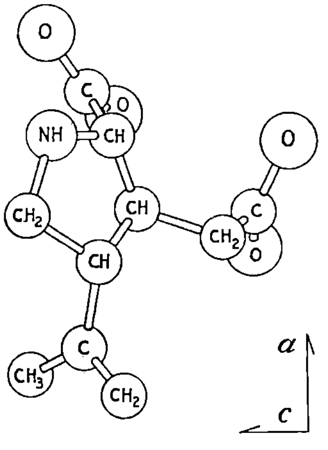


Fig. 3. The structure of allokainic acid

These X-ray results completely coincided with the conclusions[2] deduced from the chemical behaviour. This work will shortly be published in detail in the *Bulletin of the Chemical Society of Japan.*

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Colour Filters for the 4358-A. Line of the Mercury Discharge Spectrum

In connexion with other work[1], experiments have been carried out with the aim of obtaining an improved filter for the 4358-A. line of the mercury discharge spectrum which is of interest for photochemical and spectroscopic investigations.

We have found that a solution filter consisting of 9 : 10-dibromoanthracene (or 9 : 10-dichloroanthracene) and of crystal violet perchlorate in suitable concentrations and solvents will separate the 4358-A. line with a transmission of 80 per cent almost completely from all other lines of the mercury discharge lamp, including that of the intense neighbouring 4047-A. line.

Table 1 shows transmission data for various concentrations and thicknesses in ethanol–toluene solution (measured against air, if not otherwise stated).

Probably the most suitable filter containing 0·0125 per cent crystal violet perchlorate and 0·02 per cent 9 : 10-dibromoanthracene has a transmission in a 1-cm. cell measured against air at the mercury lines of 5790 ($<10^{-10}$), 5461 ($<10^{-10}$), 4358 (81 per cent), and 4047 A. ($<10^{-4}$). Reflexion losses at 4358 A. represent an appreciable part of the transmission losses and are slightly greater if the solutions of the perchlorate and of dibromoanthracene are kept in separate cells. No precautions have been taken for their reduction. The pass-band (width of band at twice the intensity observed at 4358 A.) is 325 A. (against air) and 260 A. (against cell and solvent). This may be compared with the 42 and 1 per cent transmissions at 4358 and 4047 A., respectively, and with the pass-band of approximately 500 A. for the best copper salt/sodium nitrite filter suggested elsewhere[2] and the <5 per cent transmission at 4358 A. of the commercial filters available.

Table 1. TRANSMISSION DATA FOR FILTER CONTAINING CRYSTAL VIOLET PERCHLORATE AND 9 : 10-DIBROMOANTHRACENE IN ETHANOL AND TOLUENE

Crystal violet perchlorate (per cent)	9 : 10-Dibromoanthracene (per cent)	Solvent	Cell	Per cent transmission at λ, A.			
				5790	5641	4358	4047
0·025	0·02	Ethanol/toluene (1 : 1)	2 cm.	0	0	58	0
			1 cm.	0	0	72	0
			5 mm.	0	0	83	~0·1
			2 mm.	< 0·01	< 0·01	85	4
0·0125	0·02	Ethanol/toluene (1 : 1)	2 cm.	0	0	72	0
			1 cm.	0	0	81	0
			5 mm.	0	0	83	~0·1
			2 mm.	< 0·01	< 0·1	85	6
			1 cm.	0	0	88	0*
0·00625	0·02	Ethanol/toluene (1 : 1)	2 cm.	0	0	76	0
			1 cm.	0	0	83	0
			5 mm.	0	0	84	~0·1
			2 mm.	1·3	4	89	6
0·0125	—	Ethanol	1 cm.	0	0	78	0
—	0·02	Toluene	1 cm.				
0·0125	—	Ethanol	1 cm.	0	0	82	0*
—	0·02	Toluene	1 cm.				

* Measured against cell and solvent.

The light fastness of these filters has been investigated by exposure to the G.E.C., 400-W. Osram[3] and the very intense B.T.H., 240-W. Mazda lamp[4]. The cells containing the filters were sealed to prevent evaporation and to keep atmospheric oxidation to the minimum.

Table 2 shows the transmission changes of the filter in ethanol–toluene solution on irradiation in various conditions. The light fastness is particularly satisfactory when a sealed cell containing dibromoanthracene in toluene is placed in front of one containing crystal violet in ethanol.

Table 2. CHANGE IN TRANSMISSION ON IRRADIATION

Filter	Cell	λ, A.	Per cent transmission after exposure		
			(0)	Osram (20 hr.)	Mazda (6 hr.)
0·0125 per cent crystal violet and 0·02 per cent 9 : 10-dibromoanthracene in ethanol/toluene (1 : 1)	1 cm.	5790	0	0	0·2
		5461	0	0	2
		4500	67	62	68
		4358	81	71	71
		4200	62	61	58
		4047	0	0	0
0·0125 per cent crystal violet in ethanol	1 cm.	5790	0	0	0
		5461	0	0	0
0·02 per cent 9 : 10-dibromoanthracene in toluene	1 cm.	4500	57	56	57
		4358	78	77	75
		4200	54	56	51
		4047	0	0	0

The investigation has been carried out with the help of a research grant from the Paul Fund of the Royal Society, which is gratefully acknowledged.

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Agar as Specimen Carrier in Double-Beam Infra-Red Spectroscopy

METHODS for preparing specimens for infra-red spectroscopy are limited. A workable addition to the few techniques available should extend the usefulness of infra-red spectroscopy.

Pollen polysaccharides prepared by the Bencard Allergy Research Unit gave films too brittle to be transferred from the base on which they were dried when prepared by the method of Orr[1,2]. To prepare them for infra-red spectroscopy one of us (J. G. F.) adapted a method previously reported for preparing films of antigen–antibody precipitation patterns in agar[3]. The polysaccharides were incorporated in an agar gel which was afterwards dried to a film. Films for spectroscopy have been made by others from gelatine[4], polystyrene[5] and polyethylene[6].

An approximately 0·8 per cent stock agar is made from 'Oxoid *L*.10', thoroughly clarified by a previously published method[7] and the gel dialysed by soaking in several changes of distilled water. This appears to remove a band of unreproducible intensity in the 4·9μ region. Material for infra-red examination is dissolved or suspended in distilled water in suitable concentration and mixed with an equal volume of melted stock agar cooled to about 56° C. 2 ml. of the agar-specimen mixture is pipetted on to a siliconed glass plate, for example, a lantern slide cover glass, and spread out to cover the area within a 1½-in. internal diameter metal or plastic ring. Simultaneously, a control film is prepared in the same way with distilled water.

The agar is allowed to gel, the gels are cut free of the rings with a sharp-pointed blade, the rings removed and the plates with the gel disks air-dried overnight at 37° C. The dried films are coherent and can be lifted from the siliconed glass surface for mounting in cell holders. A film may be cut to a desired size by placing a lead spacer or suitably sized disk on it and ringing with a pointed blade. Alternatively, they can be mounted on annular linen gummed reinforcements of suitable size, care being taken to avoid contaminating or straining the film.

When made with non-crystallizing substances, for example, polysaccharides, the films are clear and transparent. When crystallization occurs, for example, with glycine and urea, it does not hinder spectroscopic examination. Films have also been prepared from substances in suspension, such as micro-organisms.

Agar films (Fig. 1) were examined in the Grubb Parsons double-beam spectrometer. Adequate cancellation of the agar spectrum and uniformity of optical density, as checked by film rotation, can be obtained if the films are dried under the same conditions.

Differences in spectra associated with methods of preparation and presentation of samples are recognized occurrences. The spectra for substances in agar

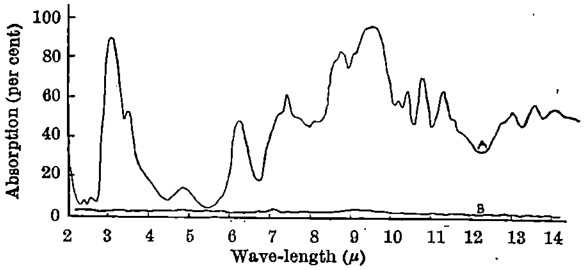

Fig. 1. Infra-red spectra of agar films. *A*, uncompensated single film ; *B*, difference spectrum of two films

films are characteristic of the method and reproducible, though differing in some details from those in potassium bromide disks (Fig. 2). Thus, in agar gel films the glucose spectrum loses some of its fine structure (also observed by Kuhn[8] in his vacuum-dried sugar preparations), and there is a reversal of the relative intensities of the $10 \cdot 9\mu$ and $11 \cdot 2\mu$ glycine bands.

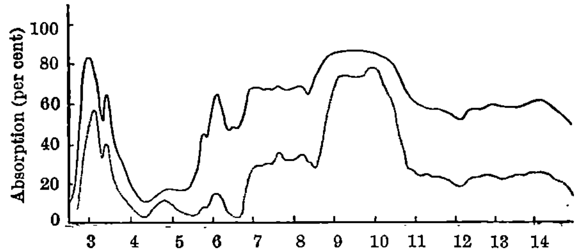

Fig. 2. Infra-red spectra of timothy grass pollen polysaccharide. · · · ·, agar films ; ——, potassium bromide disk

As the agar gel film technique is directly applicable to dissolved or suspended substances it may be particularly useful for process analysis and control.

No attempt has been made to control the water content of the films beyond the initial drying, but recent[9,10] observations on the effect of water content on infra-red spectra should be considered.

We wish to thank Mr. D. F. Lawson for photographing the spectra.

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A Rotating Hanging Mercury-Drop Electrode

THE work of Gerischer[1] and Delahay *et al.*[2] suggested to us the use of the hanging mercury-drop electrode as a rotating electrode. This electrode, used as a stationary electrode (as proposed by Ross *et al.*[3]), offers several distinct advantages over the conventional dropping-mercury electrode. The charging current is largely reduced, the current-voltage curve can be scanned in a shorter time and the curve-distorting oscillations are eliminated. However, used as a rotating electrode its advantages are even greater. The electrode owes its greater sensitivity to the accelerated diffusion of reducible species (thinner diffusion layer). Peak-formation in the current-voltage curve is prevented, because depletion of the reducible species in the diffusion layer of the electrode cannot occur. If desired, the curve can be plotted manually : it resembles the polarogram in its ideal form. Analysis of multicomponent systems offers none of the extra difficulties encountered with the stationary type[3], and compensation of the diffusion current of a more noble metal ion, preceding the diffusion current of the metal ion to be determined, is therefore possible. The reproducibility of repeated determinations on the same solution is comparable to or better than that of conventional polarography. It is possible to determine concentrations of reducible ions as low as $10^{-7}\,M$.

Fig. 1 shows the cell and the rotating electrode. The saturated calomel electrode is connected to the cell by means of a salt bridge containing a 3 per cent agar gel, saturated with potassium chloride; the end of the bridge also functions as stopper.

The cell is thermostated at 25·0 ± 0·1° C. Nitrogen may be either bubbled through or passed over the solution (when recording) through stopcock *K*. Details of the electrode are also shown in Fig. 1 : the platinum wire (diameter, 0·5 mm. ; length, 0·5 mm.) projecting from the end of a soft-glass tube is thinly plated with gold. Two drops of the conventional dropping-mercury electrode type can readily be attached to the plated platinum electrode and adhere even when the electrode is rotated at a speed of 750 r.p.m., provided the tip of the electrode is on the axis of rotation. A constant speed of rotation is necessary to obtain a constant diffusion current. The hanging mercury-drop electrode can be reproduced easily if necessary.

An example of a current-voltage curve of a two-component system ($10^{-4}\,M$ Pb^{++} and $10^{-4}\,M$ Cd^{++}

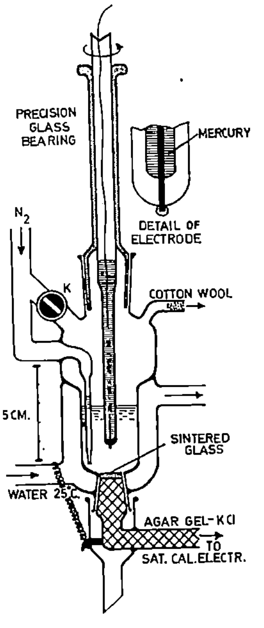

Fig. 1. Voltameter cell with detail of electrode

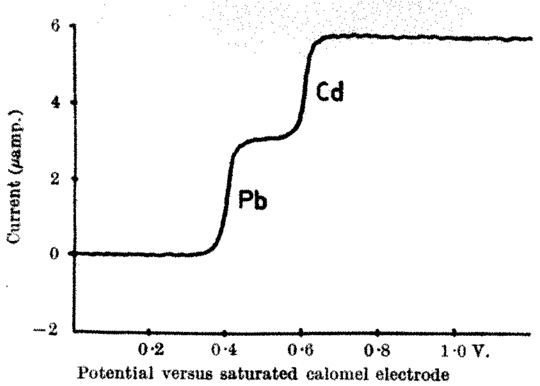

Fig. 2. Current-voltage curve of a two-component system (10^{-4} M Pb^{++} and 10^{-4} M Cd^{++} in 0·1 M potassium chloride at *c.* 500 r.p.m.)

in 0·1 *M* potassium chloride) is shown in Fig. 2. The voltage-scanning rate was equal to that commonly used in conventional polarography.

Further details of this electrode, which appears to be a useful analytical tool, will be published elsewhere. Since this communication was written, our attention has been directed to recent work by Delahay *et al.*[4] in which he used a rotating electrode in voltameter studies of anodic stripping.

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Detection of Triterpenoid Acids on Paper Chromatograms

In the course of an investigation of triterpene acids from natural sources it was necessary to devise tests for the detection of these compounds on alumina-impregnated filter paper.

A very convenient method is to spray the filter paper with a solution of phosphotungstic acid. Noller's reaction[1] has been used for the detection of triterpenoid compounds on filter paper; the Neher and Wettstein test[2] is also suitable for this. After spraying the paper chromatogram of triterpene acids with a solution of goat's blood[3], hæmolysis was observed.

The procedure is as follows. The paper chromatogram after development with the solvent is thoroughly dried by a current of hot air. It is next sprayed with a 25 per cent solution of alcoholic phosphotungstic acid and dried carefully for 2 min. in an oven kept at about 115–118° C. The paper then showed well-defined coloured spots against a white background; 3–5 μgm. of each component acid could be detected on the chromatogram.

Table 1. Colours of Spot Tests for Triterpene Acids

Substance	Alcoholic phosphotungstic acid (25 per cent)	Stannic chloride in thionyl chloride (1 per cent)	Zinc chloride in benzoyl chloride
Poliporenic acid *A*	Orange	Orange	Blue-purple
Glycyrrhetinic acid	Yellow-brown	Yellow-brown	Yellow-brown
Ursolic acid I	Pink-purple	Pink→violet	Pink→violet→blue
Betulinic acid	Brown-violet	Yellow-violet	Yellow-brown
Oleanolic acid	Pink-purple	Pink→violet→blue	Pink→violet→blue

The demonstration of triterpene acids on a paper chromatogram is also possible after treatment by the modified Noller reaction. Quantities of triterpene acids of about 5 μgm. on paper can be detected successfully after drawing the strip through a solution of 1 per cent anhydrous stannic chloride in pure thionyl chloride and heating it for 60–80 sec. at 85–90° C. Spots of different colours are obtained with the triterpene acids.

For the hæmolysis test, a solution of defibrined goat's blood in normal saline (1 : 8) is used. After spraying, the triterpene acids appeared as lighter spots on a tan background. In some cases, the spots become more distinct after the paper has dried and occasionally they were more readily discernible in transmitted light.

For the detection of triterpene acids on alumina-impregnated filter paper Gross's[4] and Belic's[5] reagents can be used. However, these reactions are not so useful in practice. Full details of this work will be published in *Chemia Analityczna* (Poland).

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Qualitative, Quantitative and Preparative Chromatography of Steroids on Fully Acetylated Paper

The majority of methods developed for the paper chromatographic separation of steroids involve impregnation of the paper with a relatively polar, non-volatile liquid, such as propylene glycol, formamide or 'Phenylcellosolve', a less polar liquid being used as the mobile phase. Some 'reversed phase' techniques have also been applied, in which the paper is rendered hydrophobic by impregnation with 'Quilon', paraffin oil, kerosene or silicone and the mobile phase is a relatively polar liquid. Impregnation of the paper is usually difficult to carry out in a reproducible way and therefore R_F values may depend on slight experimental variations. Moreover, impregnation with a non-volatile liquid may interfere in quantitative determinations.

Chromatography on acetylated paper has the advantage of requiring no such impregnation. The separation of various substances on partially acetylated paper has been described by several authors[1]. It is, however, difficult to obtain a homogeneous

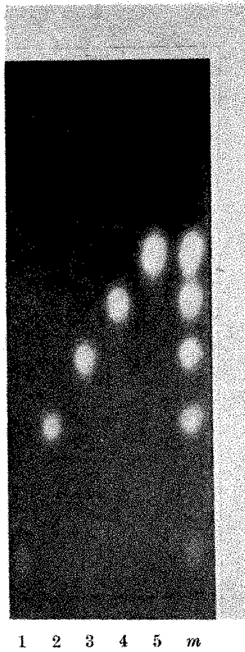

Fig. 1. Method *B*

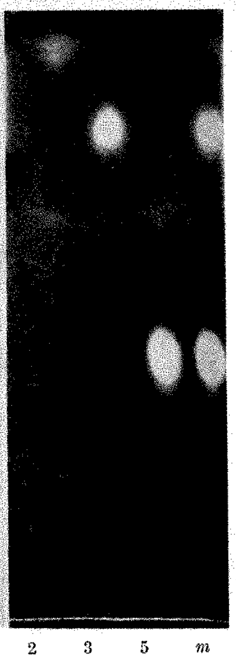

Fig. 2. Method *C*

Key: 1, Δ^4-Cholesten-3-one; 2, progesterone; 3, 17α-hydroxyprogesterone; 4, Reichstein's compound *S*; 5, hydrocortisone; *m*, mixture. Detection: sodium hydroxide fluorescence in ultraviolet (ref. 4)

partially acetylated paper and therefore irreproducible results are obtained. Recently, Zijp[2] described the identification and quantitative determination of rubber-antioxidants on fully acetylated paper, which is much more homogeneous.

We have obtained good separations of various groups of steroids on fully acetylated Whatman 1 paper, prepared by Zijp's method[3]. At first a one-phase mixture of benzene, methanol and water (1 : 10 : 3) was used as the mobile phase. Accommodation is not required in this case. The method is simple and quick, and reproducible R_F values are obtained, but some 'tailing' is usually observed (method *A*).

To prevent this, a two-phase mixture of benzene, methanol and water (4 : 4 : 1) was used, the lower layer (mainly benzene) being used for accommodation and the upper layer (mainly methanol) as the mobile phase (method *B*). A wide range of steroids from relatively weakly polar to strongly polar may be chromatographed in this way (Fig. 1).

It is also possible to use the upper (most polar) layer for accommodation and the lower layer as the mobile phase, so as to obtain 'conventional' chromatograms, in which the weakly polar steroids have larger R_F values than the stronger polar ones (method *C*). This method is especially convenient for the separation of strongly polar steroids such as the corticosteroids, but steroids less polar than progesterone move with the front (compare Figs. 1 and 2).

The R_F values (Table 1) seldom diverge by more than 0·02 from the average. The method has been applied to male sex hormones, progesterone, corticosteroids and their acetates, bile acids, cholesterol and oxidation products of cholesterol. The ascending technique was used in all cases.

Table 1. R_F VALUES OF STEROIDS AFTER CHROMATOGRAPHY ON FULLY ACETYLATED PAPER

Steroid	Method *A*	Method *B*	Method *C*
Testosterone acetate		0·27	
Δ^4-Androstene-3,17-dione		0·41	
Testosterone		0·57	
Progesterone		0·35	0·92
Deoxycorticosterone		0·45	0·80
17α-Hydroxyprogesterone		0·47	0·78
Reichstein's compound *S*		0·57	0·61
Cortisone		0·60	0·46
Hydrocortisone		0·68	0·39
Δ^5-Pregnen-3β-ol-20-one		0·40	
Deoxycorticosterone acetate		0·30	
Cortisone acetate		0·43	
Hydrocortisone acetate		0·51	
Deoxycholic acid	0·64		
Cholic Acid	0·74		
Cholesterol	0·33	0·10	
Δ^4-Cholesten-3-one	0·28	0·07	
7α-Hydroxycholesterol	0·59	0·38	
Δ^5-Norcholesten-3β-ol-25-one	0·42	0·31	

The same phase system may also be used for preparative purposes. Good separations have been obtained with thick paper (fully acetylated Whatman 3 *MM*) and with columns of paper disks or 'chromatopiles' (Schleicher and Schüll 2043 *a*, *vollazetyliert*). Experiments with columns of cellulose triacetate powder were somewhat less successful.

The quantitative determination after elution from the chromatogram and spectrophotometric evaluation at 242 mμ with respect to 240 mμ, showed that 80–120γ of cholestenone and progesterone may be determined with a relative error of less than 5 per cent.

A detailed report of this work will be published elsewhere.

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A Modified Technique in Chromatography

The methods usually adopted for the chromatographic separation of inorganic radicals on filter paper or an adsorbent column lead to the formation of coloured zones with diffusion fronts which are distorted and irregular. We have now developed a method for obtaining sharp, straight and evenly coloured bands for each one of the radicals separated. Strips of Whatman filter paper (No. 1), are dipped in a hot agar sol (2–4 per cent) containing reagents which react with the radicals to be tested. The strips are then removed from the agar sol and the excess sol drained off, leaving a thin layer of the sol on the surface of the paper, which solidifies to a gel on cooling. The paper strip thus prepared is then immersed to a height of 5 mm. in an aqueous solution containing the radicals to be tested (the concentration of the solution being 0·1 *N* with respect to each ion). As the electrolytes diffuse into the agar-gel impregnated filter paper containing the appropriate reagents, sharp, straight zones of the characteristic coloured precipitates are produced. When the layer of the gel coating on the paper is thick, these coloured bands show a fine structure due to Liesegang ring formation. In a run of four hours, bands of sufficient width for accurate measurement with a travelling

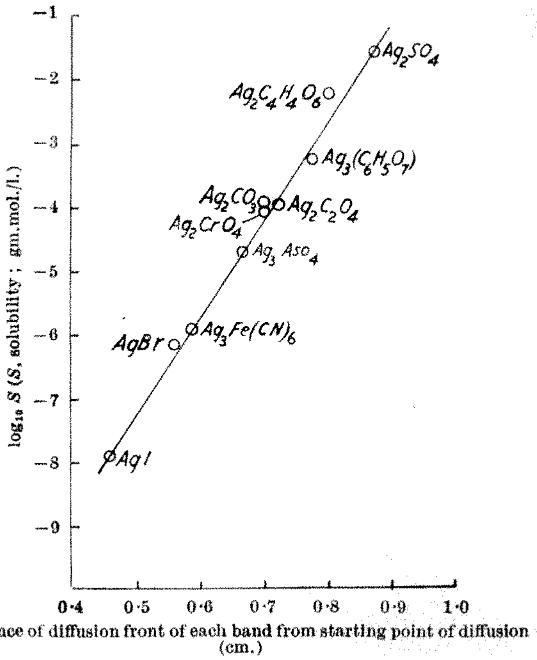

Fig. 1

microscope are produced in accordance with the solubility-product principle discussed previously[1].

Apart from the fact that a beautiful coloured band 'spectrum' is produced, the quantitative study of these bands has revealed a simple and striking relationship between d, the distance of the diffusion front of each band after a certain time from the starting point of diffusion, that is, the surface-level of the solution in which the gel-coated paper is dipped, and S, the solubility of the corresponding precipitate, namely :

$$d = a + b \log_{10} S$$

where a and b are constants. The validity of this relationship is brought out by the results represented graphically in Fig. 1.

Similar results have been obtained by allowing the electrolytes in the solution to diffuse for about six to eight hours into an agar gel layer containing the reagents spread on a glass slide. We have further observed that, when the gel layer is sufficiently thick (say 3–4 mm.), the individual coloured bands corresponding, for example, to lead, silver and copper chromates show a fine structure owing to their resolution into closely spaced lines corresponding to the Liesegang rings (see Fig. 2). The picture thus obtained is similar in appearance to an optical band spectrum viewed at high resolution.

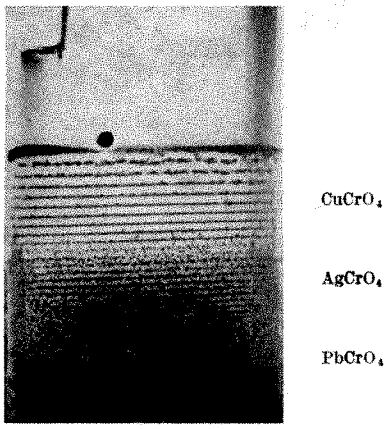

Fig. 2

We have thus worked out a new technique of chromatographic separation of inorganic ions, which also gives a new and simple method for the determination of the solubilities or solubility-products of various sparingly soluble substances. By this method we can separate the various hydrated ions in solution by their sizes ; for ions which on hydration have smaller sizes diffuse farther than those which, owing to their larger size, diffuse more slowly in accordance with the well-known diffusion equation.

In a previous communication[2] we have described a new method of determining the solubility products of sparingly soluble substances by means of the relation $\Delta v_\infty = c - b \log_{10} S$, where Δv_∞ is the limiting increase of volume observed on mixing dilute aqueous solutions of two electrolytes leading to the formation of the precipitate, and S is the solubility product ; c and b are constants. The change of volume, Δv_∞, indicates the water of ionic hydration released during the combination of ions, and is greatest for precipitates having the lowest solubility. Comparison of these results with those given earlier in this communication shows that the most insoluble inorganic precipitates are formed from hydrated ions having the largest size (including water of hydration), which consequently diffuse most slowly and produce the band in the 'chromatogram' nearest the surface of the electrolyte solution.

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A Solvent for the Paper Chromatographic Separation of Glucose and Sorbitol

GLUCOSE and sorbitol can be separated by paper chromatography in 7 hr. by means of a solvent mixture which is composed of nine parts (by vol.) of ethyl methyl ketone, one part glacial acetic acid and one part of water saturated with boric acid.

This solvent was elaborated because, of the many solvent mixtures described for the paper chromatography of sugars, none appeared to be particularly effective for the separation of these two substances.

We use the descending technique in chromatography jars held at a constant temperature of 22° C. Whatman No. 54 paper gives rather better results than Whatman No. 1 ; separations with this latter paper are also somewhat slower. The solvent has given good results in this laboratory for some two years.

The rates of movement of sorbitol and some other sugars on No. 54 paper, as compared with glucose (R_G = 1·0), are shown in Table 1.

Table 1

Sugar	R_G	Sugar	R_G
Sorbitol	3·0	D-Xylose	2·9
Mannitol	2·5	D-Ribose	7·0
D-Fructose	1·9	Maltose	0·2
D-Arabinose	2·0		

We wish to thank Prof. F. G. Gregory and Dr. H. K. Porter for their encouragement and interest in this work.

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Chromatographic Separation of Œstriol, Œstrone and Œstradiol-17β

Non-ionic adsorption of aromatic substances on ion exchange resins discussed by D. E. Weiss[1] has been successfully utilized by me for the chromatographic separation of aromatic compounds, for example, alkylated phenols[2] and N-2 : 4-dinitrophenylamines[3], on the column of carboxylic acid type cation exchange resins, 'Amberlite *IRC*–50' and 'Duolite *CS*–101' (*H* form). The technique has now been extended to the chromatographic separation of œstrogens using partially esterified carboxylic acid type cation exchanger as adsorbent. About 30 ml. of 'Amberlite *IRC*–50' (*H* form: 200–300 mesh, screened wet in sodium ion form[4]) was boiled with 400 ml. of the mixture of ethanol and *N* hydrochloric acid (2 : 1 by vol.) for 40 hr. This partially esterified resin was washed with the mixture of ethanol and water (3 : 2 by vol.) and suspended in two volumes of the same mixture. The suspension was poured into a chromatographic tube and allowed to settle under gravity. A column 0·8 cm. in diameter and 62 cm. in height was used. Œstrogens were dissolved in the same solvent as that used for the packing of the column. 1 ml. of the solution was placed on the column and allowed to drain under gravity. Elution was performed with the same solvent and the effluent was collected in fractions of 40 drops. The ultra-violet absorption was measured at 280 mμ using a Beckman *DU* quartz spectrophotometer and plotted against fraction number (Fig. 1). The elution sequence was similar to that of reversed phase partition chromatography[5], the most polar component being eluted first. Recovery from the column was satisfactory and the elution pattern was reproducible. Since the condition of the column is unchanged after chromatography, the column can be used many times.

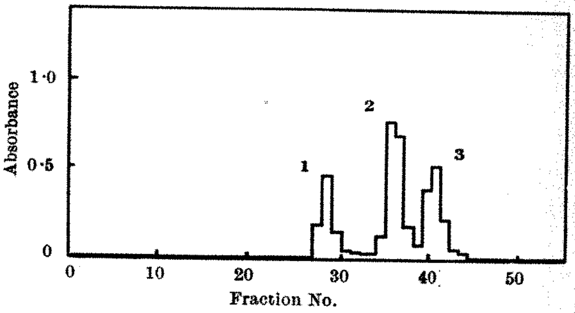

Fig. 1. Elution curve of œstrogens. 1, Œstriol; 2, œstradiol-17β; 3, œstrone. Flow-rate, 2 drops per min.; room temperature, 20° C.

Table 1. Recovery of Œstrogens from the Chromatographic Column

Œstrogens	Added (μgm.)	Recovered (μgm.)	Recovery (Per cent)
Œstriol	414	413	100
Œstradiol-17β	855	840	98
Œstrone	606	553	92

The application of this method for the quantitative analysis of urinary œstrogens is in progress and will be reported elsewhere.

I wish to thank Mr. K. Matsumoto for the generous gift of œstriol.

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Determination of Epinephrine and Related Compounds on Paper Chromatograms

The most sensitive chemical method for determining epinephrine in solution is the reaction with ethylenediamine. The reaction yields a number of products, several of which are fluorescent. These substances can be used for quantitative measurement. Nor-epinephrine produces a fluorescence of different colour so that mixtures of the two compounds can be determined by the selection of appropriate filters in measuring the fluorescent light[1].

The number of products formed in this reaction was determined by chromatographing the products produced by the interaction of the diamine and various catechols. This was done on paper by using as solvent 5 per cent ammonium hydroxide and *n*-propanol (9 : 1). There are three to five fluorescent pigments (depending on the conditions of the reaction) and several coloured but not fluorescent ones. We have observed that epinephrine yields some products different from those given by nor-epinephrine, but under these conditions of chromatography the products from catechol, nor-epinephrine, hydroxytyramine and epinine migrate similarly. Also, adrenochrome produces the same products as adrenaline, supporting the contention[1] that the catechol–ethylenediamine reaction involves oxidation.

The addition of ferricyanide or iodine to the ethylenediamine does not change the qualitative nature of the fluorescent pigments, but does increase the amounts formed. Presumably by rapid oxidation of the catechol, one can prevent other side reactions which decrease the yield of fluorescent compounds. This was the reasoning used in making this reagent.

Potassium ferricyanide (0·1 per cent in 5 per cent aqueous ethylenediamine) or iodine (0·01 *N* in 5 per cent aqueous ethylenediamine) are most useful as oxidizing agents. The alkaline iodine solution is stable (room temperature) for only a few days, whereas the ferricyanide solution is considerably more stable (weeks). After spraying with either of these solutions, the chromatograms are placed in an oven at 50° C. for 5 min. We have used the light produced by a 'Sylvania Blacklite Blue' fluorescent lamp for examining the chromatograms. By this method, one can readily detect 0·05 μgm. of a catecholamine.

For the quantitative evaluation of the fluorescence considerably more elaborate methods have been evolved. Instead of spraying the chromatograms, the dipping technique has been used. The strip is dipped first into a 1 per cent solution of iodine in carbon tetrachloride, blotted, and before it is completely dried, dipped into a 1 per cent solution of ethylenediamine in *iso*propyl alcohol, and again blotted. The strip is then hung to dry at room temperature. The fluorescence of epinephrine appears within 30 min. whereas that due to nor-epinephrine and other catecholamines is much slower. The maximal difference between background and epinephrine fluorescence occurs in about 24 hr. At that time, the strips were scanned by means of a mechanical device which pulls the strip past the beam of a Beckman *DU* photometer equipped with a photomultiplier tube. The output of the photocell is recorded on a strip chart recorder. The 417-mμ light produces the maximal fluorescence. The exciting light is removed from the beam by a Corning colour filter 4015. The areas under the peaks are related to amounts of catecholamines by the use of a standard curve[2].

For example, 1 μgm. quantities of epinephrine were placed on four one-inch strips of Whatman 1 paper and chromatographed using *t*-butanol/formic acid/water (40 : 1 : 10) as the solvent. After 40 hr. (strips were cut so that the solvent dripped from the end) the strips were dried and treated as described above. Under these conditions, areas of 132, 130, 126 and 138 cm.^{2} were measured on the strip chart record of the fluorescence on these chromatograms. (It should be noted that the absolute areas have no significance as they are determined by the sensitivity of the photocell, the slit width, the brightness of the exciting beam, etc., as well as the amount of material on the chromatogram. Thus, it is necessary to compare the areas from the scans on unknown chromatograms with those on known amounts, using the identical conditions of scanning.) Using the most sensitive techniques (brightest exciting light, most sensitive position of the photocell) one can estimate 0·03 μgm.; for example, four chromatograms, prepared in the above way with 0·3 μgm., gave areas of 33, 41, 31 and 27 cm.^{2}.

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Coding Problem in Proteins

In a previous publication[1] a hypothesis was proposed to the effect that if a nucleic acid serves as a template for the linear array of amino-acids in a protein, it prescribes only the positions to be occupied by the aromatic amino-acids in that protein. It was postulated that the planar rings of the aromatic amino-acids would be differentially bound in cavities formed by two adjacent bases in such a way that the aromatic amino-acids with only six-membered rings (group 1) would occupy the space between two pyrimidines and those with five-membered rings (group 2) would occupy that between two purines. This hypothesis imposes certain restrictions on the arrangement of these amino-acids in proteins. It requires that, sandwiched between a pair of aromatic amino-acids belonging to the same group, there will be either none or an even number of non-aromatic amino-acids, and that an odd number will separate aromatic amino-acids of different groups.

Much progress has been made in recent years in the elucidation of amino-acid sequences in proteins, affording further test for the restrictions imposed by the hypothesis. Phenylalanine does not conform to this scheme, and its position must therefore be specified in some other manner. However, with regard to the other aromatic amino-acids, tyrosine (group 1) and histidine and tryptophan (group 2), the spacing between the aromatic pairs is of the order required by the hypothesis in each of the twelve cases reported where such a test is possible. These sequences are listed in Table 1. If any arrangement of aromatic amino-acids were permissible, the probability of obtaining this result attributable to chance alone would be very small.

Table 1. AMINO-ACID SEQUENCES INVOLVING A PAIR OF THE AROMATIC AMINO-ACIDS

Insulin (refs. 2, 3)
  -TYR-glu-leu-glu-asp-TYR-
  -HIS-leu-cys-gly-ser-HIS-
  -HIS-leu-val-glu-ala-leu-TYR-

Corticotropin (ref. 4)
  -TYR-ser-met-glu-HIS-
  -TRY-gly-lys-pro-val-gly-lys-lys-arg-arg-
    pro-val-lys-val-TYR-

Melanophore-stimulating hormone (ref. 5)
  -TYR-lys-met-glu-HIS-

Glucagon (ref. 6)
  -TYR-ser-lys-TYR-

Hypertensin (ref. 7)
  -TYR-val-HIS-

Ribonuclease (refs. 8–10)
  -TYR-pro-asp-ala-cys-TYR-
  -TYR-lys-thr-thr-asp-glu-ala-lys-HIS-
  -TYR-glu-ser-TYR-

Silk fibroin (ref. 11)
  -TYR-pro-ser-TYR-

The non-randomness in the arrangement of the aromatic amino-acids offers support for the proposed coding system, although the lack of conformation of phenylalanine is a serious obstacle that must be overcome. It should be mentioned that phenylalanine stood apart from the other aromatic amino-acids even in the three protein sequences examined in the earlier paper. The observed restrictions suggest that the conclusion of Brenner[12], that "all amino sequences are likely to be found and that it will not be possible to effect a 'decoding' by discovering restrictions in sequences", may not be valid.

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* Operated by Union Carbide Nuclear Co. for the U.S. Atomic Energy Commission.

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Specificity of Crystalline Saccharogenic Amylase of Moulds

AMONG the saccharogenic amylases of moulds hitherto reported, γ-amylase of *Aspergillus awamori* Kitahara[1], gluc-amylase of *Rhizopus delemar*[2] and taka amylase *B* of *Aspergillus oryzae*[3] seem to be the most characteristic in their mode of hydrolysing starch. All these amylases, belonging to the group of amylo-(1.4)-glucosidases suggested by Schubert[4], have already been purified to a certain degree and reported as being able to split glucose directly from starch. γ-Amylase, however, has been known to leave a limit dextrin when it acts on amylopectin and to show no maltase activity. Gluc-amylase has been reported to hydrolyse soluble starch in such way that with the iodine colour test of the reaction mixture the blue colour still remains even after the starch, calculated as glucose, is more than 90 per cent hydrolysed. The enzyme has also been found to hydrolyse amylopectin almost completely to glucose and to exhibit maltase activity. Taka amylase *B*, on the other hand, has been reported as being similar to γ-amylase in the hydrolysis of amylopectin, but exhibiting maltase activity.

Recently, we have obtained in a crystalline state the two saccharogenic amylases of *R. delemar*[5] and of *A. niger*, of which the specificity of the latter is very similar to that of taka amylase *B* (Figs. 1 and 2), starting from the enzyme preparation that was isolated as almost the pure enzyme solution by the Svensson and Brattsten paper electrophoresis apparatus with the flow system[6]. The two saccharogenic amylases were completely free from α-amylase and both showed a single boundary in an electrophoresis experiment. The two crystalline amylases formed glucose directly from starch and hydrolysed maltose. They exhibited neither transglucosylation activity on a substrate of maltose nor were they able to hydrolyse *iso*maltose and dextran. However, as shown in Fig. 3, these amylases were found to hydrolyse panose(4-*iso*-maltopyranosyl-D-glucose), in which glucose and maltose were formed, the latter being hydrolysed successively to glucose and no *iso*maltose was produced. As for the panose-hydrolysing activity, however, the saccharogenic amylase of *R. delemar* was much stronger than that of *A. niger*, at an equal level of their starch-hydrolysing activity. Another difference between the two saccharogenic amylases was found in the limit of hydrolysis of soluble starch and amylopectin. The saccharogenic amylase from *R. delemar* easily hydrolysed these substrates, converting them almost completely to glucose; on the other hand, that from *A. niger* converted about 75 per cent of soluble starch and about 70 per cent of amylopectin, and an extremely large amount of the enzyme was required to increase these degrees of hydrolysis (Fig. 4). The crystalline amylase from *R. delemar* hydrolysed several kinds of substrates with the initial velocities in the following decreasing order: glycogen, amylopectin, soluble starch, α-dextrin, amylose, panose and maltose.

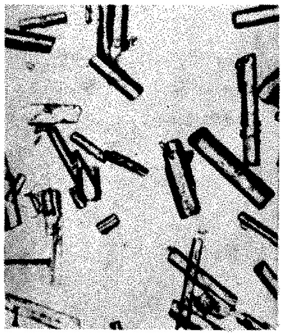

Fig. 1. Crystalline saccharogenic amylase of *R. delemar*

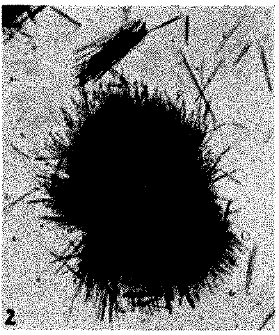

Fig. 2. Crystalline saccharogenic amylase of *A. niger*

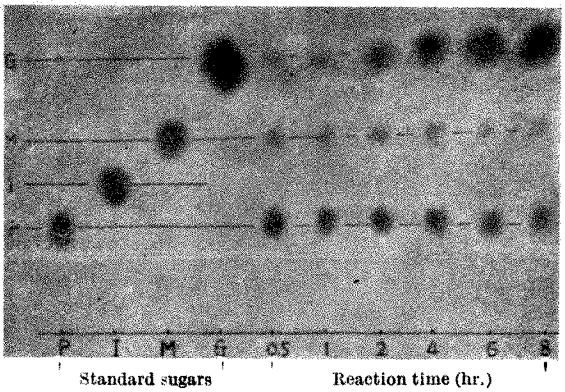

Fig. 3. Multiple ascending paper chromatogram of panose digests by crystalline saccharogenic amylase of *R. delemar*. Solvent, pyridine/butanol/water (2 : 3 : 1·5); standard sugars: *G*, glucose; *M*, maltose; *I*, *iso*maltose; *P*, panose

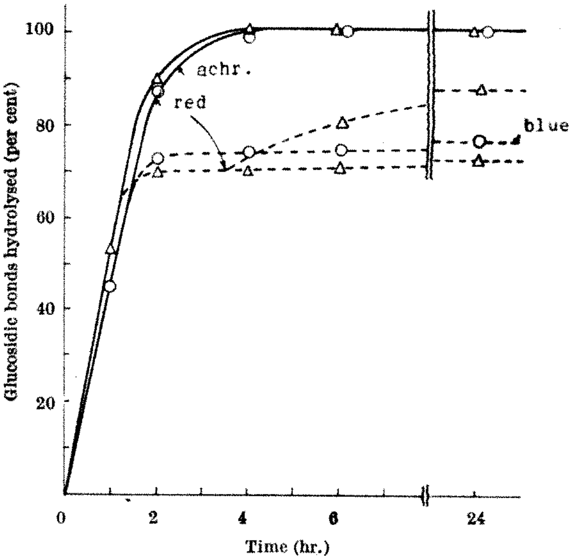

Fig. 4. Hydrolysis of soluble starch (○) and amylopectin (△) by saccharogenic amylases of *R. delemar* (solid line) and by *A. niger* (broken line). *Red* and *achr.* indicate the colour change of the reaction mixture from blue to red and to colourless respectively, by the iodine test. The long arrow indicates the addition of one thousand times the original amount of enzyme

Earlier, Underkofler[7] published an account of limit dextrinase, which appears to be consistent with that of taka amylase *B* of *A. oryzae*. Also, Yamasaki[8] and Ueda[9] have reported that the saccharogenic amylase system of *A. awamori* Kawachii completely hydrolyses several kinds of starches, and that the enzyme system consists both of saccharogenic amylases of *R. delemar* type and taka amylase *B* type. The limit dextrinase action or the ability to hydrolyse starch completely of such saccharogenic amylase as that of *R. delemar* might be explained by its powerful activity in hydrolysing panose, since amylopectin and its fission products by α-amylase appear to be hydrolysed, at first to α-1.6-linked oligosaccharides of panose type on their non-reducing ends by the amylo-(1.4)-glucosidase action of the amylase, and the oligosaccharides formed therein to be further hydrolysed by this panose-hydrolysing action.

We are indebted to Dr. K. Shibasaki, of Tohoku University, for supplying the *iso*maltose and panose used in this work.

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Degradation of Steroidal Sapogenins to 16-Dehydropregnan-20-ones

THE need for improving the reactions whereby steroidal sapogenins, now in abundant supply, are transformed into pregnane derivatives has recently been re-emphasized[1]. Earlier publications have dealt definitively with the entire sequence, so that the original Marker procedure has now been improved at each stage[2].

A modification offered here converts the sapogenin to its corresponding 16-dehydropregnan-20-one acetate, generally in 50–75 per cent yield of isolable product, without the necessity of separating any intermediates or changing the character of the reaction medium along the way. For example, 88 gm. of tigogenin was heated 25 min. with 450 cm.^{3} of acetic anhydride; 30 gm. of pyridine hydrochloride was added and heating continued for 3 hr. The mixture was cooled to 15° C., diluted with 50 cm.^{3} of acetic acid and 79 cm.^{3} of water and stirred while adding 54 gm. of chromic anhydride in 500 cm.^{3} of 90 per cent acetic acid. The temperature was maintained at 16–20° C. After standing at 25° C. for 3 hr. the solution was treated first with 31·5 gm. of 36 per cent formaldehyde and then with 80 gm. of sodium acetate. The stirred suspension was heated on the steam-bath for 1 hr., cooled in ice and diluted gradually with 3,000 cm.^{3} of cold water. A white, granular precipitate was collected, washed and dried; it melted at 120–150° C., weighed 82·1 gm. and by ultra-violet absorption contained 73 per cent of the 16-dehydropregnane. It was adsorbed from benzene on to fifteen parts of silica gel and the product eluted directly with 5 per cent ethyl acetate in benzene to give 51·6 gm. or 68 per cent of 3β-acetoxy-16-dehydro-5α-pregnan-20-one (melting point 162–167° C., $\epsilon_{\text{max.}\,(240\,\text{m}\mu)}$ 9,300 in methanol). When recrystallized twice from methanol, material of analytical quality (melting point 168·0–169·2° C., $[\alpha]_D$ 37·5° (chloroform)), $\epsilon_{\text{max.}\,(240\,\text{m}\mu)}$ 9,460 (see ref. 3), was obtained in an overall yield of 45 per cent (value extrapolated from smaller sample).

In other instances the initial heating with acetic anhydride has been omitted; also with smaller quantities the usual ether extraction of the final mixture has been used. Thus, 20 gm. of a mixture of ruscogenin and its C_{25} epimer gave 20·6 gm. of extractable material of which 11·2 gm. (59 per cent yield) of the desired 16-dehydropregnane, a glass[4] ($\epsilon_{\text{max.}\,(240\,\text{m}\mu)}$ 9,460) was obtained by direct elution with 5 per cent ethyl acetate. Hecogenin treated in the same manner yielded 59 per cent of crystalline 3β-acetoxy-16-dehydro-5α-pregnane-12,20-dione, (melting point 179–185° C.) from the eluates.

This method offers the advantages of speed and simplicity. It has been applied as a matter of routine to sapogenins and derivatives with uniform success.

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A Rapid and Specific Method for the Isolation of Pneumococcal Polysaccharide

THE report by Gessler *et al.*[1] on the use of a completely substituted ethane (trichlorotrifluoro ethane, 'Genetron 113'; obtained from the Division of Allied Dye and Chemical Corp., General Chemicals, Inc., New York) as a 'deproteinizing' agent in the purification of influenza virus, suggested to us that this solvent might have many uses. In particular, we were concerned with 'deproteinizing' bacterial cells with the consequent release of polysaccharides. In view of the observation that this solvent is not miscible with water and that pneumococcal polysaccharide is soluble in water, the following experiment was performed.

D. pneumoniae, type I, smooth-phase cells were grown on beef heart infusion agar, harvested in 18 hr., washed several times and the concentration optically adjusted to 10^9 cells per millilitre of buffered saline, *p*H 7·2.

One part of cells to three parts of solvent were agitated for ten minutes in the high-speed homogenizer at maximum speed, removed and then centrifuged at 1,500 r.p.m. for 10 min. Three layers resulted: (1) an upper aqueous layer, (2) a middle gel-like layer, and (3) a bottom layer of solvent. The upper water layer was removed and treated as above for three more successive solvent extractions. During such treatment further gel-like material was removed.

The final water layer was tested for immunological activity by use of the interfacial-precipitin test using antiserum prepared against whole smooth cells. A positive reaction resulted immediately upon contact.

After concentration by evaporation in a dialysis casing with a fan, it was determined that the material extracted was strongly Molisch-positive, ninhydrin-negative and upon paper electrophoresis showed no indications of containing protein. Moreover, ultraviolet absorption tests did not indicate any absorption at 2600 A., thus ruling out the possibility that water-soluble nucleoproteins might be present.

That the extract was not the *C* somatic polysaccharide was ruled out in two ways. With alcohol precipitation we recovered all the material in the water layer by the addition of 1·5 volumes of 95 per cent ethanol, and secondly, we did not obtain a positive precipitin reaction when rabbit anti-*C* anti-serum was employed.

Few data are available on the chemical and physical properties of this particular polysaccharide, and we examined only those properties which had been reported. The $[\alpha]_D$ of our material was +260° as compared to a reported[2] range of +253 to +278°. Acid hydrolysis followed by chromatography indicated galacturonic acid and an unidentified amino-containing material. Nitrogen values of 4·82 per cent were also obtained.

In view of the correlative findings obtained it is felt that a rapid and apparently specific method for the isolation of the pneumococcal polysaccharide has been obtained. With the present interest in bacterial polysaccharides (lipo-polysaccharide endotoxin studies) such a procedure might very well serve to obtain large amounts of microbial polysaccharides more rapidly and possibly more specifically than existing methods. One of us (A. S. M.) has also utilized this method for tissue polysaccharides and finds it just as specific. Experiments under way are designed to test the applicability of this method to a wide variety of microbial polysaccharides.

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A New Synthesis of Histidyl Peptides

Although many peptide groups containing L-histidine have been found in the biologically active substances, for example, insulin, ribonuclease, adrenocorticotropic hormones, etc., no satisfactory method for the synthesis of the histidyl peptide has been so far reported. As a starting material, N(α)-carbobenzoxy-L-histidine is not suitable except for the azide route[1], because it is scarcely soluble in the usual organic solvents. We have devised a simple synthetic method for the preparation of the histidyl peptide from dicarbobenzoxy histidine.

N(Im),N(α)-dicarbobenzoxy-L-histidine was prepared in 81 per cent yield from L-histidine monohydrochloride monohydrate and carbobenzoxychloride by the usual Schotten–Baumann method. In this procedure sodium carbonate was used as the condensation reagent instead of sodium hydroxide. The dicarbobenzoxyhistidine produced, which was readily soluble in organic solvents, was available for the synthesis of the histidyl peptide.

5 gm. of L-histidine monohydrochloride monohydrate was dissolved in 48 ml. of 1 *N* sodium hydroxide solution and, after addition of 5·3 gm. of sodium carbonate, 8·1 gm. of carbobenzoxychloride was added gradually to the solution with vigorous stirring at 0° C. for 1–1½ hr. As the reaction proceeded, the product was precipitated. The reaction mixture was allowed to stand at room temperature for ½–1 hr. with stirring. Then it was brought to *p*H 3·0 with 6 *N* hydrochloric acid. The gelatinous mass produced was separated from the supernatant by decantation and was triturated with 15–30 ml. of 99 per cent ethanol. The white crystals were collected and washed with 99 per cent ethanol. The yield was about 8·6 gm. (81 per cent). Recrystallization from acetone–water gave white needles of N(Im),N(α)-dicarbobenzoxy-L-histidine (melting point 103–105° C. (dec.); $[\alpha]_D^{14} = +34{\cdot}01$ (*c*, 28·99 mgm./ml. ethyl acetate); calc. for $C_{22}H_{21}O_6N_3.H_2O$, C, 59·86, H, 5·25, N, 9·52 per cent; found, C, 59·64, H, 5·11, N, 9·46 per cent; water of crystallization: calc., 4·08 per cent, found, 4·19 per cent).

The product is easily soluble in ethyl acetate, acetone, benzene, dioxane, tetrahydrofurane and chloroform, moderately soluble in ether, warm methyl alcohol and warm ethyl alcohol, and insoluble in water and petroleum ether. It is unstable in both alkaline and hot acidic solutions.

The carbobenzoxy groups were removed with hydrogen-bromide glacial acetic acid or with concentrated hydrochloric acid at 37° C., and the resultant product was found to be identical with the authentic L-histidine.

Some dicarbobenzoxypeptide derivatives were synthesized by Sheehan's method[2]. Derivatives of L-histidyl-O-benzyl-L-serine methyl ester, L-histidyl-L-leucine methyl ester, L-histidyl-L-threonine methyl ester, L-histidyl-L-glutamic acid diethyl ester and L-histidyl-L-methionine methyl ester were prepared from dicarbobenzoxy-L-histidine monohydrate and the corresponding amino-acid esters using dioxane or chloroform as a solvent in 81, 68, 79, 70 and 85 per cent yield, respectively. Melting points, specific rotatory power and analytical data of some dicarbobenzoxyhistidyl peptide esters are shown in Table 1.

It was shown in the preliminary experiment that dicarbobenzoxy-L-histidyl-L-leucine methyl ester underwent both saponification of ester and removal of the carbobenzoxy groups simultaneously by the treatment with concentrated hydrochloric acid at 37° C. for 50 min. and was converted to L-histidyl-L-

Table 1. Dicarbobenzoxy-L-Histidyl-L-Amino-Acid Esters

Peptide derivatives	Yield (per cent)[a]	Melting point (° C.)	Optical rotation	Analysis Found C	H	N	Calculated C	H	N.
Di-cbzo*-L-His-L-LeuOMe	68	101–3	+ 21·44[b]	63·14	6·31	10·44	63·26	6·22	10·18
Di-cbzo-L-His-O-Bz†-L-SerOMe	81	113–5	+ 19·80[c]	64·75	5·57	9·54	64·48	5·58	9·12
Di-cbzo-L-His-L-Glu(OEt)$_2$	70	78–80	+ 0·21[d]	60·42	5·92	9·06	61·17	5·96	9·19
Di-cbzo-L-His-L-ThrOMe	79	148–50	+ 12·74[e]	59·61	5·77	10·21	60·21	5·61	10·40
Di-cbzo-L-His-L-MetOMe	85	110–13	+ 9·07[f]	59·10	5·55	9·72	59·14	5·67	9·85

(*a*) Referred to the crystals primary obtained; (*b*) *c*. 29·0 mgm./ml. ethyl acetate; (*c*) *c*. 29·6 mgm./ml. ethyl acetate; (*d*) *c*. 28·5 mgm./ml. ethyl acetate; (*e*) *c*. 30·5 mgm./ml. glacial acetic acid; (*f*) *c*. 28·0 mgm./ml. glacial acetic acid, exceptionally at 22° C.

* cbzo, carbobenzoxy. † Bz, benzyl.

leucine (melting point 212–14° C. (dec.). Calc. for $C_{12}H_{20}O_3N_4$, N, 20·88 per cent; found N, 20·54 per cent).

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Electrophoretic Behaviour of *i*-Urobilin and Stercobilin

As the urobilinoid pigments *i*-urobilin and stercobilin are known to contain both basic and acidic groups, we have investigated their electrophoretic behaviour—yet unstudied—at various *p*H values. Paper electrophoresis was performed at 120 V., in acetate buffer (a mixture of *M*/5 acetic acid–sodium acetate buffer and 0·9 per cent sodium chloride solution) in the *p*H range less than 6·0, and barbital buffer (Michaelis sodium barbital–sodium acetate–hydrochloric acid buffer) at *p*H greater than 6·0; the positions of the coloured spots were observed directly during the procedure, but even minute quantities of urobilinoid pigments could be seen at the end of the run after spraying the papers with Schlesinger reagent (saturated zinc acetate solution in ethanol), and observing the green fluorescence in ultra-violet light. With the exception of the sharply defined *p*H value of 4·41 at which both urobilinoid pigments became immobile in the electric field, they moved towards the cathode at *p*H less than 4·41 and toward the anode at *p*H greater than this value, the direction of movement, which was the same for both pigments, being dependent only on the *p*H. However, the rate of movement of these materials differed at various *p*H levels: thus in buffers around *p*H 5·0 and at *p*H less than 4·41 stercobilin migrated faster toward the anode or cathode, respectively, whereas at higher *p*H values (8·6) urobilin was found to move faster than stercobilin in the anode direction.

As these substances are known to be ionized even at their isoelectric point[1], the basic and acid groups were found to be in equilibrium in the electric field around *p*H 4·41, but below this isoelectric point the direction of migration is determined by the ionized basic groups, and above this *p*H value by the ionized acid groups.

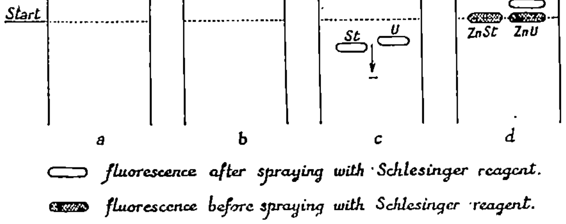
Start
St
U
+
−
ZnSt
ZnU
a
b
c
d
fluorescence after spraying with Schlesinger reagent.
fluorescence before spraying with Schlesinger reagent.

Fig. 1. Diagrams of electrophoresis paper strips. *St*, stercobilin; *U*, *i*-urobilin; arrow indicates migration in anodic or cathodic direction. Environment: (*a*) barbital buffer solution, *p*H 8·6; 7-hr. run; (*b*) acetate buffer, *p*H 5·5; 8-hr. run; (*c*) acetate buffer, *p*H 3·8; 4-hr. run; (*d*) electrophoretic behaviour of zinc complexes of urobilinoid pigments in barbital buffer, *p*H 8·6; 1-hr. run. Part of urobilin left the starting line

As the *pK* of stercobilin is known from spectrophotometric determinations[2] to be 8·0, at *p*H 8·0 only half the molecules of this substance are dissociated, whereas at the same *p*H *i*-urobilin characterized by *pK* 7·0 is far more completely dissociated, hence the greater mobility of the latter at *p*H 8·0, above its *pK*. This more acid character of *i*-urobilin and more basic property of stercobilin may be explained on the basis of the lactam structure of urobilinoid pigments proposed by Birch[3] and verified by Gray and Nicholson[4]. The NH-groups of the end rings attached to a conjugated system of double bonds in urobilin impart a greater acidity than the NH-groups in stercobilin behaving as ordinary amides. The nitrogen atom of an ordinary amide may more readily be protonated than the nitrogen atom of the end rings of urobilin; hence the faster migration of urobilin at high *p*H and of stercobilin at low *p*H.

However, the electrophoretic separation of stercobilin and *i*-urobilin is not yet sufficient for the practical isolation of either material from the other, but they may be isolated, with the aid of their electrophoretic behaviour, from mixtures containing the bile pigments.

The zinc complexes of the urobilinoid pigments were immobile during the electrophoretic procedure and could be detected at the 'start' position without spraying. However, their stability was limited, part of the pigments successively leaving the starting point and behaving as urobilinoids containing no zinc. The stability of zinc stercobilin proved more resistant to the action of the electric field than zinc *i*-urobilin.

I wish to thank Prof. C. J. Watson for sending samples of pure materials, as well as Dr. J. Toth for his valuable advice.

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A Possible Basis for the Anti-inflammatory Activity of Salicylates and other Non-Hormonal Anti-Rheumatic Drugs

RECENT studies have shown that sodium salicylate and acetyl-salicylic acid increase oxygen consumption in rats, rabbits and man[1-3]. Sproull has shown that both sodium salicylate and 2 : 4-dinitrophenol stimulate metabolism in mouse-liver slices[4], but has recently found a difference between the slopes of the concentration–response curves for the two compounds[5]. Reid has also directed attention to these similarities, and has shown that both compounds inhibit the growth of wheat coleoptiles[6]. Cochran[3] suggested that the stimulation of respiration by salicylate may be of fundamental importance in the therapeutic action of the drug.

2 : 4-Dinitrophenol is known to uncouple oxidative phosphorylation in mitochondrial preparations[7], and Brody[8] and Penniall *et al.*[9] demonstrated that sodium salicylate and acetylsalicylic acid also uncouple in very low concentrations. Smith and Jeffrey[10] pointed out that most of the previously observed effects of

salicylates on carbohydrate metabolism could be explained satisfactorily in terms of the uncoupling of oxidative phosphorylation.

The possibility occurred to us that the anti-inflammatory activity of non-hormonal anti-rheumatic drugs might be related to their capacity to uncouple oxidative phosphorylation. These ideas have recently been strengthened by the preliminary findings of M. J. H. Smith (private communication) that phenylbutazone in a concentration of 7·5 mgm./100 ml. completely inhibits the uptake of inorganic phosphate accompanying the oxidation of β-hydroxybutyrate by mitochondria prepared from rat-liver. At a concentration of 4 mgm./100 ml., phenylbutazone uncoupled oxidative phosphorylation to the extent of about 80 per cent.

The anti-inflammatory effects of a number of compounds have therefore been examined and compared with their reported ability to increase oxygen-consumption *in vivo*, or to uncouple oxidative phosphorylation *in vitro*.

For the measurement of anti-inflammatory activity we used a modification of the ultra-violet erythema test first described by Wilhelmi[11]. In this, a small area of the depilated back of a guinea pig was exposed for 20 sec. to the ultra-violet radiation from a Hanovia 'Kromayer' lamp. Animals received test-substances or saline by mouth 30 min. before irradiation, and 120 min. later the degree of erythema was estimated visually, and given a score 0–4. By using graded doses it was possible to obtain an approximate *ED*50 for those compounds which inhibited the erythema. Sodium salicylate, aspirin and phenylbutazone were all active in doses which were approximately related to their clinical anti-rheumatic doses.

The results obtained in this test, together with such data as are available on the effects of the compounds on oxidative phosphorylation *in vitro* and on oxygen consumption *in vivo*, are given in Table 1. The results for the effects of the compounds on oxygen consumption were obtained by Meade in rats[1], except for the information on 2 : 4-dinitrophenol, which was obtained by Reid[2] in rabbits. The data relating to the uncoupling of oxidative phosphorylation were obtained from Brody[8], except that for phenylbutazone[11] and 2 : 4-dinitrophenol[5].

Table 1. A COMPARISON OF THE EFFECTS OF A NUMBER OF COMPOUNDS ON THE INHIBITION OF ULTRA-VIOLET ERYTHEMA IN GUINEA PIGS, WITH OXYGEN CONSUMPTION IN RATS OR RABBITS, AND WITH THE UNCOUPLING OF OXIDATIVE PHOSPHORYLATION *in vitro*

Compound	Erythema inhibition. Approximate oral *ED*50 (mgm./kgm.)	Increased oxygen consumption *in vivo*	Uncoupling of oxidative phosphorylation
Benzoic acid	—	—	—
Salicylic acid	120	+	+
Acetylsalicylic acid	80		+
Methyl salicylate	320		+
m-Hydroxybenzoic acid	—	—	
p-Hydroxybenzoic acid	—	—	
2 : 3-Dihydroxybenzoic acid	—	—	+
2 : 3-Diacetoxybenzoic acid	—		
2 : 5-Dihydroxybenzoic acid (gentisic acid)	—	—	—
2 : 6-Dihydroxybenzoic acid (γ-resorcylic acid)	—	—	—
Salicylamide	—		—
4-Aminosalicylic acid	—		—
Phenylbutazone	12·5		+
Phenazone (antipyrine)	320		—
2 : 4-Dinitrophenol	—	+	+

+, Active; —, inactive; blank, not known.

It will be seen that there is a general parallelism between erythema inhibition, the increase in oxygen-consumption and uncoupling activity. The fact that the three most active non-hormonal anti-inflammatory compounds, experimentally and clinically, have been shown to uncouple, points to the possibility of a connexion between therapeutic activity and uncoupling.

Exact parallelism of the various properties is not to be expected since considerations of tissue distribution are likely to play a greater part in the *in vivo* tests than in the *in vitro* methods. Nevertheless, there are several inconsistencies. 2 : 3-Dihydroxybenzoic acid is inactive in our test and does not increase oxygen-consumption, though its capacity to uncouple was demonstrated by Brody who, however, found it to be less active than sodium salicylate. On the other hand, phenazone, which was slightly active in the erythema test, did not uncouple. The outstanding discrepancy, however, is the failure of 2 : 4-dinitrophenol to affect the erythema test. The explanation of this may lie in a difference between 2 : 4-dinitrophenol and salicylates in the site of uncoupling.

It is interesting, in view of the stress now being placed on the similarity of action of salicylates and 2 : 4-dinitrophenol, to note this different behaviour in a test which apparently bears some relationship to therapeutic efficiency.

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Direct Registration of an Instantaneous X-Ray Effect in Rats and Man

In order to study chemoprotection against radiation damage we tried to find radiobiological reactions as near as possible to the primary radiochemical process. In this we were guided by the assumptions that we must look for this in macromolecular systems and that we might find most radiosensitivity outside the domain of natural chemoprotection against oxidative or reductive radicals, that is, the respiring cytoplasm.

As radiobiological investigation of nuclear macromolecules does not easily lead to an instantaneously observable reaction, we restricted our research to a well-known system of extracellular macromolecules: the mucopolysaccharide matrix of the dermis connective tissue fibrils. The simplest way to study X-ray influence on the properties of the native matrix mucopolysaccharides is by collecting synovia and measuring its viscosity[1].

It was found that a moderate X-ray dose (500 r.) will at once decrease synovial viscosity by about

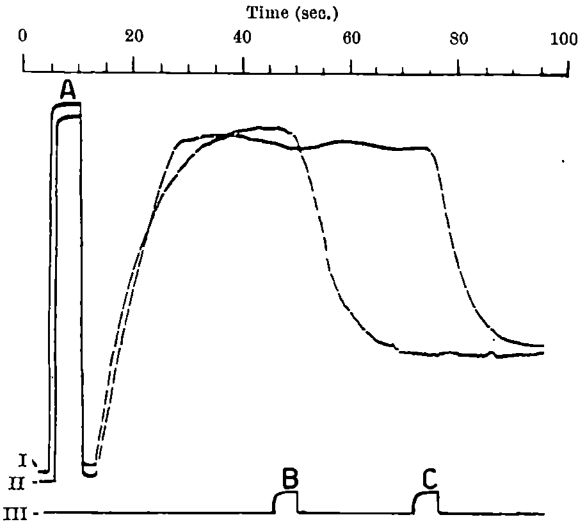

Fig. 1. Effect of X-irradiation on the intradermal injection pressure in the rat. I, II, pressure recordings of double injection apparatus. Injection with 0·9 per cent sodium chloride; III, irradiation signal; *A*, calibration (~ 100 mm. mercury); *B*, irradiation of I; *C*, irradiation of II. Dose-rate, 100 r./sec., 20 kV.

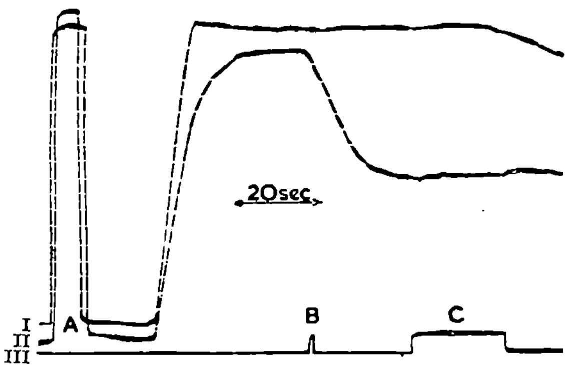

Fig. 2. Chemical protection by cystamine against the X-ray-induced pressure drop. I, II, pressure recordings of double injection apparatus. I, injection of 0·9 per cent sodium chloride with 0·01 per cent cystamine; II, injection of 0·9 per cent sodium chloride; *A*, calibration (~ 100 mm. mercury); *B*, irradiation of II; *C*, irradiation of I. Dose-rate, 100 r./sec., 20 kV.

20 per cent. It was also possible, by using an Epprecht Viscoprintmeter, to register a considerable drop in viscosity in 10 min. during irradiation with 200 r. per min. The radiation depolymerizing process is not complete, as addition of hyaluronidase to the irradiated product will cause a much greater depolymerization.

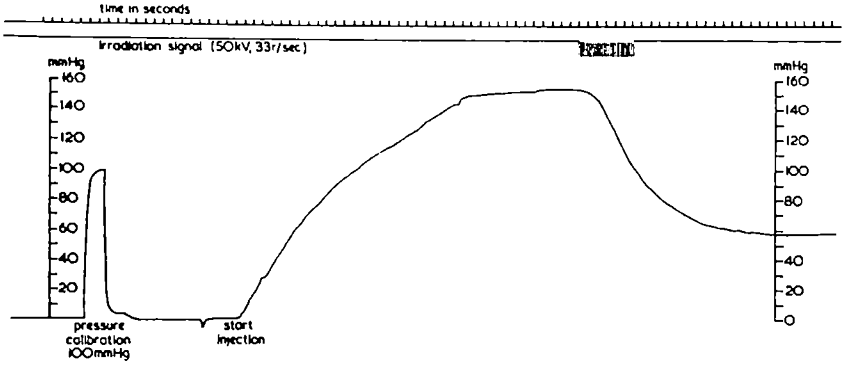

Fig. 3. Effect of X-irradiation on the intradermal injection pressure in the human forearm

We then applied similar or smaller X-ray doses to the mucopolysaccharide matrix in the rat's abdominal muscle fascia, the cock's comb and finally to rat and human dermis. We measured the effects by Day's permeability method[2] for the fascia, and registration of slow injection pressure for the others. The details will be described elsewhere[3].

Some results are given in Figs. 1 and 2. 1 ml. of saline was injected slowly, intradermally, at constant velocity, and the pressure set up by the matrix resistance to fluid motion was measured electronically. This pressure reached a constant level of about 100 mm. of mercury in 5–10 sec., and fell rapidly on irradiation at 100 r. per sec.

Fig. 1 is a photokymograph pressure record from a double injection apparatus, the needle tips being irradiated at *B* and *C*, in the nembutalized rat. Fig. 2 is a similar record, needle I injecting saline with 0·01 per cent cystamine and needle II serving as a control. Fig. 3 is a micrograph record of the slow injection of saline into the human volar forearm dermis. A distinct decrease of matrix resistance is seen with 200 r.

With a fine needle (No. 20) inserted well into the dermis connective tissue these phenomena are easily reproducible and well suited for the investigation of local chemoprotection. The results may be valuable for a more general chemoprotection.

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Changes in the Topographical Distribution of Glycogen in the Brain during Animal Hypnosis

Animal hypnosis is a general biological reaction of an inhibitory type, which is analogous to several syndromes of human psychopathological behaviour[1]. Its phenomenology is widely known, but its mechanism and metabolic basis remain unsolved[2].

A study of some of the problems of the mechanism of animal hypnosis has shown that at the onset an important part is played by certain functional units of the brain stem[3,4]. It is therefore possible to assume that the characteristic electrical manifestations of the brain-stem function are also related, in the course of this reaction, with metabolic processes which differ from the metabolism of other parts of the brain. As an indicator of changes in metabolic processes of different parts of the brain glycogen was chosen, because it is known that different functional states of the brain and different symptoms of behaviour are accompanied by changes in its concentration[5,6].

Animal hypnosis was evoked by a 180° rotation of rats about the vertebral axis in an apparatus which

Table 1. CONCENTRATION OF GLYCOGEN IN THE COURSE OF ANIMAL HYPNOSIS

Duration of animal hypnosis (min.)	Glycogen (mgm./100 gm.)*									
	Cerebral cortex	n	Diencephalon	n	Mesencephalon	n	Cerebellum	n	Medulla oblongata	n
0·01	91·5 ± 7·2	12	126·8 ± 6·8	12	133·2 ± 8·4	12	94·1 ± 9·1	10	144·3 ± 8·3	11
0·05			151·3 ± 6·1	8	142·4 ± 6·2	8				
0·10			161·7 ± 7·5	8	156·8 ± 7·4	7				
1·00	92·9 ± 10·3	9	184·2 ± 11·3	9	171·1 ± 9·4	8	86·8 ± 11·8	8	159·9 ± 9·7	8
1·10			173·4 ± 8·7	6	172·0 ± 7·1	6			162·2 ± 6·4	6
1·20			176·1 ± 6·4	7	183·2 ± 8·3	7			168·1 ± 8·8	7
1·30			182·0 ± 8·2	8	179·6 ± 6·2	8			179·6 ± 7·5	8
3·00	96·0 ± 8·1	8	190·2 ± 7·9	8	183·7 ± 8·5	7	89·4 ± 9·7	8	191·9 ± 11·3	8
8·00	94·3 ± 6·4	9	183·8 ± 7·8	8	187·2 ± 11·7	8	91·0 ± 8·3	8	188·3 ± 10·2	9

Control animals (awake): cerebral cortex, 89·6 ± 7·8 ($n = 19$); diencephalon, 128·1 ± 8·3 ($n = 21$); mesencephalon, 133·9 ± 7·4 ($n = 21$); cerebellum, 88·7 ± 7·8 ($n = 22$); medulla oblongata, 142·7 ± 7·6 ($n = 22$). n = Number of animals and of glycogen determinations.
* Mean ± standard error.

Table 2. CONCENTRATION OF GLYCOGEN AFTER AROUSAL FROM ANIMAL HYPNOSIS

Time after arousal (min.)	Glycogen (mgm./100 gm.)									
	Cerebral cortex	n	Diencephalon	n	Mesencephalon	n	Cerebellum	n	Medulla oblongata	n
0·01	90·1 ± 5·1	8	165·3 ± 7·9	7	172·0 ± 9·7	8	87·8 ± 7·4	8	151·6 ± 8·7	8
0·10			152·2 ± 9·2	10	160·8 ± 8·9	10			142·9 ± 8·2	10
0·20			133·4 ± 7·6	7	151·2 ± 10·8	6			134·8 ± 10·9	7
1·00			134·7 ± 9·8	6	130·9 ± 6·6	6			139·5 ± 9·6	6

Key as in Table 1.

makes possible a standard method of rotation. It is possible to attain in this way in the rat a state of sleep in a supine position which lasts for several minutes. The criterion of sleep evoked in this way is the absence of Magnus's righting reflexes which make the correct geotropic orientation of the animal possible. Animals were killed by decapitation into liquid air at various time intervals during hypnosis, as well as after arousal, and the concentration of glycogen was determined in the brain cortex, the diencephalon, mesencephalon, cerebellum and medulla oblongata by Kerr's method[7] except that the reduction compounds were determined after Nelson[8].

It can be seen from Table 1 that soon after the onset of animal hypnosis there is a significant increase in the concentration of glycogen in the diencephalon (after 0·05 min. $P < 0{\cdot}05$, after 0·10 min. and later $P < 0{\cdot}01$). Almost simultaneously glycogen begins to rise in the mesencephalon (after 0·10 min. $P < 0{\cdot}05$, after 1·00 min. and later $P < 0{\cdot}01$), while in the medulla oblongata significant changes appear later (after 1·20 min. $P < 0{\cdot}02$, after 1·30 min. $P < 0{\cdot}01$). There were no significant changes in the concentration of glycogen found in the cerebral cortex and in the cerebellum during the whole course of animal hypnosis.

As is shown in Table 2, there is a sudden decrease of glycogen in the medulla oblongata during arousal from animal hypnosis (the value after 0·01 min. is statistically not significant compared to the control). After 0·10 min. a decrease to values not significant when compared with the controls also occurs in the diencephalon. The same appears in the mesencephalon 0·20 min. after arousal. In general, the sequence in which the glycogen concentration returns to normal in topographically different parts of the brain after arousal is exactly opposite to the sequence of its increase during animal hypnosis.

The topographical distribution of changes in the glycogen concentration of the brain indicates that during animal hypnosis there are changes of the polysaccharide metabolism in the diencephalon, mesencephalon and the medulla oblongata, that is, in the brain stem structures, which according to electrophysiological findings also participate in this reaction. Similar changes take place in the course of natural sleep[4,9]. This finding, together with quite different changes in the topographical distribution of glycogen in the brain during pharmacological depression[10], indicates that animal hypnosis and natural sleep are probably similar forms of cerebral inhibition.

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Occurrence of Ornithine in Sulphur-deficient Flax and the Possible Place of Ornithine and Citrulline in the Arginine Metabolism of Some Higher Plants

ALTHOUGH arginine has been recognized as a constituent of higher plants for many years, both as a structural unit in the protein and as the free amino-acid, two other components of the 'ornithine cycle' of animals, citrulline and ornithine, were not considered to be normal constituents of these plants. Wada, in 1930, isolated citrulline from *Citrullus vulgaris* Schrad.; but it was not again reported in higher plants until 1952, when Virtanen and Miettinen[1] detected it in *Alnus incana* L. and *Alnus glutinosa* L. Citrulline is now known to occur as a free amino-acid in plants of a number of families.

Evidence of ornithine in higher plants remains fragmentary. It has been detected chromatographically in *Hevea brasiliensis*, Müll.-Arg.[2], *Atropa belladonna* L.[3], *A. glutinosa*[1] and *Asplenium nidus* L.[4].

I have proved the presence of free ornithine in sulphur-deficient flax (*Linum usitatissimum*) plants where it is associated with citrulline and a large accumulation of arginine. The plants were grown and the amino-acid content examined as previously described[5]. Free ornithine was first detected in the plant extracts by the position of the ninhydrin-positive spot on two-dimensional chromatograms and by its reaction with vanillin[6]. Isolation of a larger quantity of ornithine was then attempted. A preliminary separation of the basic amino-acids in the plant extract was effected by using displacement chromatography[5] on 'Amberlite *IR* 120' and '*IR* 410'. This procedure also allowed a separation of arginine, which was a major constituent, from the other basic substances. One-dimensional paper chromatography was used to follow the progress of the isolation. The basic mixture at this stage contained citrulline, ornithine, traces of lysine and two unidentified ninhydrin-positive substances. Dinitrophenylation of these substances was effected by shaking an alkaline aqueous solution with a slight excess of 1,2,4-fluorodinitrobenzene for 2 hr. at 40° C. Excess fluorodinitrobenzene was extracted with ether and the solution acidified to *p*H 2. 2,4-Dinitrophenyl ornithine was separated from the mixture by extraction with 5 per cent butanol in benzene (v/v). The 2,4-dinitrophenyl ornithine was finally purified by repeated crystallization from methanol. Comparison of the X-ray powder photographs of this and the 2,4-dinitrophenyl derivative of pure ornithine confirmed chromatographic evidence that ornithine was a constituent of the plant material. (Thanks are due to the Mining and Metallurgy Department of the University of Queensland for taking these photographs.)

The presence of ornithine in association with citrulline and arginine in sulphur-starved flax and the roots of *A. glutinosa*[1] suggests that the classical ornithine cycle, which is known to operate in the mould, *Neurospora crassa*[7], may be a factor in the nitrogen metabolism of higher plants. However, with few exceptions, it has not been possible to demonstrate the presence of the enzyme arginase in higher plants, and it would appear that the production of urea from arginine is not an important metabolic process in such plants. Nevertheless the association of ornithine with citrulline and arginine in flax and *A. glutinosa* is of interest, particularly when it is coupled with the observations of Coleman and Hegarty[8], who have shown that DL-ornithine-2-^{14}C is readily metabolized by white clover and barley, citrulline and arginine being formed in appreciable quantity. They concluded from their experiments that enzymes effecting the conversion were operative in white clover and barley, though their presence was not confirmed by isolation.

It is suggested that in sulphur-starved flax the accumulation of ornithine and citrulline occurs as a result of a disruption in arginine metabolism. In a number of micro-organisms, some of which lack arginase, arginine is synthesized from ornithine via citrulline[9]. The reaction sequence ornithine, citrulline, arginine in these organisms is then not restricted to urea formation, but represents a general pathway for providing the arginine of cellular protein.

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Influence of DDT and Lindane on Chordotonal Organs in the Cockroach

THERE has been much interest recently in stretch and strain receptors in Arthropods. Wiersma *et al.*[1] studied the responses of paired 'muscle receptor organs' in decapod Crustacea; these consist of

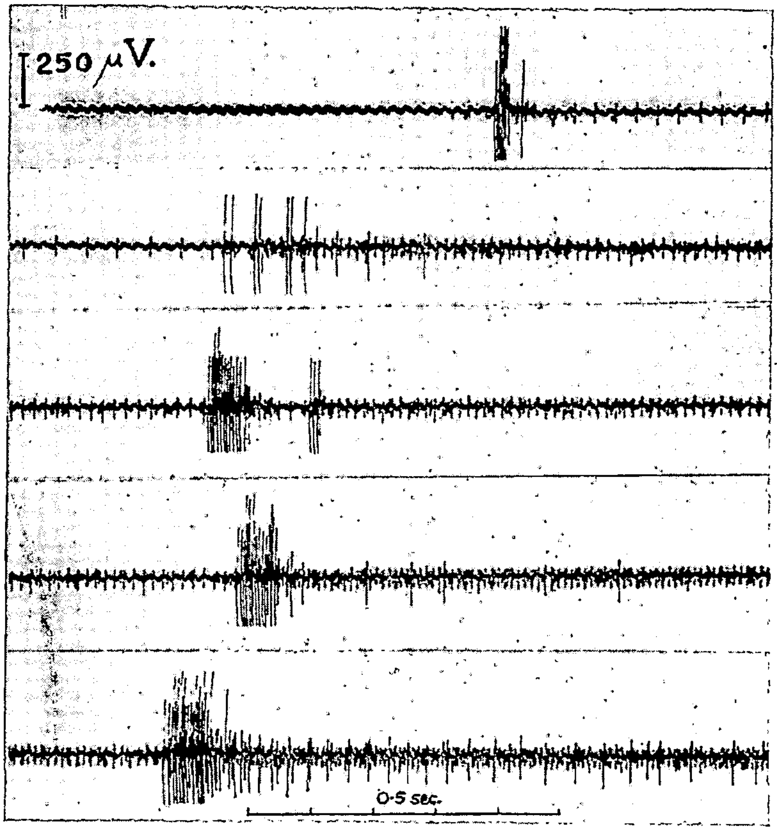

Fig. 1. Normal response of chordotonal organs in the coxa. Stepwise increase of mechanical tension produces an increasing frequency of small-amplitude impulses; the movement itself produces a burst of large spikes

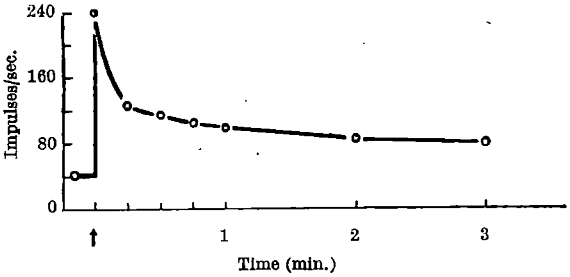

Fig. 2. Adaptation of a tonic receptor to constant tension. Tension applied at the arrow. Spontaneous activity 40 sec.$^{-1}$

muscle fibres with intercalated tendinous regions and are located dorsally in the abdomen and thorax. They found a slowly adapting unit response (tonic) and a comparatively fast adapting unit (phasic). According to Finlayson and Lowenstein[2], proprioceptors in the dorsal longitudinal muscles of the abdomen of some saturniid moths consist of modified muscle fibres, and show tonic but not phasic discharges. In *Limulus*, Pringle[3] recorded tonic discharges from proprioceptive nerve endings in the cuticle of the femoro-tibial joint, and obtained phasic responses from more internally situated chordotonal-like organs. Much histological information is available about internal stretch receptors in insects[4], but apart from Hughes's[5] work on abdominal chordotonal organs, their physiological properties are unknown.

The following observations on a stretch receptor in the coxo-trochanteral joint of the leg of the cockroach *Periplaneta americana* L. may be of interest. The anatomical situation and innervation of the chordotonal organs in the second thoracic leg have been studied in our laboratory by Nijenhuis and Dresden[6]. The coxal organs are surrounded by a group of flexor muscles and contain only a few scolopidia; they are stretched by extension of the joint. The largest of the three coxal organs is innervated by six moderate-sized fibres, and the two smaller organs by six small fibres.

Proximal hair plates which might complicate the results were removed, and the activity of the chordotonal organs was then recorded from the nerve (3*B*) with platinum electrodes, a pre-amplifier and oscilloscope. The organs at rest show a fairly constant spontaneous discharge of small amplitude and of frequencies up to about 50 sec.$^{-1}$. Extending the leg in steps produces a low-amplitude discharge, the frequency of which increases with increasing mechanical tension up to a maximum of 100–250 sec.$^{-1}$ (Fig. 1). In the first 15 sec. adaptation is rapid (to 30–50 per cent of the initial discharge frequency), and then becomes slower (Fig. 2); after 10 min. the frequency is still about 1·5 times that of the spontaneous activity in the normal resting position of the leg. The movement itself is accompanied by a considerable discharge, the frequency of these impulses depending on the speed of movement and reaching a maximum of about 250 sec.$^{-1}$. During flexion this activity is completely absent. The amplitude of the slowly-adapting (tonic) discharges seldom exceeds 250 μV.; that of the phasic impulses is generally greater than 500 μV. This difference may be correlated with the presence of smaller and larger chordotonal organs and their corresponding axons. We have been unable to discover the reflex function of these discharges, possibly because of the difficulty of realizing adequate experimental conditions for the functioning of the central nervous system.

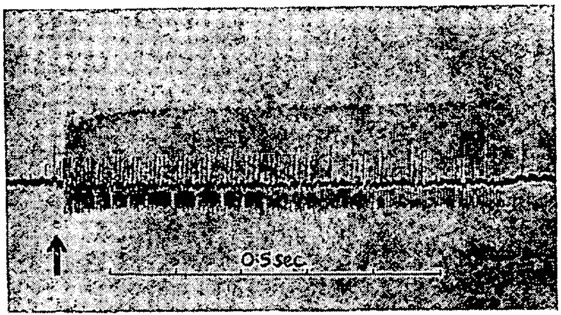

Fig. 3. A high-frequency train of impulses 1 hr. after the administration of 40 μgm. DDT. Movement indicated by the arrow

Toxicological observations have been made with some insecticides, the insects being poisoned by the injection of an emulsion. A high dosage of 30 μgm. lindane (*LD*50 = about 5 μgm.) produces a period of convulsions, followed within one hour by a stage in which the insect becomes almost completely paralysed and seemingly inexcitable. The sense organs, however, appeared to be unaffected, even after three hours. An entirely different result is obtained with DDT. A high dosage of 40 μgm. DDT (*LD*50 = about 25 μgm.) produced marked convulsions which were maintained throughout the experiment. In the first hour high-frequency 'trains' of action potentials (350 sec.$^{-1}$), as described by many authors (for example, Roeder[7]), could be observed both spontaneously and after mechanical stimulation (Fig. 3); the wide range of amplitudes (not illustrated) suggests that all types of fibre are excited. Later there was another remarkable feature of DDT poisoning;

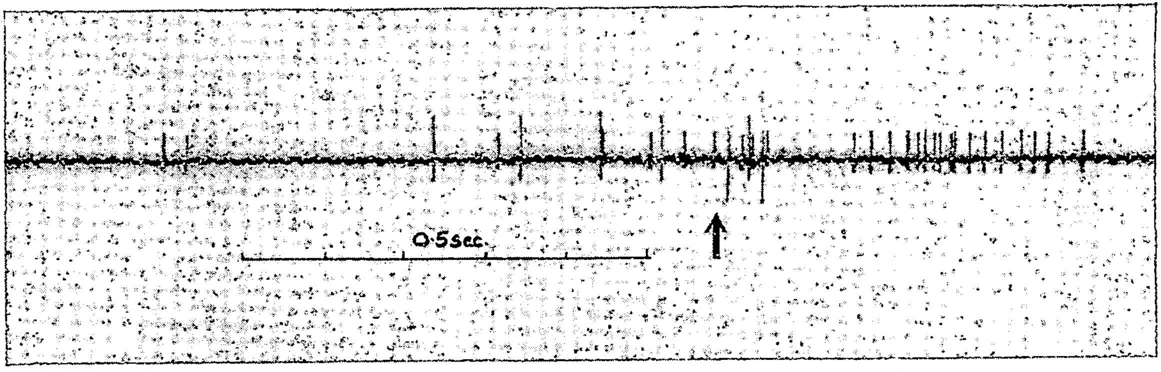

Fig. 4. The same preparation as in Fig. 3, but after 2·5 hr. Movement indicated by the arrow

the continuity and regularity of the tonic discharges was lost and only short trains at low frequency (5–10 sec.$^{-1}$) remained. At this stage the phasic response is reduced to a few impulses (Fig. 4), and the range of amplitudes becomes reduced, showing that there are fewer active fibres.

The preparations usually survived for many hours. The simplicity of the experimental procedure and the regularity of the responses make this preparation a very convenient one for physiological and toxicological investigations.

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Direct Determination of the Active Phase of End-Plate Potential

IT is well known that the duration of transmitter action in neuromuscular transmission is very brief, of the order of 4 msec., and prolonged decline of the end-plate potential is due to the slow dissipation of charge along and across the resting membrane[1-4]. The time course of the active phase of the neuromuscular transmission has been calculated by some authors[1,3], but it has not yet been obtained experimentally. In the present investigation the time course of the active phase of the transmitter producing the end-plate potential was recorded by a refined voltage clamp method (the original method was described by Hodgkin *et al.*[5]).

Two microelectrodes filled with 3 *M* potassium chloride were inserted into the end-plate focus of the curarized frog sartorius muscle. One of these electrodes recorded the membrane potential, and the feed-back amplifier regulated the current entering the other electrode in such a way as to hold the membrane potential at the resting value during the neuromuscular transmission. The membrane potential and the current which flowed through the current electrode were recorded with a double-channel oscilloscope. The focus of the end-plate was carefully located with multiple re-insertion of the electrode, and the current electrode was inserted within 50μ of the recording electrode. In order to increase the feed-back factor and also to reduce the capacitative escape of the feed-back current, a low-resistance electrode of about 5–10 MΩ was used especially for the current electrode. Fig. 1*a* shows the end-plate potential without feed-back and Fig. 1*b* the membrane potential clamped at the resting potential with negative feed-back and the feed-back current entering the current electrode during the neuromuscular transmission. The time course of the feed-back current represents the time course of the active phase, without electrotonic dissipation of charge, which produces the end-plate potential.

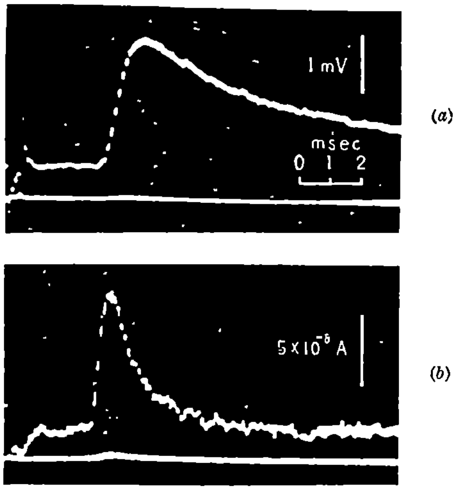

Fig. 1. *a*, End-plate potential recorded intracellularly from a curarized frog muscle; *b*, upper record—feed-back current flowing through the current electrode, so as to clamp the membrane potential at the resting value; lower record—the membrane potential held at the resting level with a voltage clamp method during the neuromuscular transmission. All records were recorded from the same end-plate using the double-channelled oscilloscope

The general time course of the current was very similar to that of the active phase obtained by calculation[1,3]. The duration of rising phase was about 0·5 msec., and the peak to half-decay time was 0·6–0·9 msec., the total duration being 3–4 msec., at 18° C. The time course was prolonged by lowering the temperature or eserinizing the preparation, as will be reported in a later communication.

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Abrasion of the Insect Cuticle by Aqueous Suspensions of Small Particles

I HAVE recently had occasion to require a standard or repeatable degree of abrasion of the cuticle of an insect, the larva of *Rhodnius*[1]. It was observed that in regions where excreta containing crystals of uric acid had dried on the surface, the cuticle appeared to be more permeable, suggesting that the drying of suspensions containing solid particles might produce abrasion. This was tested by applying suitable suspensions in distilled water, allowing them to dry in air, removing the particles in a stream of water and then testing for abrasion by exposure to ammoniacal silver hydroxide[2].

Process white (barium sulphate), 'Almicide' (fine crystalline aluminium hydroxide), 'Carborundum' 500, and activated charcoal were used as test materials. In all cases there was extensive abrasion of the surface as revealed by silver staining (Fig. 1). This abrasion was most evident over the crests of the folds in the cuticle, although the particles were deposited also in the depressions. Abrasion was usually

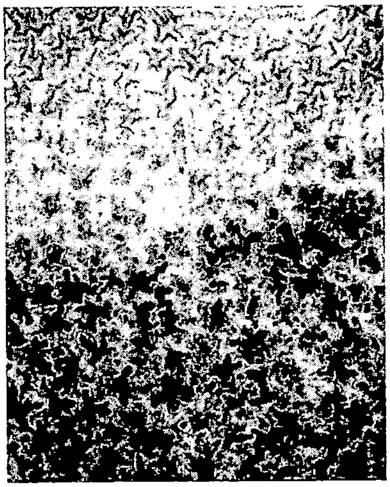

Fig. 1. Cuticle of fifth-stage larva of *Rhodnius*; intact insect immersed for 2 hr. in 5 per cent ammoniacal silver hydroxide. Upper half: normal, unstained. Lower half: area treated with alumina suspension; abrasion of crests of cuticular folds revealed by silver staining

most evident at the periphery of the dried deposit. The number of abraded points was naturally smallest with 'Carborundum' 500, where the particles are the largest. Abrasion does not occur if the powders are carefully applied to the surface in the dry state.

During the drying of these deposits the particles will be subjected to large surface tension forces. As the air replaces the water the particles or aggregates will be forcibly displaced first in one direction and then in another. The resulting abrasion would be expected to affect chiefly the crests of the cuticular folds and the margins of the deposit.

These observations have an obvious bearing on the entry of insecticides when crystals of poisons suspended in water are allowed to dry on the cuticle[3]; for abrasion of the surface facilitates the entry of insecticides[2]. They may also explain the increased loss of water from insects on which suspensions of activated charcoal have dried[4]. Indeed, it was suggested by Holdgate[5] that the increased transpiration observed by Glynn Jones[4] when suspended powders were allowed to dry on the cuticle might be due to abrasion brought about by surface forces.

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Determination of Glucose and Lævulose in Body-Fluids

THE current methods for the determination of monosaccharides in blood and other body-fluids are comparatively complicated and time-consuming. Moreover, they are more or less non-specific.

We have devised methods which are specially aimed at specific determination of blood glucose but which can also be used for a separate determination of lævulose. These methods employ condensation reactions between monosaccharides and certain aromatic amines to give coloured products in nearly water-free acid solutions[1]. The colours are characteristic and very suitable for colorimetry. Two new methods are described here: method *A*, using *p*-aminobenzoic acid as coupling reagent for the condensation; and method *B*, using *m*-aminophenol. These methods probably give principally different condensation products. *p*-Aminobenzoic acid reacts with aldosugars, such as glucose and galactose, and only to a small extent with ketosugars such as lævulose. *m*-Aminophenol reacts with both aldosugars and ketosugars.

(*a*) *Blood.* 0·1 ml. blood is pipetted into 1 ml. of a 5 per cent solution (method *A*) or 3 per cent solution (method *B*) of trichloracetic acid in water in a small centrifuge tube. The mixture is centrifuged.

Method *A*. 0·2 ml. of the clear supernatant is mixed in a 'Pyrex' test-tube with 4 ml. of a 5 per cent solution of *p*-aminobenzoic acid in glacial acetic acid. After heating for 15 min. in boiling water the tube is cooled and the absorbance measured against a reagent blank at 4700 A.

Method *B*. 0·1 ml. of the supernatant is mixed with 3 ml. of a 2 per cent solution of *m*-aminophenol in glacial acetic acid. After heating for 30 min. in boiling water the tube is cooled and the absorbance measured against a reagent blank at 5250 A.

(*b*) *Serum.* Precipitation of the proteins is not necessary for method *B*.

Method *B*. 0·01 ml. serum + 3 ml. *m*-aminophenol solution are treated as in *B* above.

(*c*) *Urine.* Method *A*. 0·002 ml. urine (or 0·1 ml. urine diluted 1/50) + 4 ml. *p*-aminobenzoic acid solution are treated as in *A* above.

Method *B*. 0·001 ml. urine (or 0·1 ml. urine diluted 1/100) + 3 ml. *m*-aminophenol solution are treated as in *B* above.

Ultramicropipettes, according to Sanz[2], can be used for the small quantities of urine. Each series of tubes should contain at least two standards of different concentration and one reagent blank.

Method *A* gives absorbances which are directly proportional to the sugar concentration between 50 and 1,200 mgm. glucose (or galactose) per 100 ml. blood or serum and between 0·1 and 6 per cent in urine. The colour is stable for at least three hours. The absorbance of lævulose is about 22 per cent that of glucose.

Method *B* gives absorbances which are proportional to the sugar concentration between 50 and 600 mgm. glucose (or galactose) per 100 ml. blood or serum and between 0·5 and 6 per cent in urine. The colour is stable for at least three hours. The absorbance with lævulose is about 138 per cent that of glucose.

The quality of some of the reagents is of utmost importance to the purity of the colour. The acetic acid must be free of both water and aldehydes, otherwise a false coloration of blank and samples is obtained. The blank must be practically colourless after boiling. The following brands of acetic acid have proved acceptable: 'Analar' p.a., 'Riedel de Haen' p.a., 'Skogen purum' (Skogens Kemiska AB, Kilafors, Sweden), but better results are obtained if the acid is redistilled. Acetic acid from some other manufacturers could not be used even after redistillation. The *p*-aminobenzoic acid causes no trouble: ours is from AB Ferrosan, Malmö, Sweden. It can be used directly, giving linear readings. The *m*-aminophenol at present available commercially is usually impure and has to be re-crystallized from toluene. *m*-Aminophenol, sufficiently pure for direct use, can be ordered from Ferrosan Co., Malmö, Sweden. The reagents must be made fresh every day.

The methods give different reactions with aldosugars and ketosugars, and consequently they can be used for quantitative differentiation between these two groups.

Added in proof. The wave-length at which *p*-aminobenzoic acid gives a linear standard curve and similar readings for the same concentration of glucose in blood and water varies with different brands of glacial acetic acid. As a routine method we definitely prefer method *B*.

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Deposition of Glycogen and Changes in some Enzymes in Brain Wounds

IT is well established that areas of fresh brain injuries are surrounded by a concentric zone showing a marked deposition of glycogen[1-3]. In the healthy adult mammalian brain, however, glycogen is scarcely demonstrable by routine histological fixation and staining methods, except for the paraventricular structures[4,5]. In addition to possessing a large amount of rather stable glycogen, the paraventricular structures reveal an evident action of phosphatases[6,7] and relatively slight activity of respiratory enzymes[8,9].

Stab wounds were made in the cerebral cortices of adult rats and the cerebri examined from 6 hr. to 21 days after the operations. For staining glycogen, animals were subjected to rapid intravascular perfusion fixation and the sections were stained with the lead tetraacetate–Schiff method[4]. (This method brought out not only glycogen in the paraventricular structures and in the brain wounds but also labile glycogen present in other portions of the brain.) Fresh frozen sections were used for histochemical demonstration of acid and alkaline phosphatases, 5-nucleotidase, phosphorylase, succinic dehydrogenase and cytochrome oxidase[3].

The lead tetraacetate–Schiff method, applied to paraffin sections of the brain, stains the mucopolysaccharide of the ground substance as well as glycogen similarly to the periodic acid–Schiff method. The stab wounds were surrounded by two distinct zones in 6 hr.–3 days, the inner Schiff-negative or slightly positive zone, deprived of ground substance, and the outer Schiff-positive glycogen-containing zone[2,3] (Fig. 1). After 3 days the inner zone began to diminish in extent and disappeared in 10 days. The outer zone showed moderate glycogen deposition in the intercellular ground substance, glial cells and capillary walls in 6 hr. The zone revealed the maximal glycogen accumulation at 3 days and was followed by a gradual decrease, reaching normal conditions in 14 days. In accordance with the result for glycogen, the outer glycogen-containing zone exhibited a gradual increase in activity of both phosphorylase (Fig. 2) and alkaline phosphatase (Fig. 3) for a period of three days in the intercellular ground substance and capillary walls. Afterwards it was followed by a diminution of both enzyme reactions. The same area showed, however, a slight decrease of succinic dehydrogenase activity (Fig. 4) from 1 to 3 days and subsequent gradual recovery. The reduced reaction could be estimated from the decrease in diformazan granules of smaller size compared with those in the adjoining healthy brain tissues (Fig. 4). The inner layer, deprived of mucopolysaccharide, showed a general decrease in activity of most enzymes tested, excepting a slight increment of 5-nucleotidase and acid phosphatase. With recovery of the wounds, the activity of all enzymes tested in the inner layer was restored to normal conditions. From about 7 days onwards edges of the wounds began to adhere to each other. The adhered linear portion revealed marked amounts of mucopolysaccharide and small amounts of glycogen granules. There were also increases in activity of alkaline and acid phosphatases, 5-nucleotidase and phosphorylase and a reduction of respiratory enzymes.

From these results it is clear that the glycogen deposition in the walls of the brain wounds is accompanied by the concomitant increase in activity of phosphorylase and alkaline phosphatase, and by a slight decrease in succinic dehydrogenase activity. It is suggested by several investigators[10,11] that glycogen deposition may be correlated with a poor oxygen supply or a high anaerobic metabolism. Friede[12] expressed a similar opinion that an increment of glycogen in the brain may be an indication

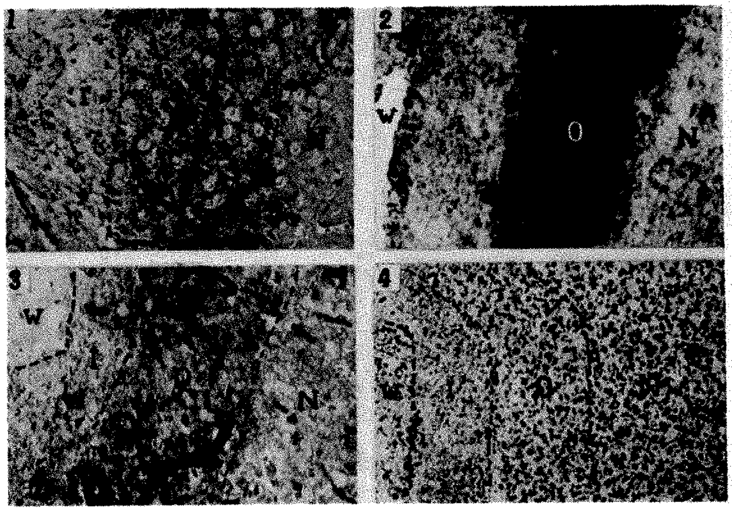

Fig. 1. The lead tetraacetate–Schiff method. Marked deposition of glycogen is observed in the outer layer, which occurs in the neuroglial cells, intercellular ground substance and capillary walls. The inner zone shows a decreased staining. × 125. Fig. 2. Takeuchi–Kuriaki's method for phosphorylase using iodine reaction. Enzyme activity is shown in the outer zone. × 150. Fig. 3. Gomori–Takamatsu's phosphatase method. Marked activity of alkaline phosphatase is demonstrated in the capillary walls and intercellular substance especially of the outer layer. × 150. Fig. 4. Seligman–Rutenburg's method for succinic dehydrogenase as modified by Rosa-Velardo. The inner layer reveals little, if any, activity, the outer layer somewhat weaker activity than the normal healthy brain tissue. × 150
All the sections were taken from brains three days after the stab wounds. *W*, wound ; *I*, inner layer ; *O*, outer layer *N*, normal healthy tissue

of lowered metabolic rate. Our histochemical observations lead us to suppose that glycogen accumulation, at least in brain wounds, may be correlated with the decreased oxidative metabolism and possibly with prevailing anaerobic glycolysis in the same localities. Apart from somewhat stable glycogen, either in the paraventricular structures or in brain wounds, adult mammalian brains contain variable amounts of labile glycogen, which are demonstrable only after intra-vital perfusion fixation. This labile glycogen co-exists with some respiratory enzymes[4,9]. The probable presence of at least two kinds of glycogen in the brain seems to be comparable with the results on the heart muscle and conducting system reported by Schiebler[13].

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Clearing Action of Lysolecithin

RECENT communications[1,2] indicate the growing interest in the properties of lysolecithin. Its clearing action on lecithin sols is remarkable, and mixed sols of lecithin and lysolecithin show an interesting viscosity maximum[3]. The lyso-compound has a considerable effect on the stability of lecithin sols in the presence of salts[3]. Neumann and Habermann point out[2] that the formation of lysolecithin *in vivo* could provide a mechanism for changes in cell membrane permeability.

In these laboratories, we are at present studying the physical properties of lysolecithin sols. Diffusion measurements indicate that the aqueous sols contain large micelles consisting of about 273 molecules of the monomer[4]. These large micelles can incorporate lecithin, and our diffusion measurements with mixed sols of the two phosphatides indicate that the mixed micelles are very much larger than those of pure lysolecithin.

The surface activity of lysolecithin is very high; 10^{-4} per cent wt./vol. in water gives a surface tension (Saunders, L., and Robinson, N., unpublished) of 66 dyne $cm.^{-1}$ at 20° C. It is this combination of high surface activity and large micelle size which makes lysolecithin so effective as a clearing agent for lipid sols.

By Hanahan's method[5], we have made batches of up to 15 gm. of lysolecithin, using Russell viper venom, for the gift of which we are indebted to Dr. A. C. White of the Wellcome Research Laboratories, Beckenham. However, we have found that the product does not give a clear solution in warm ethanol. Prolonged spinning of this warm solution in a high-speed centrifuge gave a residue of weight similar to the weight of venom used in the preparation. We therefore recommend that lysolecithin should be recrystallized several times from warm ethanol, clarifying the warm solution each time[3]. If this is not done, the product will contain traces of venom which will confuse the results of experiments in which the lysolecithin is brought into contact with lecithin sols.

The final product is a white solid, of crystalline appearance, which shows a parallel extinction under the polarizing microscope.

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Relative Distribution of the Mitochondria in the Two Types of Fibres in the Pectoralis Major Muscle of the Pigeon

IT has been noted that the pectoralis major muscle of the pigeon consists of two types of fibres, one of them a white, broad and glycogen-loaded variety, and the other red, narrow and fat-loaded[1], and that the lipase activity is much greater in the latter than in the former[2]. Recent studies conducted in our laboratories[3,4] suggest the presence of a well-organized fatty acid oxidation system in the breast muscle of flying birds. Since the mitochondria are known to be the seat of oxidative processes, it was thought desirable to study the relative distribution of the mitochondria in the two types of fibres in the pectoralis major muscle of the pigeon.

For the demonstration of mitochondria, Altmann's method, as described by Gray[5], was adopted. On observing the sections under oil immersion, mitochondria were found to be mainly located in the narrow fibres and extremely sparse in the broad ones. Chappell and Perry[6] reported that mitochondria in the breast muscle of pigeon constitute about 20 per cent of the total nitrogen of the muscle. Our work shows that the broad fibres, which make up not less than one-fifth the volume of the muscle, are poor in mitochondria. Evidently the main bulk of mitochondria obtained by Chappell and Perry must have come from the narrow fibres.

Studies on the cyclophorase preparation of skeletal muscle by Paul and Sterling[7] show that there exists a correlation between granule count and oxidative activity. Chappell and Perry[6] correlated the low oxidative activity of the rabbit muscle suspension with the low granule content, and suggested that this tissue (rabbit muscle) must be largely anaerobic in function.

From all these observations it is evident that the pigeon breast muscle is made up of two distinct components the morphological characteristics of which seem to be correlated with function. With the poor mitochondrial content associated with the high glycogen-load, lack of myoglobin and smaller surface area, the white broad fibres seem to be well equipped largely for functioning anaerobically. On the other hand, the high mitochondrial content, together with the large store of fat, greater lipase activity, the presence of myoglobin and greater surface area afforded in the narrow fibres, suggests that they have a well-organized oxidative system. Further work towards a clearer understanding of the potentialities of these two distinct types of fibre and their mitochondria is in progress.

One of us (R. M. N.) is indebted to the Government of India for the award of a Senior Research Scholarship, which made this work possible.

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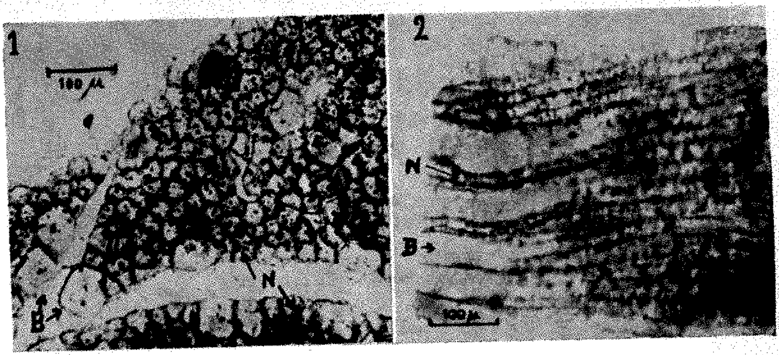

Photomicrographs of (1) a transverse and (2) an oblique section of the pectoralis major muscle of the pigeon showing the disposition of lipase. *B*, broad fibres; *N*, narrow fibres

Histochemical Demonstration of Lipase Activity in the Pectoralis Major Muscle of the Pigeon

Our earlier observation that the pigeon breast muscle contains a lipase[1] has led to the present attempt to demonstrate its presence in this muscle using histochemical methods. The 'Tween' method of Gomori[2] was chosen for the purpose. The substrate used was 'Tween 80' (Atlas). The incubation medium contained 2 ml. 10 per cent calcium chloride, 2 ml. 5 per cent 'Tween 80', 5 ml. bicarbonate buffer[3] of *p*H 8·4, 40 ml. distilled water and a crystal of thymol as preservative. The mixture was kept overnight in an oven at 40° C. and the precipitate formed was filtered off before use. Sections were incubated for 10–12 hr. at 40° C., which is the optimum temperature for this lipase[1]. Parallel experiments were run with sections of pancreas of the same animal for comparison and confirmation of the results. It was noted that acetone destroyed the lipase, and experiments with paraffin sections of tissue fixed in acetone yielded negative results.

A very simple method of preparing sections was adopted and was found to be highly satisfactory. The tissue was cut out immediately after decapitating the animal and placed over ice in the deep freeze of a refrigerator; it was frozen hard in less than half an hour, and without removing it from the deep freeze it was trimmed to shape and thin sections cut with the aid of a cold, sharp razor blade and transferred to an albuminated slide by means of a cold needle. Very thin sections without any appreciable loss of the enzyme in them could thus be obtained. After drying at room temperature to ensure adhesion, the sections were fixed for 16 hr. in cold (4° C.) 6 per cent formalin neutralized with phosphate[4]. They were then washed in running water for about an hour, washed with distilled water and incubated in the above incubation medium. The rest of the procedure was the same as described by Pearse[4]. Since the fibres were stained brown after treatment with ammonium sulphide, the sections were differentiated by treatment with a few drops of hydrogen peroxide in a Coplin jar of 70 per cent alcohol for a few seconds. The sections were not counterstained. Sections which were boiled for 10 min. were used as controls.

Fig. 1 shows the cross-section of a part of the pectoralis major muscle of the pigeon (*Columba livia*) in which the two types of fibres, a narrow and a broad variety, as described by George and Naik[5,6], are clearly discernible. The dark spots in the photograph represent the brownish black precipitate of lead sulphide. It can be seen that the precipitate is abundant in the fat-loaded narrow fibres, whereas the glycogen-loaded broad fibres contain very little. Control sections do not show any precipitate. It is therefore inferred that in the pigeon breast muscle the lipase occurs mostly in the narrow fibres. However, the occurrence of a few grains of the precipitate in the broad fibres is not convincing evidence that they are formed in the same fibres; study of a large number of sections indicates that these granules in the broad fibres are the result of diffusion of products of hydrolysis from the narrow fibres. Fig. 2, showing an oblique section of the muscle giving the longitudinal aspect of the two types of fibres, shows large areas of the broad fibres devoid of these precipitates. This supports the view that lipase is confined, by and large, to the narrow fibres, and very little, if any, occurs in the broad fibres. By contrast, in the pancreas, where lipase is known to be present in large amounts, the precipitate was found to be thickly dispersed throughout the section.

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Separation of Bull Spermatozoa carrying *X*- and *Y*-Chromosomes by Counter-Streaming Centrifugation

EXPERIMENTS[1] in which a small fraction (1/20–1/15) of the most easily sedimenting spermatozoa, separated by counter-streaming centrifugation, were used for inseminations gave the unexpected result that the 11 calves obtained from 23 first inseminations were all males. Recent experiments on a larger scale with the same technique have now been performed on semen from 10 different bulls. Whereas in the earlier experiments 1,100 r.p.m. was used, the separation in seven of the present experiments was performed at the same velocity and in eight at 1,000 r.p.m.

The total number of first inseminations with separated spermatozoa was 142, resulting in 63 calves (fertility 44·4 per cent). Compared with the fertility (60·5 per cent) of the corresponding control group (104 pregnancies from 172 first inseminations) this figure is rather low ($\chi^2 = 8{\cdot}26$, $P < 0{\cdot}01$). Of the 63 calves, 36 were females and 27 males (sex ratio 42·9). The sex ratio of this total group does not deviate significantly from the normal one for cattle (106 : 100)[2]. However, a review of the different experiments reveals a considerable variation in fertility, a high proportion of females being apparently associated with high fertility. Therefore the experiments were pooled in two groups, one with fertilities equal to or more than 50 per cent, and the other with fertilities less than 50 per cent. The fertilities for these two groups, 63·8 and 31·0 per cent, respectively, differ significantly ($\chi^2 = 14{\cdot}99$, $P < 0{\cdot}001$).

Of the calves belonging to the first group 28 were females and 9 males (sex ratio 24·3). The corresponding figures of the second group are 8 and 18 (sex ratio 69·2). Also the sex ratios of these two groups differ significantly ($\chi^2 = 12{\cdot}57$, $P < 0{\cdot}001$). This means that the spermatozoa of certain samples are damaged by the counter-streaming centrifugation, and that thereby the female-determining spermatozoa are more sensitive than the male-determining ones. Most probably the factor causing this damage is mechanical stress. This idea is supported by the fact that two groups of experiments which have been pooled according to the r.p.m. used differ significantly as to fertility (pooled samples separated at 1,000 r.p.m.: 53·6 per cent; pooled samples separated at 1,100 r.p.m.: 35·6 per cent; $\chi^2 = 4{\cdot}66, P = 0{\cdot}05$), the high velocity having decreased the fertility more than the low one.

In the light of the present results, the male predominance in the earlier experiments is more easily understood; the spermatozoa were submitted to 1,100 r.p.m. in these experiments.

The group of pooled experiments, having a fertility equal to or higher than 50 per cent, shows a sex ratio which deviates significantly from the normal one of cattle ($\chi^2 = 9{\cdot}31$, $P < 0{\cdot}01$). It thus seems possible to select viable-determining spermatozoa by running the counter-streaming centrifuge at a moderate speed.

In another series of experiments the spermatozoa most difficult to sediment were isolated at 1,100–1,200 r.p.m., and used for inseminations. Here also the female-determining spermatozoa have been eliminated more frequently than the male-determining ones in connexion with decreased fertility. No accumulation of male-determining spermatozoa could be detected in this fraction.

A more detailed account of this work will be published in *Acta Agriculturae Scandinavica*.

Financial assistance from the Swedish Agricultural Research Council is gratefully acknowledged. I am very much indebted to the A.I. Association of Enköping for allowing me to perform these experiments, and to the chief veterinarian, Dr. T. Svensson, and to Dr. K. Idla for most valuable co-operation. The counter-streaming centrifuge was run by Mr. P.-Å. Lindström. All information on the calves was collected by Miss G. Thelin.

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Structural Differentiation in the Nucleoid of Mature Vaccinia Virus

IT has been known for some time that mature virus particles of the pox group contain a brick-shaped central body, or nucleoid, surrounded by an outer layer of protein[1]. The fact that in pepsin-treated particles this nucleoid cannot be hydrolysed by deoxyribonuclease alone, but only by deoxyribonuclease followed by a further pepsin digestion, has been taken as an indication that the nucleoid itself contains protein as well as nucleic acid[2]. However, when mature vaccinia virus particles are examined with the electron microscope in thin sections after either osmium or ethanol–acetic acid fixation, the nucleoid presents a more or less homogeneous appearance[3].

In order to investigate further the nucleoidal structure of this type of virus, samples from pellets of purified vaccinia virus particles were dehydrated and embedded in methacrylate for thin sectioning, after fixation with buffered osmium-sucrose[4,5] at *p*H 7·6 or potassium permanganate[6] at *p*H 7·6, for about 1 hr.

Examination of the osmium-fixed particles served to give a point of departure for the work and confirmed the observations of Peters[3] on the general structure of the mature virus and the homogeneity of its nucleoid.

On the other hand, permanganate-fixed particles, although showing an overall internal arrangement similar to the foregoing, exhibited in addition two new features of interest. First, the outer zone of the virus, lying between the outer double-limiting membrane and the double membrane surrounding the nucleoid, appeared both much narrower and considerably less electron dense than in material fixed with osmium (Fig. 1); it is this zone which is usually considered to consist of the peripheral protein layer of the virus[3]. Secondly, and more important, the brick-shaped nucleoid within its double membrane was found to be strikingly differentiated into an inner and an outer region; the electron density of the former was great and that of the latter was slight (Fig. 1), being very similar in this respect to the peripheral protein layer of the virus. In view of this similarity, it is possible that the less electron-dense region lying within the double membrane surrounding the nucleoid might represent the protein constituent of this part of the virus, the nucleic acid corresponding perhaps to the very electron-dense

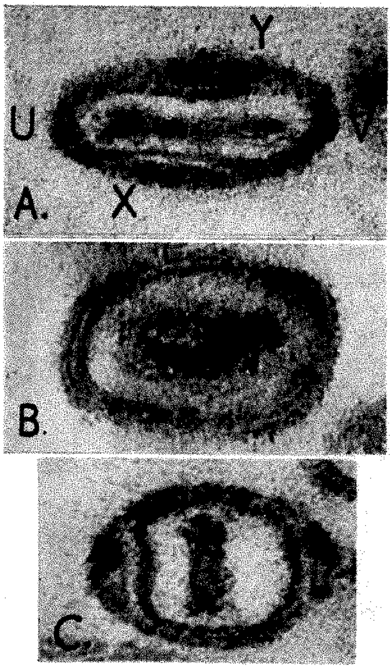

Fig. 1. Thin sections of mature vaccinia virus particles cut in various planes. *A*, Longitudinal section across the shortest dimension of the particle. *B*, Longitudinal section across the longest dimension of the particle; this is at right angles to plane of section *A*, along the line *U*—*V*. *C*, Transverse oblique section along the line *X*—*Y* shown in *A*. Permanganate fixation for about 1 hr. × 120,000. Note in particular the nucleoid within its double membrane showing a central electron-dense disk with a less dense region round about

disk in the centre. However, whatever the answer to this question may ultimately prove to be, the difference in response to permanganate fixation shown by different regions of the nucleoid of mature vaccinia virus particles reflects a definite underlying structural differentiation.

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Effect of Glycerol and Low Temperature on Survival of Unfertilized Mouse Eggs

Some unfertilized eggs of the rabbit are still fertilizable subsequent to cooling to temperatures as low as 0° C.[1]. In our attempts to preserve unfertilized mouse eggs at temperatures above and below freezing we have discovered that some of these germ cells survive exposure to −10° C.

The technique of transplanting unfertilized eggs from one female to another was employed in evaluating survival of these cells. Eggs obtained by induced ovulation of immature brown *C*57 females were experimentally treated prior to transplanting them into fertile, mated Bagg Albino (*BALB/c*) recipients where eye colour of the fœtuses served to identify them[2]. The medium used was modified Locke's solution (distilled water, 500 ml.; sodium chloride, 3·38 gm.; calcium chloride, 0·09 gm.; potassium chloride, 0·16 gm.; sodium bicarbonate, 0·05 gm.; dextrose, 0·36 gm.) containing 5 per cent glycerol by volume. Eggs were placed in 0·3 ml. of the medium in each of the 1·5-ml. glass ampoules used as containers. The ampoules, sealed by flame, were then clipped to fibre-glass canes which were immersed in an alcohol bath cooled to −10° C. by pieces of solid carbon dioxide. Glycerol facilitated supercooling and under these conditions the medium was free from ice at −10° C. during the storage periods. The experiment involved the transplantation of 180 eggs into 30 recipients. Results are summarized in Table 1.

Table 1. Survival of Unfertilized Mouse Eggs exposed to −10° C.

Exposure time (hr.)	No. of recipients		No. of transplanted eggs in pregnant recipients		
	Total	Pregnant	Total	Developed	Survival (per cent)
¼	12	8	48	8	17
2	13	7	42	3	5
6	5	4	24	0	0

In the light of current knowledge, the presence of glycerol in a medium designed to favour low-temperature preservation of germ cells seems desirable, perhaps essential. This substance has been found to favour survival of certain mammalian spermatozoa during cooling to and rewarming from sub-freezing temperatures[3]. Although its role as a protective substance against temperature shock in cooling above the freezing temperature is still not evaluated[4], its presence is compatible with survival of unfertilized mouse eggs[2] cooled to 5° C. There is some evidence that exposure of bull spermatozoa to glycerol at 5° C. enhances fertilization following insemination by them[5]. On the contrary, glycerol is said to be responsible for inhibition of fertilization in the fowl during the customary intravaginal insemination of glycerolated semen[6,7]. We recently reported that unfertilized mouse eggs shrank irreversibly at 5° C. in 5 per cent glycerol prior to transplantation, without deleterious effect[2]. According to permeability studies with other cells[8], this would indicate non-penetration by glycerol. We suggested that eggs might re-expand with the penetration of glycerol at the higher temperature in the recipients but this was not investigated. It was decided to ascertain whether or not the presence of glycerol within unfertilized mouse eggs is compatible with their survival as tested by production of normal progeny in the technique of egg transplantation.

Preliminary experiments showed that when eggs are placed in media containing 5 per cent glycerol by volume at 37° C. they shrink initially but quickly re-expand within 8–10 min. Therefore, eggs were exposed to 5 per cent glycerol in modified Locke's solution for 15 min., to ensure penetration, prior to transplantation. Samples of a harvest of eggs from which experimental eggs were obtained were inspected microscopically to check re-expansion phenomenon in each experiment. This phase included 10 recipients and 60 eggs, numbers sufficient for qualitative but not quantitative evaluation as to effect on fertility. Six out of the ten animals became pregnant. Autopsy of these six animals near term revealed that 14 per cent of these glycerol-containing eggs produced apparently normal progeny.

These results establish that: (1) some unfertilized mouse eggs can be cooled to, and stored at, −10° C. for at least 2 hr. in an ice-free medium without loss of functional activity; (2) the presence of glycerol within unfertilized mouse eggs does not prevent their fertilization and subsequent normal embryonic development.

Further details of this work will be included in our subsequent report on temperature shock and hypothermia in unfertilized mouse eggs which will appear elsewhere.

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Influence of Time of Mating on the Segregation Ratio of Alleles at the *T* Locus in the House Mouse

THE series of recessive alleles (*t* series) that have been shown to occur at the *T* locus in the house-mouse have aroused considerable interest because of their widespread distribution[1], their effects on embryonic differentiation[2], and their effect on the segregation ratio in males[3,4]. Males that are heterozygous for one *t* allele (that is, $+/t$ or T/t) have been found to sire litters in which the proportion of offspring carrying the *t* allele differs markedly from that expected on the basis of normal Mendelian ratios. In most instances the number of offspring inheriting the *t* allele is greatly in excess of expectation, but with certain *t* alleles the number may be lower than normal. The segregation ratio in females of these genotypes is normal.

Bryson[5] could find no evidence in favour of the suggestion[2] that the segregation ratio abnormality was the result of extra divisions in those spermatids that bore the *t* allele. Other hypotheses that have been put forward[3,6,7] have involved meiotic irregularities or gene conversion; but there is as yet no evidence to support them. Working on the assumption that the mechanism involved in this abnormality was of a physiological rather than a cytological nature and that it came into action only after the sperm had been introduced into the female genital tract, a study was made of the effect of varying the time of coitus in relation to the time of ovulation on the segregation ratio of the alleles *T* and *t*.

Outbred Swiss albino female mice were mated with males of the genotypes T/t^0, T/t^1, T/t^3 and T/t^{12}. Some of the females were caged continuously with a male (three females/male) so that coitus would occur at the normal time (which is about 5 hr. before ovulation[9]); other females were only permitted coitus during a 3-hr. period commencing several hours after the approximate time of ovulation—these are designated 'late-mated'. The mice were kept in a room in which the times of light and dark were automatically controlled so that the time of ovulation could be estimated[8,9]. In mice mated at the normal time, sperm penetration of the eggs begins about 8 hr. after coitus; but in mice mated several hours after ovulation this interval is only about 1 hr.[8]. The normal and late matings were carried on concurrently, that is, males were taken from the 'normal mating' pens for a 3-hr. period each day and placed in the 'late mating' pens. The segregation ratio of *t* and *T* was determined by examining the tails of the new-born offspring: in $+T$ offspring the tail is shortened, but it is normal in $+t$ mice. Many of the females had several litters so, in order to minimize any differences due to the females, they were used in different groups in successive pregnancies.

With each of the eight males tested the proportion of $+t$ offspring was lower after late mating than after mating at the normal time (Table 1), and with one exception the results from each male were highly significant. The mean litter size in the two groups was very similar (about 8·0). The reason for the insignificance of the difference between normal and late mating with male *C* is not clear. It is possibly related to the low fertility of this male—less than half of the females with which he copulated had litters. Two other features of the results should be noted. First, males of the same genotype tended to have very similar segregation ratios and, secondly, the segregation ratio of the T/t^3 male was normal (approximately 1 : 1) in normally mated females, but after late mating the proportion of $+t$ offspring was much reduced ($31 + t : 69 + T$).

These results suggest that the mechanism of the male segregation ratio abnormality in mice carrying a *t* allele has a physiological rather than a cytological basis, and that its time of action is between ejaculation and fertilization. It is not possible at this juncture to be more specific as to the nature of the mechanism. There are many possible hypotheses; but some of them have become unlikely as a result of concurrent studies on the infertility of males carrying two *t* alleles[10]. Further work is in progress. The present results provide evidence in support of the suggestion by earlier workers that the function of a sperm in the female genital tract may be affected by a single genetic locus in such a way that its chances of fertilizing an egg are radically altered. This finding has

TABLE 1. THE MALE SEGREGATION RATIO OF THE ALLELES *t* AND *T* AFTER NORMAL OR LATE MATING

Male	Genotype	Normal mating				Late mating				Significance of difference
		No. of litters	No. of offspring $+t$	No. of offspring $+T$	Ratio	No. of litters	No. of offspring $+t$	No. of offspring $+T$	Ratio	
A	T/t^1	11	53	16	77 : 23	9	39	35	53 : 47	$P < 0·01$
B	T/t^1	12	54	18	75 : 25	11	40	34	54 : 46	$P < 0·01$
E	T/t^0	11	90	22	80 : 20	9	42	26	62 : 38	$P < 0·01$
G	T/t^0	8	58	10	85 : 15	10	52	36	59 : 41	$P < 0·001$
C	T/t^{12}	9	40	5	89 : 11	9	71	13	84 : 16	N.S.
F	T/t^{12}	6	55	6	90 : 10	3	10	6	63 : 37	$P < 0·01$
I	T/t^{12}	8	67	5	93 : 7	5	29	12	71 : 29	$P < 0·005$
D	T/t^3	12	61	59	51 : 49	6	17	38	31 : 69	$P < 0·02$

a bearing on quantitative genetical theory, for one of the premises of this theory is that there is random union of gametes.

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Survival Curves for Male and Female House-Flies (*Musca domestica* L.)

DURING the course of a study on the biochemical changes accompanying ageing in the adult house-fly, the attention of the senior author was directed to the differential longevities of the male and female members of the common house-fly, *M. domestica* L. Paradoxically enough, a search of the literature revealed only scattered and inconclusive information on the longevity of this species under controlled laboratory conditions. Several authors have been cited by Roubaud[1] to the effect that the longevity of the house-fly can be extended to as much as 90 days by exposure to temperatures of 15° C. (59° F.); West, on the other hand[2], states in no convincing terms that the longevity of the house-fly varies from two to three weeks, at most, during the summer and up to three months during the winter months. A side study was therefore undertaken to obtain reliable vital statistics for the male and female members of this species, bred, reared and maintained under standardized laboratory conditions. This report will summarize briefly one phase of this study to be published, *in extenso*, at a later date.

The flies studied represent offspring from many generations of inbreeding of (standard laboratory strain) *NAIDM* flies from the Technical Development Laboratories of the United States Public Health Service (through the kind co-operation of Dr. Albert S. Perry). Results summarized in this communication cover more than 4,000 members of each sex (more than 8,500 flies in all), through nine successive generations; all were maintained, bred and reared (and permitted to age) at 80° F. and 45 per cent relative humidity in our laboratory as described earlier[3]. Eggs were collected from a standard medium when the parents were 4½–5 days old. Offspring were reared on this medium[3] and, under these conditions, emerged as adults exactly 14 days after the first appearance of the parent flies. Parents, as well as ageing flies, were maintained on a powdered whole-milk, sucrose and water diet (*ad libitum*) in bronze screen cages 7½ in. × 7½ in. × 16 in., under temperature and humidity conditions indicated above, in numbers of 150–200 of each sex per cage.

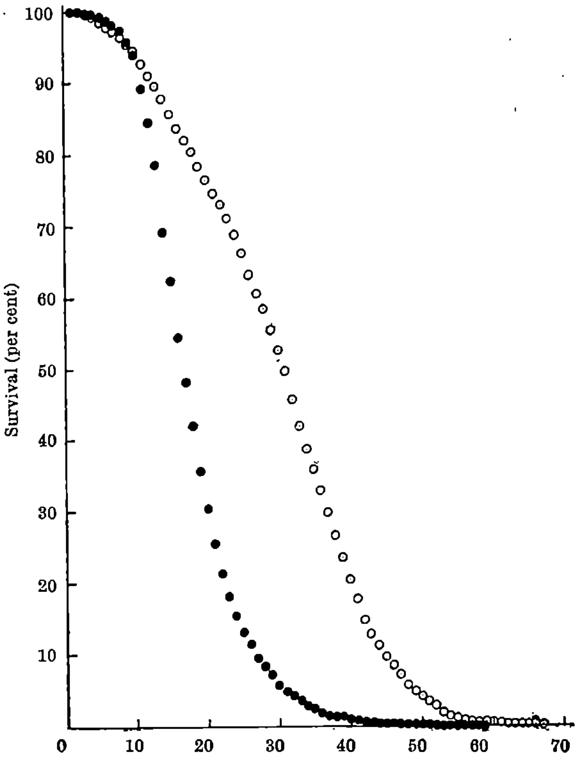

Fig. 1. Survival curves of male and female house-flies. ●, Males; O, females

Fig. 1 shows the survival curves for each sex. These clearly suggest a typical, rectangular form of survival curve representative of animal populations showing senescence (that is, slow rate of death of youthful members of the population followed by an acceleration of mortality during a specific period of the life-history). However, during the final days of adult life this species exhibits a logarithmic-like survival curve with a markedly retarded rate of dying off (40–60 days for the male and 55–70 days for the female). The marked difference in average and maximum longevities of the two sexes is apparent from an examination of the two curves. Thus, about 90 per cent of the males die between ten and thirty days of age, whereas the females die off to the same extent between the tenth and fiftieth day of adult life. What had been observed earlier for only 600 pairs of flies[3] has held true for more than 4,000 flies of each sex through nine successive generations; namely, that at thirty days of age 50 per cent of the females have survived; by the end of this same period of time only about 5 per cent of the males are still alive (indeed, 50 per cent mortality for males occurs at about 16 days of age). In actual longevity figures, males had a mean longevity of 17·4 and a maximum of 54 days; females had a mean longevity of 29·4 days and a maximum of 63 days. Such data clearly confirm the rather widespread occurrence of higher female longevity in animal species discussed elsewhere by Hamilton[4] and Rockstein[3].

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Pattern of Humus Decomposition in East African Soils

Humus decomposition under bare fallow has now been measured during five successive wet and dry seasons. Soil samples were taken periodically (about once a week during the wet season) and put in the macro-respirometer[1]. The average daily rate of decomposition for the following two days was taken as a comparative measure of the rate at the time of sampling. Using this technique it was found that a relatively high and similar rate of decomposition occurred at the start of each wet period but fell rapidly as uniform moist conditions continued (for example, from 12 mgm. carbon per day at the start of the rains to 4 mgm. three to four weeks later with a soil containing about 6 per cent carbon). Decomposition during the intermediate dry periods was almost negligible.

This simple pattern of composition is of fundamental importance. Since decomposition involves nitrate production it puts soil nitrogen availability on a more predictable basis and emphasizes the importance of timing in planting. This should be done before the start of the rains, or as soon after as possible, when nitrate production is at a maximum, rather than later, when production is much slower and losses of nitrate produced earlier may have occurred through leaching. The pattern also shows that humus decomposition proceeds spasmodically according to the drying and wetting cycle and involves, on each occasion, the rapid decomposition of discrete amounts of humus rather than the slow decomposition of the humus fraction as a whole (see below). An appreciation of this behaviour, and the slow rate of decomposition which may be reached under steady moist conditions, should be of value in work involving humus depletion and build-up. The persistence of this behaviour has been demonstrated in laboratory experiments with the same soil. After forty successive oven-drying and rewettings, with decomposition after each rewetting, the flush of decomposition still occurs, but is declining in magnitude as the reserve of decomposable organic material gets less. So far about 35 per cent of the total soil carbon has been decomposed in this way.

Recent work has shown that while an air-dry soil saturated with different bases gave very different amounts of soluble organic material (10 gm. soil extracted with 40 ml. water), the magnitudes of decomposition (100 gm. soil at field capacity) were almost identical. Similar results, but of greater magnitude, were obtained with the oven-dry soils.

	Air-dry			Oven-dry		
	Na	K	Mg	Na	K	Mg
mgm. organic nitrogen/ 10 ml. extract	0·44	0·26	0·12	0·43	0·40	0·20
mgm. carbon decomposed in 16 days	77·7	77·7	76·4	113·9	120·6	123·3
*p*H	6·3	6·6	7·1	6·3	6·8	6·9

Evidently decomposition involves the humus itself, is little affected by the base present and is not dependent on the preliminary solution of organic material. It appears from this, and further evidence to be published elsewhere, that the drying effect is due almost entirely to its influence on the microbial population. In this respect the uniform pattern of decomposition following each successive drying and rewetting is noteworthy. Since there is ample available substrate, as shown by the frequency with which the drying effect occurs, the rapid fall-off in the rate of decomposition after each rewetting may be due to the development of unfavourable conditions. Alternatively, the same bacterial culture cycle may follow each re-wetting, with high metabolic and enzyme activity during the early phase (characterized by high uptake of oxygen, evolution of carbon dioxide and production of ammonia) falling off during the stationary phase and period of decline. Heat activation of spores may also be involved, and these possibilities are being investigated.

This repetitive behaviour of humus decomposition emphasizes the importance of the wetting and drying cycle in soil fertility. This is particularly marked with nitrate production but other elements such as bases and phosphorus are similarly affected[2]. The behaviour of the soil as regards nutrient supply is clearly very different at the start of the rains from what it is later on, and in soil fertility studies this dynamic aspect of nutrient supply must be considered in conjunction with soil data obtained by conventional methods of analysis.

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Effect of Carbon Dioxide on Multiplication of *Fusarium* in Soil

Numerous studies have been made on the effects of carbon dioxide on fungal growth in pure culture, and on substrates other than soil. Since soil is the natural habitat of many fungi, and frequently has carbon dioxide-levels exceeding that present in normal air, it is important that effects of carbon dioxide-enriched air on fungal behaviour in soil be investigated. With the exception of work by Lundegårdh[1] using sterile soil and *Fusarium* species, there is little information available on the effects of carbon dioxide on fungal behaviour in soil. Recently, techniques have been developed[2] for studying *Fusarium* multiplication in natural soil, as indicated by sporulation and increase in number of colonies on soil dilution plates. It was found that carbon dioxide at levels of 2–25 per cent in air for 16–42 hr. frequently stimulated multiplication of *Fusarium oxysporum* f. *cubense*[3]. Studies were initiated with other *Fusarium* species and with carbon-14 dioxide to determine the action of carbon dioxide in stimulating *Fusarium* multiplication. The soil-plate technique[2] was used for studying the effect of carbon dioxide tension on *Fusarium* population as determined by soil dilution plating.

Certain *Fusarium* species in artificially infested loam and sandy loam (*p*H 5·6 and 7·4) were exposed for 42 hr. to normal air and air enriched with 4 per cent carbon dioxide, after moistening the soil with a

Table 1. STIMULATION OF MULTIPLICATION OF *Fusarium oxysporum* IN SOIL PLACED IN AIR ENRICHED WITH 4 PER CENT CARBON DIOXIDE

(Average *Fusarium* colonies per ml. of 1 : 1,000 soil dilution)

	Soil incubated in*	
Culture	Air	Air + 4% CO_2
F. oxysporum f. *lycopersici*	0·8	5·0
F. oxysporum f. *nicotianae*	3·6	18·2
F. oxysporum f. *cucumerinum*	1·6	14·4

* 1 gm. of infested soil moistened with 1 per cent glutamic acid and dilution plates made 42 hr. later.

1 per cent solution of glutamic acid. The species used were : *F. oxysporum* f. *lycopersici*, *F. oxysporum* f. *nicotianae*, *F. oxysporum* f. *cucumerinum*, *F. solani* and *F. roseum*. The forms of *F. oxysporum* were isolated from their respective hosts and *F. solani* and *F. roseum* were isolated from the soil. Results of a representative experiment are shown in Table 1.

In about two-thirds of the experiments performed over a one-year period obvious stimulation of *Fusarium oxysporum* forms occurred in air enriched with 4 per cent carbon dioxide in contrast to normal air.

The behaviour of *F. roseum* and *F. solani* in air enriched with 4 per cent carbon dioxide was more erratic than *F. oxysporum*. In a few instances stimulation was evident but usually there was no stimulation. Apparently these species are less sensitive to the effect of carbon dioxide and/or other soil factors influencing multiplication than *F. oxysporum*. At concentrations up to 25 per cent carbon dioxide in air for 48 hr. there was no evidence of inhibition of survival or multiplication in soil of the *Fusarium* species studied.

To determine if carbon dioxide was being fixed by the fungus, studies were initiated with carbon-14 dioxide and *F. oxysporum* f. *cubense* freshly isolated from diseased bananas. A spore suspension of *F. oxysporum* f. *cubense* was added to 5 ml. of medium in 50 ml. beakers placed in stoppered 920-ml. Mason jars. The medium contained 10 gm. NH_4NO_3, 5 gm. KH_2PO_4, 2·5 gm. $MgSO_4.7H_2O$, 0·02 gm. $FeCl_3.6H_2O$ and 50 gm. sucrose per litre of distilled water, and after autoclaving was at *p*H 4·0. 10–100 μc. of carbon-14 labelled sodium carbonate was then introduced to the bottom of the jars around the beakers and 25 per cent perchloric acid added to release carbon dioxide. The capped jars were sealed with modelling clay. The cultures, thus exposed to radioactive carbon dioxide, formed a large pellicle of fungus in about four days. The resulting pellicles were removed and thoroughly washed with distilled water on filter paper. The washed pellicles were dried at 70° C. in a forced-draft oven, weighed and then ground in a mortar. Each ground pellicle was then thoroughly mixed with sufficient dried banana leaf tissue to make 1 gm., placed in a steel cup planchet and its radioactivity measured. Counts per min. of known quantities of carbon-14 in 1 gm. of banana leaf tissue had previously been determined[4] so that it was possible to estimate the quantity of carbon-14 incorporated by the fungus in the above samples. Two identical experiments were conducted and the results are shown in Table 2.

The total quantity of carbon-14 fixed by the fungus increased with increasing concentration of carbon dioxide, although the dry weight of the fungus (approximately 31 mgm.) differed little in the various concentrations of carbon dioxide studied. The percentage of the total carbon-14 fixed by the fungus, however, decreased slightly with increasing concentration of carbon dioxide in the atmosphere.

Table 2. CARBON DIOXIDE FIXATION BY *Fusarium oxysporum* f. *cubense*

Volume per cent CO_2 in jar	$^{14}CO_2$ (μc.)	Radioactivity in fungus in counts per min. Exp. 1	Exp. 2	Average	Total supplied radioactivity in fungus (per cent)
2·26	100	2,315·8	2,783·7	2,549·8	2·46
1·16	50	1,401·2	1,714·9	1,558·8	3·00
0·48	20	770·6	732·2	751·4	3·62
0·03	0	47·4	34·1	40·8	—

The foregoing results show that carbon dioxide, at concentrations commonly found in the soil atmosphere, can be fixed by mycelium of *F. oxysporum* f. *cubense*. Thus carbon dioxide stimulation of multiplication of the *Fusarium* species studied may be due to participation of carbon dioxide from the soil atmosphere in metabolic processes of the fungus.

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Extracellular Products in Pure Cultures of a Brown Alga

USING antibiotics in a way similar to those described by Fish[1] and Spencer[2] for other algae, we have obtained *Ectocarpus confervoides* in bacteria-free uni-algal culture. Bacteria-free cultures of Phaeophyceae (*Waerniella lucifuga* and *Ectocarpus parasitica*) have been grown by Provasoli, McLaughlin and Droop[3], but these do not appear to be particularly suitable for physiological study. It is clearly desirable that studies with pure cultures should be made if exact information about the metabolism of this group of algae is to be obtained.

In natural sea water enriched with nitrate, phosphate, iron and manganese, *E. confervoides* has a mean doubling time, in the early stages of growth, of about one week at 20° C. and a light intensity of 6,000 lux. Growth continues slowly for up to 30 weeks, according to the volume of the cultures, giving final yields of about 0·9 gm. dry weight per litre. In such cultures the medium becomes coloured distinctly yellow-brown after three weeks. Following up this indication, an investigation has been made of the extracellular products liberated by *E. confervoides* in pure culture.

The absorption spectrum, as determined with a 'Unicam *SP* 500' spectrophotometer, of the yellow-brown medium from an 11-week culture, after filtration through a sintered glass funnel of porosity 15–40μ, is shown in Fig. 1, curve *A*. After extraction with ether, material having an absorption maximum at 260 mμ remained in the aqueous phase (Fig. 1, curve *B*). The ether extract was yellow in colour with an absorption maximum in the region of 400 mμ (Fig. 1, curve *C* ; vertical scale × 8 that for curves *A* and *B*).

Filtrate from a 5-week-old culture, containing about 7 mgm. cell nitrogen per litre, after concentration and desalting by a method of electrodialysis, gave a positive reaction with ninhydrin, indicating the presence of about 0·15 mgm. α-amino-nitrogen per litre of the original medium. After hydrolysis with an equal volume of 50/50 concentrated hydrochloric acid and glacial acetic acid for 24 hr. at 105° C., 0·2 mgm. α-amino-nitrogen were found. This suggests that the view of Fogg and Westlake[4], that

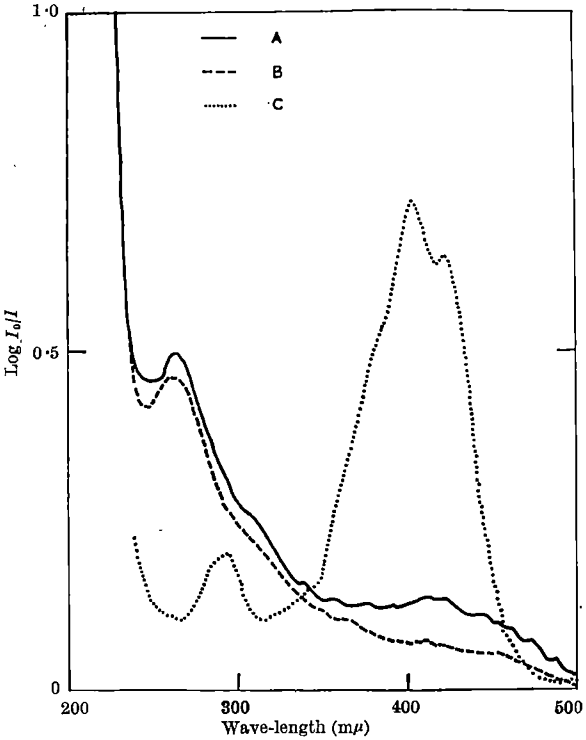

Fig. 1

extracellular nitrogenous compounds are liberated to an appreciable extent by most algae, applies to marine as well as freshwater species. It seems likely that this nitrogenous material is responsible for the absorption at 260 mμ observed in *E. confervoides* media after extraction with ether, but its further characterization has been hampered by the difficulty of desalting the large volumes of sea water required.

Paper partition chromatography, using mixtures of methyl alcohol and toluene, showed the ether-soluble fraction to contain four pigments. In their absorption spectra and ether solubility these resemble carotenoids. It is possible to reconcile this with their solubility in water by supposing that they are protein–carotenoid complexes such as those obtained from the chloroplasts of higher plants by Nishimur and Takamatsu[5].

Separation on a powdered cellulose column gave three well-defined fractions, the first of which appeared to have two components. When attempts were made to transfer these from ether to distilled water it was found that they were readily photo-oxidized when in contact with water and air. However, the pigments appear to be stable in the cultures and in the filtered medium prior to ether extraction, and are also stable when dissolved in ether. This further indicates the presence of a complex in the medium which is broken down on ether extraction.

Spectrophotometric examination of the filtrates from cultures of different ages has shown that the amount of the water-soluble ether-insoluble material absorbing 260 mμ is proportional to the growth of the alga as measured by dry weight. The total amount of yellow ether-soluble material also increases with the age of the culture, but it seems from the less regular relationship that the proportions of the individual pigments liberated vary during the course of growth. It seems likely from this that both types of extracellular product are liberated from healthy cells.

Work directed to the further characterization of these extracellular products of *Ectocarpus* is in progress. Meanwhile, it seems worth recording these results in view of the current interest in dissolved organic substances in natural waters, as discussed by Lucas[6], Saunders[7] and Vallentyne[8]. It is possible that extracellular nitrogenous compounds such as those of *Ectocarpus* contribute to the dissolved organic nitrogenous material present in sea waters, the ecological importance of which as a chelating agent may be considerable. No yellow pigments exactly corresponding with those liberated by *Ectocarpus* appear to have been recorded in sea water, although the absorption spectrum[9] of the 'yellow substance' found in neritic waters by Kalle has some resemblance to that of one of the components of the ether-soluble fraction.

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A Freshwater Mutant of *Balanus amphitrite*

A few species of animals which were known to be marine have become freshwater dwellers. An example of these freshwater mutants is the gastropod *Hydrobia jenkense* which, according to Ellis[1], was known to have been confined to brackish waters until the early part of the last century and is now abundant in freshwater in many parts of Great Britain and seems to be spreading widely in continental Europe.

The limiting ecological factors of the freshwater environment are only survived by mutant types of marine animals which were endowed with proper thermo- and osmo-regulation systems and a totally embryonic development. The absence of such adaptive mutations, or their inaccessibility to freshwater, from whole phyla such as Echinodermata, or whole classes of phyla such as Cephalopoda and Cirripedia, have made their representatives still exclusively marine.

In the north-east of the Nile Delta, some 40 miles south of the mouth of the river, freshwater from the Damietta branch of the Nile is constantly pumped by powerful machines during the floodless season (November–July) through a deep cement-built tank for the irrigation of a large area of land. The machines stop during the flood season (August–October) and the water in the tank falls to the level of the Nile. When the tank was studied for its fauna in

Fig. 1. *Balanus amphitrite* var. *denticulata*. (× 25)

July 1954, the walls and rocky floor were found densely populated with colonies of barnacles. Fixed specimens were identified by Dr. J. P. Harding of the British Museum (Natural History) as *Balanus amphitrite* var. *denticulata* Broch[2]. Broch's specimens, described in 1927, came from the Suez Canal, where the salt beds make the salinity higher than that of the sea. Since then the variety has been found in a number of localities, including the coast of Great Britain. *Balanus amphitrite* is often carried on ships' bottoms.

When the tank was investigated in December of the same year, only dead shells the inner walls of which were stuffed with embryo-like structures were found (Fig. 1). The tank has since been visited at irregular intervals, but so far no live specimens have been recovered.

It is believed that the mutant barnacle is of a seasonal occurrence. It exists only in the presence of favourable environmental conditions and dies when unfavourable conditions prevail, leaving resting embryos which remain dormant until the favourable conditions return. The reason why live specimens ceased to be found is now being investigated.

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Microbenthos of the Shore at Whitstable, Kent

WHILE the results of a study conducted in the period September 1953–November 1955 have now been analysed, the inevitable delay in publication makes a summary of the results obtained both of interest and use. The term microbenthos is taken to include all those forms which will pass through a 1-mm. sieve.

The sandy flats studied lie at a gradient of 1/600 and consist of fine sand of average depth 7 cm., overlying London Clay of indeterminate depth. Drainage is such that the shore is covered to a greater or lesser degree by surface water in every exposure period. The microfauna but not the microflora showed marked differences in distribution dependent on differences in the soil grade. The microbenthos exhibited a patchy horizontal distribution, while vertically diatoms, copepods and ostracods were confined or tended to be confined to the surface 4 mm. of soil, nematodes lived in large numbers below this level in the sand, but not in the London Clay, which acted as an effective barrier to further penetration. All groups had a maximum population in the surface 2 mm. of soil.

The fauna here is the richest so far recorded in an unpolluted area, being, in 1955, $5 \cdot 22 \times 10^6$ nematodes per sq. m., $7 \cdot 422 \times 10^5$ ostracods per sq. m. and $4 \cdot 863 \times 10^5$ copepods per sq. m., at the time of their respective seasonal maxima, and the constitution of the microfauna at Whitstable seemed to be markedly different from other recorded microfaunas.

Seasonal changes were investigated at a position on the shore with a 3-hr. exposure period. It was found that the nematodes always dominated the fauna, while the ostracods and copepods only reached a maximum when the nematodes had started to decline. Ostracods dominated the copepods in the autumn, winter and spring months but in summer the copepods were dominant over the ostracods. *Leptocythere pellucida* was the most abundant form of ostracod, while *Asellopsis intermedia* was the most abundant harpacticoid copepod at all times of the year.

The microfauna as a whole showed one seasonal maximum in numbers, the population changes showing a correlation coefficient of $+ 0 \cdot 75$ with the mean sea temperature at the 0·1 per cent level of significance. Not only is the breeding cycle dependent on temperature, but it was found that between 0° and 20° C. activity of the harpacticoid copepods increased, while, in the shore itself, if temperatures fell below a value about 4° C., the microfauna showed a marked downward migration. A positive reaction to light was exhibited by many members of the three major groups; in particular the harpacticoid copepods reacted positively at all light intensities investigated between less than 2- and 2,000-ft. candles.

With the methods used, only the nematodes were found to exhibit a tidal rhythm. All three groups, nematodes, ostracods and copepods, moved actively on the surface during exposure and in the main body of sea water when covered. Some species, both of microflora and microfauna, occurred in considerable numbers in the inshore plankton while other forms occurred exclusively in the shore. Zonation was of the extended nature expected of the microfauna of a shore with such a low gradient as the sandy flats at Whitstable.

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Absence of the Diego Blood Group and Abnormal Hæmoglobins in 92 Maoris

RECENT investigations of Mongoloid populations have shown in some of them a high incidence of hæmoglobin *E* and of the Diego blood group. The highest frequencies of hæmoglobin *E* have been found in Siamese, Burmese and north-east Malaysians, and the highest frequencies of the Diego blood group in South American Indians, followed by Japanese, North American Indians and Chinese. Hæmoglobin *H*, although seen in some Greeks and in a Jordanian Arab, has in the majority of the still relatively few observations been found in people of Asiatic Mongoloid origin, notably Chinese and Siamese, and occasionally in Philippinos and Malaysians. Lastly, thalassæmia or Mediterranean anæmia is now known not to be restricted to persons of Mediterranean origin, for the observation of a high incidence in Siamese[1] has been followed by similar reports from other

Asiatic populations, both non-Mongoloid and Mongoloid.

In the Australasian region so far no abnormal hæmoglobins have been found in 166 Australian aboriginals[2] and 56 Melanesians (Horsfall, W. R., and Lehmann, H., unpublished). No example of the Diego blood group has been found in 62 Australian aboriginals, 23 eastern Papuans, 74 natives of New Britain and 80 eastern Polynesians[3].

We have examined 92 Maoris, of whom 65 were not first-degree relations. There is considerable intermarrying and as the people investigated live in a small area it is likely that some of these 65 are also related. The aim has been to obtain a gene pool which represents Maoris without White admixture. 85 belonged to the Tuhoe and 7 to the Arawa tribe. All were examined for the Diego blood group and for hæmoglobins *E* and *H* as well as for other abnormal hæmoglobins which can be detected by the sickling test or by electrophoresis. Hæmoglobin *H* is unstable, and control experiments were made to exclude the possibility that it escaped detection under the conditions of our experiments. In 84 samples a search was made for evidence of thalassæmia by examining the cells morphologically, by determining the alkali-resistant fraction of the hæmoglobin and by searching for an increased proportion of hæmoglobin A_2.

No hæmoglobin *E*, *H* or any other abnormal hæmoglobin, no Diego blood group and no evidence of thalassæmia were found. Our findings distinguish these Maoris from the North and South American Indians so far examined, and from the Siamese, Burmese and Malaysians. It cannot be taken to distinguish them clearly from Indonesians, Dyaks and other South Asian Mongoloids. Hæmoglobin *E* and the Diego blood group have been found at low frequency in some of these populations, but it is more likely that this is due to their mixing with neighbours in whom these characters are common than to represent in them essential racial features. We hope to extend these investigations and to examine in the first instance a tribe in the Ruatoki area in the coming year.

It is noteworthy that the Diego factor has not been found so far, in view of Heyerdahl's theory of the American origin of the Polynesians.

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---

[1] Minnich, V., Na-Nakorn, S., Chongchareonsuk, S., and Kochaseni, S., *Blood*, 9, 1 (1954).

[2] Horsfall, W. R., and Lehmann, H., *Nature*, 172, 638 (1953); 177 41 (1956).

[3] Simmons, T. R., *Nature*, 179, 970 (1957).

Carbon-14 Dated Palæoliths from Borneo

1957 excavations by the Sarawak Museum at Niah Great Cave, West Borneo, produced a succession of human phases from subsurface Bronze Age through 'Neolithic' polished axes and adzes (to 24 in.), then edge-ground and 'pebble' tools, and below these unworked flakes and blades; deeper again (below 72 in.) crude 'choppers', in the sense lately re-defined by Prof. H. J. Movius[1]. A preliminary report[2] lacked carbon-14 information from the lower levels. Now Prof. Hl. de Vries, of the Physical Laboratory, University of Groningen, Holland, who has kindly carried out all our tests, reports on a charcoal sample from about 100 in.:

GRO. 1339 39,600 ± 1,000 years (1957)

It is not yet possible exactly to co-ordinate crude depths with artefact stratification, owing to unevenness in Niah's enormous human (not geological) deposit. It is clear, however, that we are down into the Palæolithic on an orderly sequence, for the first time in south-east Asia. Other early stone-age finds in this area have been at geological or casually exposed sites, without clearly interrelated animal remains, bone, shell, fire and extraneous stone associations.

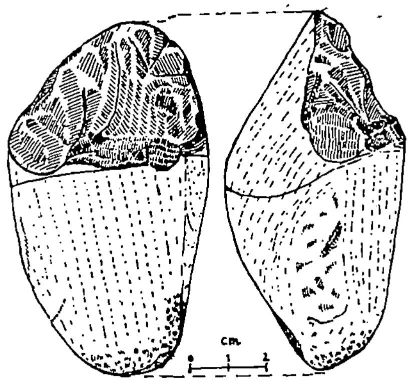

Fig. 1. Stone chopper from below 72 in. Niah Great Cave, Sarawak

The stone tools occurring between *GRO.* 1339 and a previous carbon-14 date (*GRO.* 1158) of 32,630 ± 700[2], are often uniface choppers, with hammer marks on the butts (Fig. 1). These closely parallel some from the 'Soan Culture' of north-west India, as figured by Dr. Kenneth Oakley[3]; five tools found on a gravel terrace in south-east Borneo[4]; and part of a recent collection from west Thailand[5], which I have examined in the National Museum, Bangkok. We should eventually be able to get a clearer idea of the Later Palæolithic in south-east Asia, using Niah stratified material as provisional yardstick, with further excavation in 1958 (thanks to a grant from the Calouste Gulbenkian Foundation of Lisbon[6]). It already seems that more caution should be exercised before attributing crude tools in any general way to the Lower Palæolithic in Asia—as has lately been done for the south-east Borneo pieces[4] and the Malayan 'Tampan'[7]—unless there is supporting evidence beyond the superficial look of the artefacts themselves.

TOM HARRISSON

Sarawak Museum,
Kuching,
Sarawak.
Jan. 1.

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[1] Movius, Hallam J., *Man in India*, 37, 2, 150 (1957).

[2] Harrisson, Tom, *Man*, 57, 211 (1957).

[3] Oakley, Kenneth P., "Man the Tool-Maker", 2nd. edit., Fig. 20 (London, 1950); and one examined with Dr. Oakley, *Brit. Mus.* No. *G.D.E.* 1178; cf. Lal, B. B., *Ancient India*, 12, 59, and Plates xxiii–xl (1957).

[4] von Heekeren, H. R., "The Stone Age of Indonesia", 35 and Fig. 9 (The Hague, 1957).

[5] Helder, Karl G., *J. Siam. Soc.*, 46, 1, 61 (1957).

[6] See *Nature*, 180, 1028 (1957).

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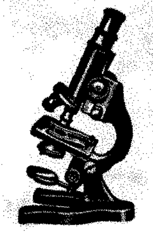

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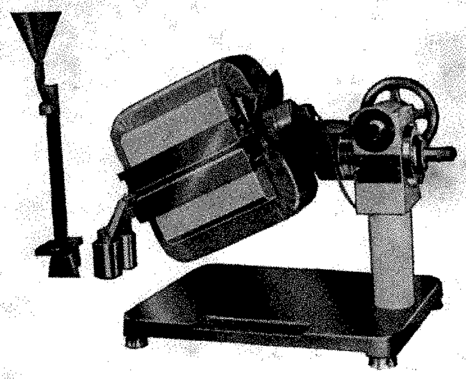

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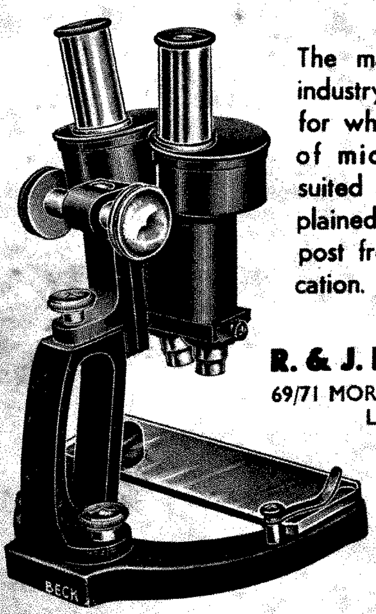

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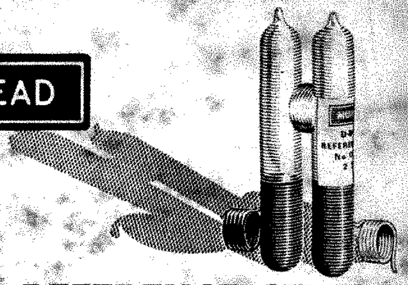

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FORTHCOMING EVENTS

(*Meeting marked with an asterisk * is open to the public*)

Monday, March 17

Institute of Metal Finishing (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Mr. H. Cann: "Anodes".

Monday, March 17—Tuesday, March 18

Society of Chemical Industry, Pesticides Group (at 14 Belgrave, Square, London, S.W.1), from 5.30 p.m. to 9 p.m. each day—Conversazione—"New Techniques in Pesticide Research".

Tuesday, March 18

Parliamentary and Scientific Committee, General Committee (in Committee Room 12, House of Commons, Westminster, London, S.W.1), at 5.15 p.m.—Discussion on "Space Satellites and Relevant Matters". Opening Speakers: Prof. A. C. B. Lovell, O.B.E., F.R.S., Prof. H. S. W. Massey, F.R.S., and Dr. D. H. Sadler, O.B.E.

Royal Society of Arts, Commonwealth Section (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—The Hon. F. W. Bulcock: "The Pastoral Industry of Australia".

Institute of Physics, Electronics Group (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Annual General Meeting, followed by Mr. L. A. Thomas: "Microwave Ferrites".

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Sir John Cockcroft, F.R.S.: James Forrest Lecture.

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Prof. W. E. Curtis, F.R.S.: "Magnetism". (Further lectures on March 19, 25 and 26. Lectures for Sixth Form Boys and Girls from Schools in London and the Home Counties.)

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Discussion on the Technical Committee's Report "Recommended Method of Expressing Electronic Measuring Instrument Characteristics. 1: A.M. or F.M. Signal Generators".

Wednesday, March 19

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2) at 2.30 p.m.—Sir Christopher Hinton, K.B.E., F.R.S.: "Industrial Power of the Future" (Trueman Wood Lecture).

Royal Institute of Chemistry (joint meeting with the London Branch of the Institute of Biology and the London and Home Counties Branch of the Institute of Physics, in the Sir William Beveridge Hall, Senate House, University of London, W.C.1), at 4.30 p.m.—Symposium on "Science and Society". Speakers: Prof. P. M. S. Blackett, F.R.S., Prof. L. T. Hogben, F.R.S., Prof. A. Haddow, Prof. Dame K. Lonsdale, F.R.S. and Mr. Anthony Smith.

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Sir Robert Shone and Mr. H. R. Fisher: "Industrial Production and Steel Consumption".

Eugenics Society (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Symposium on "New Human Demands in Industry". Speakers: Mr. Alec Rodger, The Hon. Michael Layton, Mr. R. Peddie and Dr. K. Hutton*.

Society for Analytical Chemistry, Microchemistry Group (in the restaurant room of "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion Meeting on "The Microdetermination of C, H and N in the Presence of Interfering Elements (Metals and Non-metals)".

Thursday, March 20

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Meeting for Election of Fellows. 4.30 p.m.—Mr. L. Rotherham: "Atomic Energy Authority Industrial Group Research Organization (Dounreay Reactor)".

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—General Meeting.

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. N. Jacobson: "Representation Theory for Jordan Algebras".

Institution of Mechanical Engineers, Lubrication Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "How to Bridge the Gap between Theory and Practice in Lubrication".

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. G. M. Dormon and Mr. A. W. Jarman: "Some Factors Influencing the Behaviour of Bitumen Road Surfacings".

Scientific Film Association, Sciences Committee (in the Mezzanine Cinema, Shell-Mex House, Strand, London, W.C.2), at 6.30 p.m.—Meeting on "Recent Development in Research Film". Chairman: Dr. R. H. Brown, M.A.

Royal Photographic Society (at 16 Princes Gate, London, S.W.7), at 7 p.m.—Dr. B. H. Crawford and Dr. J. M. Burch: "The Use of Colloidal Photographic Emulsions in the preparation of Interference Filters and Diffraction Gratings".

Royal Society of Tropical Medicine and Hygiene (at the Royal Army Medical College, Millbank, London, S.W.1), at 7.30 p.m.—Laboratory Meeting. Chairman: Brigadier J. S. K. Boyd, O.B.E., F.R.S.

British Institute of Radiology, incorporated with the Röntgen Society (at 32 Welbeck Street, London, W.1), at 8 p.m.—Dr. L. F. Lamerton: "An Examination of the Clinical and Experimental Data relating to Possible Hazard to the Individual of Small Doses of Radiation" (Presidential Address).

Friday, March 21

Faculty of Radiologists (at the Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2), at 4.45 p.m.—Meeting on "Medical Problems associated with Applied Atomic Energy". Speakers: Dr. J. F. Loutit, Dr. A. S. McLean and Dr. J. D. Abbatt.

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Mr. E. J. Dickie, M.B.E.: "The Effective Utilization of Airspace".

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Dr. Ekhart Schmidt: "High-Speed High-Performance Diesel Engines—Their Development and Application" (James Clayton Lecture).

Royal Photographic Society (joint meeting with the Association of Printing Technologists, in the Lecture Theatre of the Science Museum, Exhibition Road, London, S.W.7), at 7.15 p.m.—Mr. M. Hepher: "Three Colour Lithography for Short Runs".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Cyril Dean Darlington, F.R.S.: "The Control of Evolution in Man".

Saturday, March 22

British Social Biology Council (at Victoria Hall (North), Bloomsbury Square, London, W.C.1), at 10 a.m.—Conference on "The Education of Scientists".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer (qualified in either pure or applied mathematics) in Mathematics—The Registrar, University College of North Staffordshire, Keele, Staffs (March 21).

Lecturer or Senior Lecturer (male, British, with an honours degree in electrical engineering) in the Physics and Electrical Engineering Department—The Director of Studies, Royal Naval College, Greenwich, London, S.E.10 (March 21).

Patent Officers (with an honours degree in science or engineering or equivalent qualifications, and preferably some patent experience) at the U.K.A.E.A. London Office and the Research Establishment at Harwell—The Establishment Officer, United Kingdom Atomic Energy Authority, 11 Charles II Street, London, S.W.1 (March 21).

Lecturer or Assistant Lecturer in Plant Physiology (with special reference to metabolism and plant biochemistry)—The Secretary and Registrar, The University, Southampton (March 24).

Research Officer (veterinary surgeon, preferably with postgraduate laboratory experience) at the Farm Livestock Research Centre, Animal Health Trust, Stock, Essex, to specialize in diseases of pigs—The Scientific Director, Animal Health Trust, 14 Ashley Place, London, S.W.1 (March 24).

Guide Lecturer (with a university degree or equivalent qualification in geology, and preferably lecturing or teaching experience) at the Geological Museum, London—Civil Service Commission, 30 Old Burlington Street, London, W.1, quoting Ref. No. S/4817/58 (March 27).

Chemist or Biochemist (with a good honours degree in chemistry or biochemistry) in the Department of Plant Cell Biology, to use and develop ultramicrochemical techniques—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts (March 29).

Physical Chemist or Biochemist, for research work on special derivatives of viruses and on the preparation of virus crystals in conjunction with a team studying the structure of viruses by physical methods—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (March 29).

Senior Scientific Officer (with a first- or second-class honours degree in civil engineering or equivalent) at the Building Research Station (D.S.I.R.), Garston, Herts, for research on engineering design and construction of nuclear power plants, particularly in concrete and reinforced concrete—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting R.609/7A (March 29).

Assistant Algologist (with a degree in botany) at the Windermere Laboratory, for research in freshwater algology—The Director, Freshwater Biological Association, The Ferry House, Ambleside, Westmorland (March 31).

Imperial Chemical Industries Fellows (preferably with the degree of Ph.D. or equivalent research experience), to carry out original research in Chemistry or Physics for a period not exceeding three years—The Registrar, University College of North Staffordshire, Keele, Staffs (March 31).

University Demonstrator in Organic Chemistry—Dr. F. B. Kipping, University Chemical Laboratory, Lensfield Road, Cambridge (April 2).

Zoologist (man, with a good honours degree and preferably postgraduate experience in marine ecology), to join, and eventually to lead, a team studying plankton in relation to the herring, and duties will include occasional work at sea in fishing vessels and research ships—The Officer-in-Charge, Oceanographic Laboratory, Scottish Marine Biological Association, 78 Craighall Road, Edinburgh 6 (April 5).

Chief Technician in the Department of Physics, University College of Ghana—The Assistant Registrar (London), University College of Ghana, 29 Tavistock Square, London, W.C.1 (April 10).

Assistant Lecturer (suitably qualified graduate in chemistry or agricultural chemistry) in Chemistry—The Registrar, Wye College (University of London), near Ashford, Kent (April 12).

Electronics Technician (with a wide general knowledge of electronics, an interest in instrumentation, an inventive mind and the ability to accept responsibility) in the Department of Chemistry, for duties which will include the development and maintenance of special equipment for teaching and research—The Registrar, The Manchester College of Science and Technology, Manchester 1 (April 12).

Research Fellow and a Research Demonstrator in the Department of Chemistry—The Registrar, University College, Singleton Park, Swansea (April 12).

Research Student (graduate, preferably with qualifications in physical geography) in the Coastal Geography of Roman Britain, centred initially on the Thames Estuary—The Director and Secretary, Royal Geographical Society, 1 Kensington Gore, London, S.W.7 (April 14).

Lecturer in Mathematics, and a Lecturer in Philosophy at Acadia University, Wolfville, Nova Scotia, Canada—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (April 15).

Assistant in the Zoology Department and Gatty Marine Laboratory of St. Salvator's College—The Joint Clerk to the University Court, College Gate, St. Andrews (April 16).

Assistant Lecturer in Social Anthropology—The Secretary, London School of Economics and Political Science, Houghton Street, London, W.C.2 (April 16).

Imperial Chemical Industries Research Fellows in Chemistry, Engineering, Pharmacology or Physics—Joint Clerk to the University Court, College Gate, St. Andrews (April 19).

Technician in the Department of Physiology, University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 20).

Chair of Education, with special reference to education in tropical areas tenable at the Institute of Education—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 23).

Walter Myer and Everett Dutton Chair of Parasitology and Entomology—The Registrar, The University, Liverpool (April 26).

Chair of Geography—The Registrar, The University, Hull (April 30).

Research Fellow in the Department of Nuclear Physics, Research School of Physical Sciences, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

English Electric Research Fellow for postgraduate research into the problems of vibration or stability and control of aircraft—The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks (May 1).

Mathematicians (2) (preferably with a Ph.D. degree in mathematics)—G. R. Magee, Department of Mathematics, University of Western Ontario, London, Ontario, Canada (May 1).

Professor (with high academic qualifications in science and experience in teaching or research) of Soil Science at Canterbury Agricultural College (University of New Zealand)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, June 30).

Entomologist (under 35 years of age, a university degree (preferably honours) in entomology or zoology and postgraduate experience in applied entomology) in the Tsetse Control Department, Uganda, to conduct investigations into tsetse distribution and ecology in the field; plan and supervise tsetse surveys and control; and train junior staff—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.77/9/02.

Instructors and Assistant Professors (with the Ph.D. degree, or equivalent, in inorganic or physical chemistry) in the Department of Chemistry—Prof. C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver, B.C., Canada.

Lecturer (preferably qualified in some branch of applied physics) in Physics in the Department of Natural Philosophy—The Secretary, Royal College of Science and Technology, Glasgow.

Lecturer/Senior Lecturer (with a degree in pharmacy or a related subject) in Pharmacy at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 12).

Physicists (with a first- or second-class honours degree in physics and preferably a working knowledge of electronics and experience in one or more of the following fields: gas discharges, detonation processes or solid state physics), to undertake work in the field of electrical physics, devising novel items and proving their feasibility for special application—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. A/1640/34.

Scientists (degree standard), for research into the application of existing sources of energy and the exploitation of new ones in the iron and steel industry—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "F.T.5".

Senior Lecturer (with considerable practical experience in the rubber industry and professional and/or academic qualifications) in Rubber Technology; a Senior Lecturer (with laboratory and/or industrial experience of rubbers and rubber-like plastics and their physical testing) in Physical Chemistry of Polymers; a Lecturer (science graduate prepared to teach polymer chemistry and to work on colloid dispersions) in Polymer Chemistry; and a Lecturer (qualified young engineer prepared to treat rubber as an engineering material, particularly in dynamic applications) in Rubber in Engineering—The Clerk to the Governors, National College of Rubber Technology, Holloway, London, N.7.

REPORTS and other PUBLICATION

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Seri A: Mathematical and Physical Sciences. No. 979, Vol. 250 (1 December, 1957): An Experimental Determination of the Ferm Surface in Copper. By A. B. Pippard. Pp. 325–357. 10*s*. 6*d*. No. 980, Vol. 250 (12 December, 1957): The Angular Acceleration of Liquid Helium II. By H. E. Hall. Pp. 359–385. 10*s*. (London: Royal Society, 1957.) [1612

Polish Cultural Institute. Selective Quarterly Guide to Polish Periodical Literature, Vol. II, 4, 1957. Pp. i+74. (London: Polish Cultural Institute, 1957.) [1612

Ministry of Education. Report on the Regional European Seminar on The Universities and Adult Education, Bangor, North Wales, September 1st–14th, 1956. (Arranged by the United Kingdom National Commission for UNESCO.) Pp. xii+155. (London: H.M. Stationery Office, 1957.) 5*s*. net. [1712

Milford Haven Conservancy Bill. Pp. iv+38. (London: H.M. Stationery Office, 1957.) 1*s*. 9*d*. net. [1721

The Boards of the Nationalized Industries. By Lord Simon of Wythenshawe. Pp. 54. (London: Longmans, Green and Co., Ltd., 1957.) 2*s*. 6*d*. net. [2012

Other Countries

Food and Agriculture Organization of the United Nations. FAO Report No. 680: Report to the Government of India on Soil Conservation. By R. M. Gorrie. Pp. ii+15. (Rome: Food and Agriculture Organization of the United Nations, 1957.) [1612

Fifth Annual Report of the West African Institute for Oil Palm Research, 1956–57. Pp. 132. (Benin City: West African Institut for Oil Palm Research; London: Crown Agents for Oversea Goverr ments and Administrations, 1957.) 2*s*. 6*d*. [161

Institut des Parcs Nationaux du Congo Belge. Exploratio Parc National Albert (Mission J. de Heinzelin de Braucourt, 1 50 Fascicule 3: Mollusques Quaternaires de la Region du Lac Édouar By William Adam. Pp. 172+11 planches. Exploration du Pa National Albert. Deuxième Serie. Fascicule 4: Coagulation du Sar Chez les Arthropodes. Par Charles Grégoire et Pierre Jolivet. P 45+9 planches. Exploration du Parc National de la Garamba (Miss H. de Saeger, en collaboration avec P. Baert, G. Demoulin, L. De J. Martin, M. Micha, A. Noirfalise, P. Schoemaker, G. Troupin et J. Verschuren). Fascicule 8: Nematodes—Parasites d'Oiseaux. Par Claire Vuylsteke. Pp. 20. (Bruxelles: Institut des Parcs Nationaux du Congo Belge, 1957.) [1612

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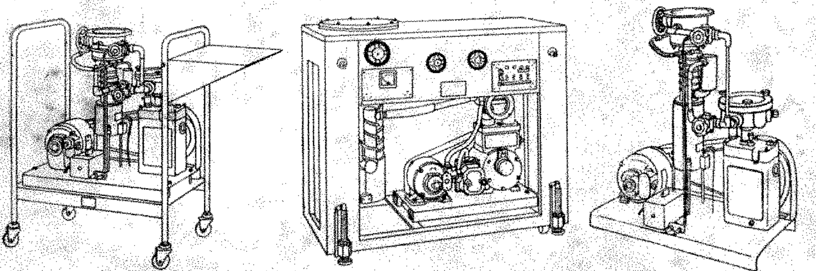

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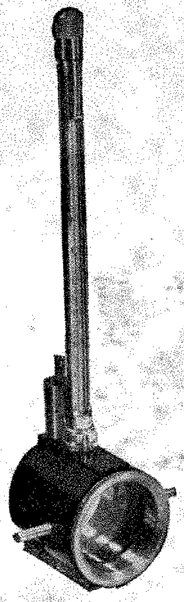

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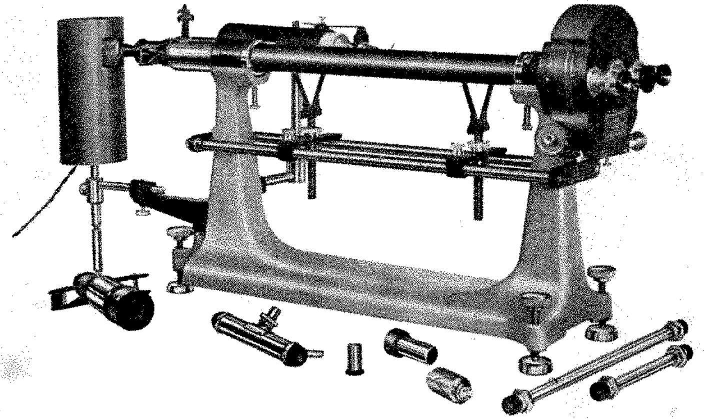

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THE PRESENTATION OF SCIENCE

THE new policy recently announced by the Council of the British Association and discussed in *Nature* of January 4 represents in essence an attempt to improve the communications of science, particularly the understanding of science by the layman, and also the intercommunications of science itself. One aspect of this task is considered by Sir Lawrence Bragg elsewhere in this issue (p. 807). Sir Lawrence is Fullerian professor of chemistry in the Royal Institution, which was founded specifically for interpreting science to the public, although its early history shows that the word 'public' had to be interpreted in a narrower sense than is usual nowadays. However that may be, the Royal Institution has a worthy record in this field, won by the distinction of the professors who have been associated with it; and their distinction has been based on scientific achievement and also on the power to convey their knowledge to others. Both young and older people have been served in this way by the Royal Institution and, as Sir Lawrence comments, special efforts are now being made on behalf of the schools in the London area.

The distinctive feature of the Royal Institution lectures has always been the practical demonstrations, and indeed Sir Lawrence believes that this feature has been, and is of even greater significance than, the substance of the lectures. "The primary way to interest the general public in science is to show experiments and demonstrations and so let them share in the thrill of understanding how things work, which is, after all, a good popular definition of science." The Royal Institution has, of course, special facilities and the necessary technical staff to make such lectures possible, and Sir Lawrence estimates their cost at £5,000 a year. This is not a large sum in these days, and there is much to be said for establishing half a dozen or so such centres, properly equipped for lecture demonstrations, and distributed over Great Britain in accordance with density of population; no doubt some existing buildings could be adapted for the purpose. While this is a long-term scheme, the British Association has already shown how a move in that direction can be made without delay. Working in collaboration with some local education authorities in East Anglia and the Atomic Energy Authority, it arranged a talk on the peaceful uses of atomic energy accompanied by an exhibition of equipment in a school in Ipswich, and school children from the neighbourhood were enabled to attend. This is not the lecture demonstration that Sir Lawrence clearly has in mind, but it is a step forward. It suggests that other national bodies, nationalized industries and some of the larger industrial concerns should consider whether they cannot associate themselves with such a development. They have the technical staff and the equipment, and it should not be difficult, with the collaboration of education authorities and other local bodies, to arrange suitable public lectures.

Having said this much of Great Britain, it is of interest to learn what is thought in the United States about scientific communication—between scientists themselves, and between scientists and the general public.

The sixth annual report of the National Science Foundation had a section entitled "The Communication Report", describing the efforts of the Foundation to improve scientific information services in the United States, including both the information of the public and making federal research results more accessible. A Committee on the Social Aspects of Science, established by the Council of the American Association for the Advancement of Science in 1955, reported in December 1956 on the impact of science on American society likewise, and discussed difficulties in scientific communication and the public interest in science. The latest report of Dr. Caryl P. Haskins, president of the Carnegie Institution of Washington, discusses at some length the fundamental challenge to communication presented by the formidable diversities which characterize the scientific effort to-day.

Dr. Haskins points out that the interlocked character of the present world, the growing similarity of its cultures and the universality of its communication render meaningless any such designation as an Athenian or Elizabethan age; and he suggests instead that it can be characterized in terms of subject-matter, of the loci of ideas, and especially in the natural sciences, where, however, the present age confronts us with communications of almost new dimensions. Diversity of approach, he emphasizes, is the very life-blood of the scientific effort, and under the common rubric of scientists, not only do the observers differ widely in their characteristics, but also their subject-matter diverges even more. Scientific disciplines vary enormously among themselves in their degree of sophistication and in their intricacy; and although the new disciplines must always be in some measure rooted in the older, and the tested approaches of older fields generally have some relevance for the newer ones, the transfer is far from literal. It demands talent and sophistication in the investigator as well as the wisdom and sense of proportion derived from broad experience and a flexible point of view.

These profound diversities among investigators and within the structure of science, while characteristic and immeasurably precious, harbour also all the dangers of fragmentation, and pose the most serious challenges to communication within the core of the scientific effort. Many factors promote the compartmenting of subject-matter which constantly threatens the unity of science. The mere growth of vocabulary and specialization of terminology in a given field may render its jargon unintelligible even to an investigator working in an adjacent area. Even more formidable barriers to understanding may be presented by words, which are basically the coin of ideas and to some degree their generators, so that some basic concepts, as well as words, which govern scientists in one field of knowledge may be almost, if not quite, unintelligible to those in another.

Differences of language and concept, Dr. Haskins points out, tend to be reinforced by many of the social factors involved in scientific work. The scientist's desire to live and talk with those who will understand his meaning, and the pragmatic influences which lead him to seek identification with others in his immediate field, affect both the investigator and his work. While it means the exposure of each man's work to intimate and continuing criticism by his peers in the same general subject, it can harden an incipient conventionalism and raise the most serious barriers to communication within the body of science itself.

These challenges to communication within the framework of science, which have been taken up by the British Association with its new proposals for its annual meeting and for inter-meeting activities, are the background against which we should consider the further and, to some extent, intractable threat of fragmentation inherent in the very magnitude of the scientific effort itself and the consequent tremendous volume of scientific publication. This threat, as Dr. Haskins notes, has rapidly increased since the Carnegie Institution was established and, while some progress has been made in dealing with the sheer volume of paper, of titles and content, through the use of modern aids for storing and sorting information, intensive research could probably make them much more effective. The Nuffield Foundation is already doing something to encourage this, and a paper by Dr. H. Coblans in the *Unesco Bulletin for Libraries* last July elaborated proposals for new methods and techniques of communication. But the major need is, as was emphasized by Dr. R. E. Fairbairn in a paper read before the Society of Chemical Industry in March 1957, for new thinking about methods of providing information.

Such creative thinking, rather than the improvement and intensive application of mechanical aids, is the only way of meeting the basic challenge of communication inherent in the diversity of the natural sciences. Mechanical aids themselves will not stimulate the fruitful synthesis of ideas even in one field of work, or the transfer of systems of ideas from one field to another from which major innovations of point of view often arise, though their successful application can assist this process by removing obstacles. As Dr. Haskins wisely remarks, the vital factor, apart from the creative thinking already stressed, is a very particular type of environment such as is notably provided by the great universities and the great research institutes. From such environments, comprising communities of investigators, working together in a common mode but in divergent fields, in continuous converse, in sympathy and in rivalry, without predetermined goal, without over-commitment as a body to any given sector or to any one approach to the natural world, have come a goodly proportion of the real conceptual advances which have proved to be landmarks in the history of science.

The real value of the Science Centre in London, to which Sir Robert Robinson gave so much time and thought, during his tenure of the presidency of the Royal Society, lies largely in the contribution which it could render to that end, and it is from this point of view that the folly of successive Governments in rejecting the scheme should be judged. Dr. Haskins's arguments as to the importance of this kind of communication within the sciences at a time when the forces of fragmentation and diversity in science are more powerful and the barriers to interchange higher and more formidable might well stimulate a fresh attack on Government apathy and neglect. It is unlikely indeed that the scheme will be revived until we have in Britain not simply advisers with personal understanding of science, but men of science in posts comparable in standing with the appointment which President Eisenhower has recently made of Scientific Assistant, and also Ministers of State capable themselves of such appreciation.

Dr. Haskins points out that the creation of such an atmosphere is a task to which the Carnegie Institution of Washington is dedicated and for which it is unusually well equipped. As a scientific community, its membership represents almost the full range of gifts and attitudes already described, and its various departments address themselves to scientific fields ranging from the descriptive to the analytical, from the pioneer to the more sophisticated, while the mobility of its organization and its community of spirit preclude isolation either of workers or of fields. Moreover, since its whole work is directed to so-called uncommitted research, it is peculiarly fitted to assist this major task of scientific synthesis. Indeed, Dr. Haskins argues that in the future the Institution's task will be increasingly to lead the way to the breakdown of barriers between the numerous separate fields of knowledge and to the creation of new fields.

The methods used by the Institution, outside its internal substantive work, such as carefully planned and organized symposia and its relation to the universities, are, of course, widely used in Britain by the learned societies and professional institutions, and there are fellowship programmes comparable with the Vannevar Bush Fellowships of the Massachusetts Institute of Technology. As yet, at a time when the isolation of university departments is a matter of common criticism, Britain can, however, offer no such place as the Carnegie Institution in which such senior fellowships could be tenable. In the absence of such an institution, it should be a cardinal object of any strategy of research to provide the conditions which most favour scientific communication and the intermingling of disciplines, either by improvement in the mechanical means of communication or by the establishment of such opportunities as a Science Centre, for example, would provide.

Dr. Haskins, however, suggests that this is not the only challenge to communication to be met, and in the concluding part of his report he discusses the deeper unities that underlie the diversities of the scientific mode—the unities of value, of standard, of goal and of motivation. The kinds of communication which have had the most profound significance in human affairs have often been, he suggests, neither wholly conscious nor entirely verbal. They have come instead from the sharing of a common experience or a common view, simply and grandly symbolized, and can thus be largely divorced from material stimuli. Few bonds of communication can have been stronger, for example, or have had a deeper influence on the cohesiveness and the world view of a whole people, for good and for ill, than that Augustinian concept of knowledge and research which so dominated early Puritan America. Its exact opposite, however, the approach to Nature typified by the scientific revolution of the sixteenth and seventeenth centuries, has long since proved itself a mode of communication at least equal in its sweep, more flexible and perhaps more viable and, above all, conducive to positive action, and to the growth of ideas and to human joy. This effective entwining of philosophy with practical experiment is now some three centuries old, and Dr. Haskins argues that the very practical success of scientific research and the pragmatic genius of the American people make it imperative to see that these two strands do not become unwound. The inherently more basic element—science as a way of life—requires constant affirmation if it is to retain the vitality, allegiance and comprehension on which its vigour depends, and this is the prime task to which the Carnegie Institution is dedicated. Its most essential duty is to communicate, in virtue of its own mode of being, the essential verities of the scientific way that are too easily forgotten. On one side lie the joy and the underlying human values of the road of the investigator, the compelling life-challenge that is offered to the seeker after ideas about the natural world. On the other lie the great unities of approach and of preparation that bind those dedicated to the scientific path: the requirements of verification; the discipline of parsimony; the emphasis on individual effort.

As Dr. Haskins rightly comments, the scientific mode offers one means by which these priceless elements in human culture can be assured their proper and permanent place. Although it is in relation to the problem of communication that he has emphasized our need to defend and affirm these cultural elements, it might be as well to reflect that to do so may have other important consequences, especially for Britain. Exposition of the cultural values of science might well play a part in drawing into a scientific career a proportion larger than hitherto of the ablest and the most imaginative and constructive minds of the rising generation, upon whom the expansion of scientific and technological education depends; and this, in turn, must be the basis, not only of the material prosperity of Britain, but also of her position in the vanguard of scientific progress.

HUMAN ARTIFICIAL INSEMINATION

Artificial Insemination in the Human

By Dr. A. M. C. M. Schellen. Pp. xii+420. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1957.) 72*s*.

THE practice of artificial insemination has, in recent years, become a commonplace. In cattle-breeding, it is now a well-established procedure, offering many advantages to the farmer. For him, fortunately, it appears to be devoid of controversy. When applied to human beings, as it appears to have been in some form or another since John Hunter, in the eighteenth century, is credited with having advised its successful use by a man with hypospadias, it has aroused strong emotions. Within the past twenty years, human artificial insemination has been used with increasing frequency, and public interest has steadily been growing. In general, insemination with the husband's semen (A.I.H.) has encountered little opposition except by the Roman Catholic Church, which, taking its stand on the fact that it is "contrary to Nature", prohibits it; and by those who will not countenance masturbation, the process by which alone semen can ordinarily be obtained in a form suitable for artificial insemination. Insemination with semen provided by a donor, be he anonymous or otherwise (A.I.D.), is obviously in a different category, since, in addition to any moral or religious problems it may raise, it is also fraught with a wide range of potential legal difficulties, about which the lawyers themselves find no unanimity of opinion. The subject, therefore, is one of far-reaching interest, and it is against such a background that Dr. Schellen's book must be judged.

Several things strike one on reading this book: it is a serious and scholarly attempt to survey the subject in all its minutiæ; it is exhaustive and very fully documented; it deals with many matters which are at most only barely relevant to the subject itself; it is unnecessarily repetitive—a source of irritation to the reader; it contains a great deal of sophistry, much the product of earlier writers to which reference is made, but much the author's own—another source of irritation to the reviewer; but perhaps most irritating of all is the bias which continually intrudes itself, especially against the practice of A.I.D. This would seem to have been introduced without the author's having actually been consciously aware of it, since the final chapter of the book is intended to represent the author's personal views, arrived at as a result of consideration of "all the facets of A.I." and its problems presented "as objectively as we could". The author is a Roman Catholic, and the attitude of his Church has very clearly coloured his emphasis on the numerous objections to A.I.D. and of the less-numerous ones to A.I.H., as well as his interpolations throughout the book. Whereas the literature records numerous highly successful instances of the use of human artificial insemination —not merely from the point of view of overcoming infertility but also from that of the happiness it has caused—Dr. Schellen dwells disproportionately on instances, almost entirely anecdotal, where the outcome has been psychologically or sociologically disastrous.

In spite of these criticisms, and because Dr. Schellen has made such a careful and extensive study of the subject, its literature and, by personal interview with some of its leading practitioners, its practice, his book is undoubtedly a very important contribution, providing an enormous amount of information on its legal, theological and sociological, as well as purely medical aspects. As such, it commands the attention of everyone whose interest in artificial insemination extends beyond the merely prurient or sensational.

G. I. M. SWYER

SCIENTIFIC PHOTOGRAPHY

Manuel de Photographie Scientifique

(Sciences Physiques et Biologiques.) Par Gérard de Vaucouleurs, Jean Dragesco et Pierre Selme, avec la collaboration de Henriette Faraggi et H. Tellez-Plasencia. Pp. 391. (Paris: Éditions de la *Revue d'Optique*, 1956.) 3,000 francs.

PHOTOGRAPHY has been usefully applied in almost every ramification of scientific work. It is probable that modern photographic techniques could with advantage replace many of the more laborious or less comprehensive methods, in use both in the laboratory and in the field, of obtaining and recording information. This manual makes available a large body of well-classified information (in the old-fashioned sense of the phrase) and is concise and lucid in its presentation. It should be of considerable value to those whose work involves photographic methods.

The earlier chapters are concerned with the properties of emulsions and descriptions of types of apparatus of use in various applications. A photographic darkroom is described and processing and after-treatment of the emulsion are discussed. Then follow sections dealing with special techniques for recording the various spectral bands, electron beams and charged particles. Geometric and photometric measurements are considered in some detail and the remainder of the text is devoted to discussion of several of the more important applications of the photographic method: photomicrography, cinémicrography, photomacrography, document copying, the photography of plants and animals and, finally, of landscapes in the broadest sense. A most useful appendix consists of forty-nine tables of quantitative information and there is a subject index to the whole.

There are some features which might perhaps receive the editors' consideration in another edition. The thirty-eight half-tone plates are not integrated with the text and are often far removed from the appropriate chapters. There is no general bibliography, each chapter having its own, and sometimes (for example, in Chapter 12) authors referred to in the text do not appear in the bibliography. The subject index could well be expanded considerably. Omissions include astrophotography (apart from two plates, of Mars and Finsler's comet respectively), aerial photography and photogrammetry and, more seriously because more generally applicable, stereoscopic photography.

One or two minor improvements suggest themselves: it is possible that estimation of exposures in colour photomicrography simply by measurement of the background (field) brightness might lead to under-exposure with less translucent specimens, and it is doubtful whether such treatment would justify the care in development of the film recommended on p. 202 (± 0·25 deg. C. and ± 10 sec. for first development). Reference might have been made to the ease with which most modern monochrome negative emulsions can be processed for reversal simply and satisfactorily. Perhaps a little more space could have been devoted to the question of depth of field in photomacrography and some mention made of the concept of 'circles of confusion' as an aid to calculation. Typographical errors are few. The page heading on p. 315 is obviously displaced from the following chapter.

This manual will be so useful in laboratories using photographic techniques that early consideration will have to be given to replacing the paper covers by a more substantial binding.

J. WALTON SIDDORN

YEASTS IN INDUSTRY

Yeasts

By K. Arima, W. J. Nickerson, M. Pyke, H. Schanderl, A. S. Schultz, A. C. Thaysen, and R. S. W. Thorne. Edited by W. Roman. (Biologia et Industria, 1.) Pp. 246. (The Hague: Dr. W. Junk, 1957.) 25 guilders.

THIS book is the first of a series of monographs to be called "Biologia et Industria" designed "to tell the industries using biological raw materials what the biological scientists and also the chemists and physicists can give them, and on the other hand to tell the scientists what industry expects of them". The main sections deal with baker's yeast, brewer's yeast, wine and fruit yeasts, sake yeasts, food and fodder yeast, and yeast preparations.

The articles are very uneven in content. They vary in style from Thorne's comprehensive and concise review of the literature on brewer's yeast with an average of 19 references to the page, to Thaysen's personal account of food yeast production with about one reference to the page. They vary in quality from the lucid and reasonably critical article on the cytology of yeast by Nickerson, in which only three minor errors were noted, to the article on wine and fruit yeasts by Schanderl in which some extraordinary statements are made without proof or reference, and in which errors are frequent. Overlapping occurs between sections as, for example, in the biochemistry of baker's yeast, brewer's yeast, sake yeast and food yeast, each of which is treated separately by a different author. At the same time there are gaps in the coverage so that some aspects of the subject, such as, on the scientific side, the taxonomy and ecology of yeasts and, on the technical side, the behaviour of yeast during distillery, cider and panary fermentations, are almost untouched by any of the authors. For the non-scientific reader the treatment is in general too detailed to appeal, and there are too many errors for the book to be recommended without reserve to the non-critical. For scientific readers the book is neither explicit nor stimulating in its treatment of what industry expects of them; for example, there is little discussion of where new knowledge might be of most value to industry or of where advances in technique are probable or desired. This book, therefore, cannot be said to succeed in the objects quoted at the commencement of this review, objects which are admittedly very difficult to attain.

Although scientific workers may find that in their own particular field the information given is insufficient to satisfy them, yet they should find that in other less familiar fields some of the articles are of interest and value to them. For example, the articles of Nickerson, Nickerson and Schultz, and Thorne are good and useful summaries of the literature up to about 1952 and in one short section to 1955; Pyke's articles summarize the literature up to about 1950 and give a fair idea of industrial practice; the article by Thaysen gives a very detailed description of the evolution and working of a plant for the production of *Torula utilis*; and Arima's short description of the preparation and composition of sake is probably the only one available in English. The book is adequately bound and printed, it contains eighteen figures and four plates, and carries on its dust-cover the reproduction of a very pleasant painting of sake barrels and bowl.

R. B. GILLILAND

MAGNESIUM IN PLANTS AND SOILS

Magnesium

The Fifth Major Plant Nutrient. By Dr. A. Jacob. Translated from the German by Dr. Norman Walker. Pp. xii+159+8 plates. (London: Staples Press, Ltd., 1958.) 40*s*. net.

THE importance of magnesium in crop nutrition has probably been under-estimated in many areas both by growers and to some extent by agronomists also. Dr. Jacob has undertaken through his book to rectify this failing by emphasizing the widespread significance of magnesium deficiency and correctly classifying magnesium as a major element in relation to the effects of nitrogen, phosphorus, potassium and calcium.

The first of twelve chapters deals with the chemistry of magnesium with reference to geochemistry, co-ordination and complex salt formation. The second and longest describes symptoms of magnesium deficiency in more than forty crops. Many descriptions are detailed and effective; some, however, for example, legumes and tomato, seem unduly brief and lacking in detail. Colour plates and black-and-white prints illustrate symptoms in several crops, but a number are either indistinctly reproduced or are not sufficiently close up to reveal diagnostic details. The association of 'sickle-leaf' in cocoa (p. 36) with magnesium rather than zinc deficiency without reference to other evidence may be questioned.

The discussion on ion antagonisms of magnesium is a useful contribution and it is gratifying to find an account of effects of nitrogen supply on magnesium requirements. Four chapters deal with magnesium content of plants and soils, selected methods of determining soil magnesium status, and the balance between plant uptake, soil content and fertilizer practice. In general these subjects are discussed in detail, informatively and widely. A chapter deals with results of fertilizer experiments with general crops including some tropical ones. The account of work on fruit trees and tomatoes is, however, brief and inadequate, though some further details are provided elsewhere in the final chapter on types of magnesium fertilizers.

Animal and human nutritionists will also find useful data in the chapter allocated to this field.

The functions of magnesium in plants are reviewed in Chapter 5, which provides much information on the effects of magnesium on their organic composition. In other respects, however, this important chapter is superficial in its treatment of biochemical aspects of magnesium function. References to specific phosphokinase and transferase enzymes are omitted. The glycolysis cycle and other major pathways of carbohydrate metabolism, many steps of which in plants depend upon magnesium-activated enzymes, are dismissed in some seven lines including but one reference of twenty years ago to 'saccharolytic cozymase', and a few references of doubtful relevance to unspecified phosphatase activity.

It is probably fair to suggest that Dr. Jacob intended his book to be read mainly by agronomists and soil chemists to whom these simplified ideas were addressed. It would be desirable, however, in a future edition to expand this treatment with a more detailed account of the biochemical role of magnesium in plants and in general, for the benefit of readers who do not normally study closely the literature in this field. The inclusion of an index would be helpful.

Soil advisory chemists, agronomists and all interested in mineral nutrition will nevertheless find this book useful and informative and will benefit from an appreciation of the widespread practical importance of providing the optimum magnesium status for soils and crops.

E. J. HEWITT

CALCIUM IN THE ANIMAL ECONOMY

Calcium Metabolism

By Prof. J. T. Irving. (Methuen's Monographs on Biochemical Subjects.) Pp. xi+177. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1957.) 11*s*. 6*d*. net.

ACCORDING to the final sentence of this book, "there is hardly any physiological action which does not involve the intervention of calcium". A reader unaware of this fact beforehand would certainly agree after reading Prof. Irving's monograph, where are to be found discussions on many different aspects of calcium metabolism. Confronted with so vast a field, the selection of topics for the space allowed must have been difficult. In the event, the choice will please many readers; especially those working on bones and teeth, for whom, in several ways, the author seems to have catered best. Cytologists, protozoologists and physiologists, on the other hand, and others interested in extra-skeletal calcium, may be a little disappointed.

The actual plan of the book seems logical. Dealing first with the calcium value of foods, the question of intestinal absorption is next considered; separate chapters discuss the role taken by phytic acid and vitamin D. There follows an account of the calcium content of the body and its various tissues. This might be made more complete by brief mention of the actual localization of the calcium in the tissues as revealed by methods such as microincineration. Subsequent chapters are concerned with the utilization and retention of calcium, and dietary requirements. There is an account of the calcium of the blood. Next follow three chapters on bone. The first of these deals with the histological features, the formation of bone, and the factors known to influence ossification. The usefulness of this chapter to the non-specialist reader would be much increased by the incorporation of a few simple diagrams. Next comes a description of the physics and chemistry of bone, followed by a discussion of the role of enzymes in ossification. At this point, the medical reader at least would have been interested to hear modern views on the causation and biochemistry of ectopic calcifications. Finally, there follow chapters on the calcium metabolism of teeth, the excretion and extra-skeletal functions of calcium. In future editions it might be possible to include a brief discussion of the part played by chelate compounds in its mobilization and transport. If, as has been suggested, certain of the cells of bone secrete chelating agents, our ideas about the part played by them will need revision.

This is a most useful review of the subject. The scope is wide, the style is clear and vigorous, and the work as a whole is illuminated by Prof. Irving's wide experience in the field. N. M. HANCOX

EPIDEMIOLOGY

Principles of Epidemiology

By Ian Taylor and John Knowelden. Pp. vii+300. (London: J. and A. Churchill, Ltd., 1957.) 30*s*. net.

Uses of Epidemiology

By J. N. Morris. Pp. viii+135. (Edinburgh and London: E. and S. Livingstone, Ltd., 1957.) 17*s*. 6*d*. net.

THIS is the first English text-book of epidemiology, and many first text-books tend to look rather solid and conservative soon after their production. They bring together the important investigations of the immediate past and attempt to confine them within general rules. This book is no exception. Epidemiology, being more a method of investigation than a separate discipline, appears to stand rather shakily on its own feet within these boundaries, and although one can understand its past successes, this book gives no clue as to its future development.

These criticisms, which could be directed at most text-books about an expanding but undefined subject, are not directed at the way this volume has been produced. It is a well-written account of the epidemiology of infectious disease with a large number of examples, and it includes a clear description of the statistical basis of the calculations leading up to the solutions. The assumptions made are those accepted by a graduate in medicine, and to a postgraduate student or to a teaching department this book could be the framework of an adequate and interesting course in epidemiology.

It is a fortunate coincidence that "Uses of Epidemiology" was published at about the same time as "Principles of Epidemiology". Although written for different reasons the two books are ideally complementary. Dr. Morris has felt free to speculate upon the wider applications of the epidemiological methods worked out by the classical school of investigators into infectious disease. The fields considered range from the evaluation of services to specific clinical problems. The flexibility demonstrated appears to be a function both of the possibilities which are present in the use of epidemiological techniques and the author's original outlook towards disease and treatment.

"Uses of Epidemiology" is a short book which can be read pleasantly in an evening. Many of the problems considered are under intensive study at the moment and it is probable that for this reason the book is easy to read now but will very quickly become dated. Some parts appear to be unnecessarily condensed and there is some difficulty in discovering the tables or figures referred to in the text. These disadvantages are minor ones and this series of ideas could be exciting reading to the epidemiologist or any medical graduate, and a gold mine to the postgraduate research worker looking for a subject or a cause. KENNETH NEWELL

VOLUMETRIC ANALYSIS

Volumetric Analysis

By Prof. I. M. Kolthoff and R. Belcher, with the co-operation of V. A. Stenger and G. Matsuyama. Vol. 3: Titration Methods: Oxidation-Reduction Reactions. Pp. ix+714. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 15 dollars.

AS Prof. Kolthoff says in his preface this third and last volume of "Volumetric Analysis" is long overdue. Volumes 1 and 2 of this series were published in 1942 and 1947, and are by Kolthoff and Stenger alone. Volume 3 is a much larger book than either of the preceding volumes and Prof. Kolthoff's account of the necessary changes of authorship reveals the magnitude of the effort needed for its completion.

It treats with commendable thoroughness and detail the practical aspect of one of the largest and most important sections of analytical chemistry. The reputation of the authors will be for most analysts a sufficient assurance of the worth of this book. Its detail is supplemented by a wealth of references, some of them as late as 1956. There are chapters on reactions, indicators and general techniques, permanganate, ceric salts, dichromate, iodometry, Karl Fischer reagent, iodate, periodate, hypohalites, ferrous and titanium salts and miscellaneous titrants. Electrical methods are not generally discussed, but an exception to this is made in dealing with the Karl Fischer method.

The treatment of each reagent includes sections on its preparation, stability and uses. Tests for purity of the reagents and of substances used in their standardization are given. It is interesting to notice that equivalent weights are given in the rational system of Schoorl as well as the international system. Methods of standardization are critically discussed. The collection of carefully selected methods for the determination of various inorganic and organic substances makes the bulk of the book. The scope of the work is evidently confined as in Volume 2 to these useful and reliable procedures, and as in that volume no attempt has been made to cover exhaustively all applications of the methods to specialized subjects in technical analysis. Many such applications are, however, given. Thus Lea's procedure for organic peroxides is included, but details of the bromometric titration of magnesium oxinate as applied to metallurgical analysis are said not to be within the province of the book. A detailed account is given of many applications of the Malaprade reaction.

This book is likely to remain for a considerable time the best and most complete account in the English language of this branch of analytical chemistry.

E. I. JOHNSON

Birds of Eastern and North-Eastern Africa

By C. W. Mackworth-Praed and Captain C. H. B. Grant. Second edition. (African Handbook of Birds, Series 1, Vol. 1.) Pp. xxv+806+53 plates. (London and New York: Longmans, Green and Co., Ltd., 1957.) 45*s.* net.

FOR those who do not know the first edition of this excellent book the following information may be given: the area covered comprises Sudan, Eritrea, Abyssinia, Somalilands, Kenya Colony, Uganda, Ruanda-Urundi, Tanganyika Territory, part of Nyasaland and part of Portuguese East Africa. 618 species, from ostriches to pittas, are described, species or subspecies being discussed under the following headings: distinguishing characters, general distribution, range in East Africa, habits, nests and eggs, recorded breeding, food, call, and distribution of other races of the species (if any). In the second edition six species and three subspecies have been added as well as a considerable number of notes on distribution, habits, breeding, etc. The small marginal maps showing the geographical distribution of each species described deserve special mention, being not only an excellent idea but also a great and important visual help for the reader. There are fifty-three tables in colour depicting 1,027 species, painted by Roland Green, H. Grönvold, D. M. Reid-Henry, Miss C. E. Talbot Kelly, and N. C. Lighton, and six tables of excellent photographs by Van Someren.

It is a pity that a bibliography has not been included in the book. A work of this kind (even in spite of the authors' intention) is considered by most readers as a reference book, and for this reason its value would be enhanced if it were to contain references to the most important sources of information. A full bibliography of the East African birds is badly needed and the authors are certainly the ornithologists most competent to compile such a work, which might usefully form a third, supplementary volume to this book.

Elsevier's Dictionary of Electronics and Waveguides in Six Languages

English/American, French, Spanish, Italian, Dutch and German. Compiled and arranged on an English Alphabetical base by W. E. Clason. Pp. viii+628. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1957.) 90*s.*

THIS volume is one of an excellent series in which technical terms are defined in English, and then the corresponding words or phrases are given in five other languages. An ingenious arrangement of numbering the terms, which are in alphabetical order, makes it very easy by a simple cross-index to translate a term from any of the other languages. An earlier volume dealt with the terms used in the fields of television, radar and their associated antennæ (see *Nature*, 177, 1099; 1956); the present book covers the corresponding subjects of electronics and waveguides. More than 2,000 terms are defined and they include most of, if not all, the accepted words and phrases used in semiconductor and transistor work, as well as in the general field of electronics. Terms relating to physical electronics are not, however, included since it is intended to deal with the subjects of nuclear science and technology and radiation in a subsequent volume. It is noteworthy that the present dictionary includes definitions already established by the British Standards Institution, the International Electrotechnical Commission and the publishers of the "International Dictionary of Physics and Electronics". As with the former volume referred to above, the book is very well produced in a handy size, with a flexible binding and a convenient thumb-index to the different languages. These qualities combined with the high technical standard throughout make this dictionary a reference work of permanent value to scientists and engineers engaged in the use of electronic devices and microwave equipment.

R. L. SMITH-ROSE

Lecture Notes on the Use of the Microscope

By R. Barer. Second edition. Pp. vii+76. (Oxford: Blackwell Scientific Publications, 1956.) 7*s.* 6*d.* net.

DURING the three years since its first appearance, Dr. R. Barer's little book has become known to a wide circle of scientists; it is evident from the demand for a second edition that this book meets a definite need, by introducing biologists to the correct use of one of their most important tools. As a result of the increasing use of the electron microscope in biology, it might be thought that the usefulness of the light microscope would diminish, but it is evident that the two methods should be used in conjunction, and that the proper use of the light microscope will continue to be of extreme importance. Dr. Barer has deliberately omitted any mention of the specialized forms of modern microscopy, because, as he points out in his preface, these methods are still in a state of flux but the fundamentals of direct microscopy do not change.

There have been only minor alterations in this edition, which resembles the earlier one in retaining its valuable chapters on the theory of the microscope and practical instructions for its use. The appendixes are of particular interest, giving simple experiments to illustrate such points as the effect of numerical aperture of both the condenser and the objective on resolution; the use of Köhler illumination is also described in detail. The book is very well written, and provides a clear explanation of the basic theory of the microscope; although it is intended for biology and medical students, all users of the microscope would be well advised to study it. If they did so, there would perhaps no longer be grounds for the author's opening comment that, "Probably no instrument is more often misused than the microscope".

S. BRADBURY

Old Stone Age

By Stevan Celebonovic, with a Commentary by Geoffrey Grigson. (Nature and Art: a Series.) Pp. 96. (London: Phoenix House, Ltd., 1957.) 30*s.* net.

AS a picture book this volume is delightful and has a real value for the prehistorian. While many of the plates illustrate well-known palæolithic works of art, a number represent sculptures and drawings that are less known and not often reproduced. Frankly, the text is not very helpful, though some readers will find the chronological table at the end useful. Specialists will find little they did not know already, and non-specialists will not learn very much about the art or the cultures that produced it. But, of course, the illustrations are what really matter and at the price they are truly magnificent. No prehistorian should fail to have a copy by him, and the ordinary reader interested in art photography will revel in the beauty of some of the cave and home art subjects as here presented.

M. C. BURKITT

POSSIBLE CORRELATIONS BETWEEN EARTHQUAKES AND MICROSEISMS

By C. A. NANNEY
Department of Physics, University of Chicago

IN August 1954 I observed that a rapid decrease of microseism frequency (inverse period) occurred in coincidence with the Samoa Islands earthquake ($M = 7$–$7\frac{1}{4}$) which occurred at 4h. 42m. G.M.T. on August 18, 1954. The observation was made at the Naval Research Laboratory's Microseism Station at Chesapeake Beach, Maryland. Afterwards, an investigation was undertaken to determine whether the observed change of the microseism frequency might have been correlated with the earthquake, or might have arisen as a chance coincidence, since the microseism frequency is known to vary in time.

To the best of my knowledge, no studies have been carried out to determine whether any correlations exist between earthquakes and microseisms. The following discussion is a summary of some interesting and apparently significant results of such a study.

Microseismic data covering a span of three years were analysed. Most of them (about 90 per cent) were from previously published papers, and the rest were taken by me. The three-year total is the sum of various intervals of data from some eight stations the distribution of which virtually encircles the globe.

Since earthquakes occur fairly frequently, an unbiased sampling method must be used in their selection for a study of this kind. The sampling criteria for earthquakes (such as, all earthquakes occurring during the interval covered by data with magnitude greater than $6\frac{1}{2}$, or all earthquakes with depths reported greater than 30 km.) were established prior to the study of a given set of data. In the subsequent analysis, all earthquakes which fell in the specified category were used, and none was omitted. Similarly, the whole interval of data which were available was always used, and no sets of data analysed were omitted from the statistical tests. The earthquake occurrence times and other relevant information were taken from well-documented sources, such as the "International Seismological Summary". Altogether, some three hundred earthquakes were considered in the analysis.

It should be pointed out that the problem was considered almost entirely on the basis of earthquake information, and no attempt was made to interpret existing meteorological and oceanographical conditions. These conditions are not as well defined as earthquake data (for example, time of occurrence, location, etc.). Furthermore, it is entirely possible that several of the numerous postulated mechanisms for the generation of microseisms may exist at any one time.

Nevertheless, in a statistical study of this type, it is possible to consider the earthquakes independently of any other phenomena which might alter the microseisms. First, if there is no correlation between microseisms and earthquakes, the number of cases contradicting, and the number of cases supporting, the correlation will tend to average out in a statistically large sample of data, and the correlation will not be supported at any statistically significant level. Secondly, any changes of microseisms due to other phenomena will only reduce any correlation that might exist between microseisms and earthquakes, thus requiring a large quantity of data to establish a correlation between the latter, if one should exist.

The findings to be discussed are all based on results which were found to be significant at the 0·01 significance-level. Most of them were significant at a considerably higher level.

The study disclosed that the microseism frequency begins to increase approximately 24 hr. before the occurrence of many large earthquakes. The increase of frequency continued to approximately the occurrence time of the earthquake, and the frequency decreased following the occurrence of the earthquake. The amplitude of the microseisms was found to increase before earthquakes and to decrease afterwards in a similar manner. The average changes, for earthquakes with magnitude $6\frac{1}{2}$ (Gutenberg–Richter scale) or greater, appear to be approximately a 10 per cent increase of the frequency and a 20 per cent increase of the amplitude. The maximum changes that have been observed, which were believed to be associated with seismic phenomena, were an 80 per cent increase of the frequency, and a number of cases of several hundred per cent for the amplitude increase. However, there were some large earthquakes for which no increases of frequency or amplitude were evident.

Microseism data from the following stations were studied: Japan, Guam, Hawaii, California, Missouri, Maryland, New York and Finland. The results indicated that a correlation between earthquakes and microseisms existed at all these stations. The frequency and amplitude effects have been observed for earthquakes which occur at very great distances, even a semi-circumference, from the microseism station. A simultaneous change of these parameters has also been observed to occur for widely separated stations in coincidence with a particular earthquake.

In general, the frequency and amplitude increases occurred only for the larger earthquakes ($M \geq 6\frac{1}{2}$); however, two exceptions were found. First, smaller earthquakes, if closer to the microseism station, were often found to be associated with significant increases in the amplitude and frequency of the microseisms. Secondly, deep earthquakes, though not necessarily large, were found to be correlated with increases of the microseism amplitudes.

The data analysed showed that there is reason for believing that many of the so-called 'microseism storms' may be correlated with earthquakes. This conclusion is based upon a study of a number of papers on microseism storms. From these, the following example is given for illustrative purposes.

Rameriz[1] graphs the microseism amplitudes at St. Louis for about six months of 1938. A study of the microseism storms and earthquakes occurring during this interval disclosed that the time of the maximum intensity of a majority of these storms coincided closely with deep or large earthquakes. The possibility that the correlation observed might be due to chance was shown to be less than one in ten thousand.

Infrequently occurring, long-period (greater than ten seconds) microseisms are known to exist. A study of microseisms of this type was conducted by Oliver and Ewing[2] during the Atlantic Ocean hurricane seasons of 1954–55. The amplitude of these microseisms often reached a maximum, and rapidly decreased during a time when any existing hurricane, its path and its distance from the microseism station exhibited no unusual change. An examination of earthquake records revealed that a majority of the long-period, microseism-amplitude maxima occurred in close coincidence with either a deep earthquake or a relatively local quake occurring in the Atlantic Ocean. The correlation between a maximum of the amplitudes of the long-period microseisms and the occurrence of one of these two types of earthquakes was very strong and far greater than would be expected by chance. Since the authors[2] point out that a hurricane is not a necessary condition for the occurrence of this type of microseism, there is reason to believe that some of these long-period microseisms may be related to earthquakes, particularly deep ones. Indeed, this is not an entirely new suggestion, as I discovered later. Donn[3], in noting similarities between these and certain types of earthquake waves, has suggested that there might be a relationship between the two.

Numerous attempts have been made to locate meteorological storm centres by means of microseism propagation directions. In many cases these were not completely successful, and were largely abandoned as a consistent means of locating storms. I studied several papers[1,3] where microseism directions were given for times during which no hurricanes were present. This study revealed that the directions found for the propagation of the microseisms sometimes showed rather remarkable agreement with the azimuth directions of the great circle path from the microseisms station to the location of impending earthquakes of significance.

For example, Rameriz[1] determined the azimuth of propagation of microseisms at St. Louis at frequent intervals during the month of November 1938. The majority of these fell in the octant between N. and N.N.E. However, of the six exceptions to this octant, four were found to correspond in time to the intervals during which four significant earthquakes occurred. Two of the earthquakes were probably the largest during the interval for which data were given, the third was relatively close to the station, and the fourth was of deep focus.

However, even more remarkable than this coincidence in time were the results of a comparison made between the four observed microseism directions and the azimuths to the respective earthquakes. The first three cases agreed within three degrees and the fourth case differed by fifteen degrees.

While the directional correlation was greater than expected by chance, I do not believe that the data examined to date are sufficient to constitute a conclusive case for a directional correlation with earthquakes. It is merely pointed out here as being a possibility which has some substantiation, and should be further considered.

The preceding observations offer some hope that they might lend themselves to the prediction of earthquakes. Whether any predictions can be made by utilizing the preceding effects awaits detailed investigations of the earthquake-microseism problem and its ramifications. I hope this article will cause sufficient interest to result perhaps in the genesis of some such investigations.

Even if such an endeavour does not prove successful, the studies should give new insights into the Earth's crust and interior, as well as a better understanding of the little-understood microseisms.

I would like to thank Profs. Harold C. Urey, John C. Jamieson and A. W. Lawson, of the University of Chicago, for the opportunity to discuss this problem with them. I am particularly grateful to Dr. J. E. Dinger, at the United States Naval Research Laboratory, for his continued support and advice.

A detailed report of the study is to be published in the near future.

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CONTROLLED THERMONUCLEAR REACTIONS

A DISCUSSION on thermonuclear reactions was held by the Royal Society on February 5. The chair was taken by Sir Cyril Hinshelwood, and the discussion was opened by Sir John Cockcroft, director of the Atomic Energy Research Establishment.

Sir John briefly outlined the earlier work which has led to the present successes in the thermonuclear field. He spoke of the discovery of the D–D reaction by Oliphant, Harteck and Rutherford in 1934, of the pinch effect by Northrup in 1907, and of its experimental consequences by Tonks in 1939. Of the more recent work, Sir John emphasized that of Ware in 1948 on toroidal discharges, of Kurchatov on straight pinches, and of Bickerton and Tayler in England, Rosenbluth in the United States and Shafranov in the U.S.S.R. on the use of an axial stabilizing field. Bickerton and Tayler had established that metal walls and axial fields could together definitely stabilize a discharge. After mentioning the work of the laboratories of Associated Electrical Industries, Ltd., and of the Los Alamos group, Sir John briefly described the papers to be presented. He concluded by pointing out that much useful work could be done in the universities in the now unfashionable field of atomic physics on such processes as excitation and ionization in stripped atoms.

Dr. P. C. Thonemann, who read a paper entitled "The Plasma Physics of ZETA", said that ZETA is essentially a large transformer with which high currents are passed through a low-pressure gas. The ring current in the gas forms the secondary of the transformer. A ring current of this type is self-constricting, but highly unstable: to achieve stability an axial magnetic field is used in conjunction with a metal-wall vacuum vessel. The most significant aspect of the results obtained with ZETA is that stability can be achieved in a toroidal tube.

An isolated plasma is a diamagnetic body, which can remain in an equilibrium position indefinitely in a static magnetic field. As a result of collisions, however, the currents giving rise to plasma diamagnetism decay with time, until finally the gas is no longer confined. The time for which isolation of the gas from the walls can be maintained increases with the electrical conductivity of the gas, which in turn increases rapidly with temperature. On the other hand, high temperatures cannot be produced until isolation from the walls is achieved. Thus the required conditions of isolation and high temperatures cannot be approached stage by stage.

As a result of experiments by R. Carruthers and R. J. Bickerton, ZETA was designed to achieve stability by using metal walls to remove long wave-length instabilities, and axial magnetic fields to remove short wave-length instabilities.

The best indications that the discharge is, in fact, stable are obtained from measurements of the internal magnetic field. Provided the gas can be prevented from breaking up into small pieces, the possible containment-time increases as the square of the linear dimensions of the system. The large size of ZETA has been justified by the containment-times achieved; at present these are only limited by the energy available from the external circuit.

The stable configuration is set up in the following way. Deuterium at a pressure of about 10^{-4} mm. of mercury is weakly ionized by a radio-frequency oscillator. An initial electric field of about one volt per centimetre is applied to the surface of the gas, the ratio of electric field to pressure being chosen to give the maximum rate of ionization without causing the electrons to behave as though they were in an accelerator. As the electron-density increases, current flows predominantly at the discharge surface. When the field due to this current exceeds the axial field initially present, the discharge contracts, and provided the contraction is fast enough the axial flux inside the discharge is conserved. If the metal wall is sufficiently thick no further flux can penetrate it, and the field between the discharge and the walls is just that due to the axial current. Such a system, with sharply separated fields, is known to be stable for short wave-length instabilities. In ZETA, conditions lie between the extremes of completely separated fields and uniformly mixed fields. The time for which such a system remains stable is not yet known.

The metal walls, in addition to excluding the axial magnetic field after the collapse of the discharge, serve to stabilize the discharge against long wave-length instabilities. This is achieved by the image current induced in the wall by any movement of the ring current. The required stability cannot be obtained unless the conductivity of the gas is sufficiently high. This implies almost complete ionization and electron temperatures in excess of 10^5 °K. in the early stage of the discharge, before collapse.

Dr. Thonemann said that the discharge is cooled largely by radiation from impurities, and not by particle bombardment of the walls. Thus, when a probe of area 1/3000th of the wall area is immersed in the discharge, the neutron flux is reduced to an almost undetectable level and the resistance of the discharge is greatly increased. The high temperatures, thermonuclear reactions, and all the other interesting observations follow as a natural consequence once stability has been achieved for relatively long times. If the gas column remains stable as the magnetic fields confining it are increased, then there are no fundamental reasons why temperatures exceeding 10^8 degrees should not be produced.

A paper on "Experiments with ZETA" was read by Mr. R. S. Pease, who said that ZETA is essentially an apparatus for producing high temperatures. The first task, when ZETA began to work on August 12, 1957, was to find the best operating conditions. The guiding principle was that the highest temperatures were likely to be obtained with the largest currents, the lowest starting pressures, and the lowest axial magnetic fields compatible with a discharge which did not damage the apparatus. After considerable experimenting it was found that the best values for the axial field and initial pressure are 160 gauss and $\frac{1}{8}\,\mu$ of mercury (in deuterium). During this experimental period it was noted that alarming voltage transients of up to 1 kilovolt appeared between adjacent liners; this led to concern about the glass-tape insulation between the liners. Another phenomenon encountered at this stage was the sudden fall in current at the end of the pulse, associated with a formidable voltage transient. It is now known that the transient appears when the torus is clean, but a satisfactory explanation of it is not yet available.

Neutrons were first observed on August 30 when the current reached 120 k.amp. at an axial field of 160 gauss and a pressure of $\frac{1}{8}\,\mu$ of mercury. The results of other investigations carried out on ZETA at that time have already been reported in *Nature* (January 25, p. 217).

Mr. Pease described some of the work undertaken since October. The machine has been improved in a number of ways: the insulation between the liners has been changed to polytetrafluoroethylene; irregularities have been removed from the axial magnetic field; the current pulse has been prolonged and condenser overswing prevented by short-circuiting the discharge when the condenser voltage drops to zero. Further modifications to obtain high currents are possible, but these involve removing protecting devices from the circuit and have not yet been attempted. It is hoped soon to replace the liner system by an improved one.

Mr. Pease concluded by describing the magnetic probe measurements; they confirm the densities and temperature obtained by other methods, and show that the gas is confined. They also show, however, that there is considerable mixing of the magnetic fields, and that the volts per turn at maximum current is not that associated with the resistance of the main channel.

When the discussion was resumed, with Sir John Cockcroft in the chair, Sir George Thomson complimented Sir John and the Harwell team on their achievement. He said the evidence that the observed neutrons have a true thermonuclear origin is strong. The temperature measurements themselves are sufficient to indicate that neutrons should be produced. If the neutrons are not thermonuclear, then the temperature measurements are in error and there must be a non-thermal neutron source which, by chance, gives the neutron yield predicted for the incorrect temperatures; Sir George himself did not believe this.

Sir George went on to indicate the importance of electric fields in contained plasmas. The ions in ZETA have a large Larmor radius and would reach the walls in a very short time by scattering. The electrons, however, have a small Larmor radius and are firmly contained. The strong electrostatic correlation between the electrons and ions prevents the ions reaching the walls. The particle paths, being influenced by these strong electric fields, are trochoidal. These electric fields will get stronger and stronger as temperatures get higher.

Dr. A. A. Ware, of the Associated Electrical Industries Research Laboratory, gave an account of the work done there with a torus, Sceptre III, the dimensions of which are scaled down by about one-third compared to ZETA. The design of Sceptre III was originally based on theoretical proposals made by Liley at the beginning of 1957, but in view of the results obtained with ZETA a larger torus than that proposed by Liley was used. The main constructional difference between ZETA and Sceptre III is that the latter has the primary turns near to the torus. This construction reduces the leakage inductance and increases the gas current.

Much information has been obtained from inductance and resistance measurements made on the current and voltage wave-forms. In particular, the skin depth before the discharge leaves the wall is about 1/20th of the tube radius at high magnetic fields, and somewhat larger at lower magnetic fields. Measurements of inductance at peak current indicate that 90–100 per cent of the applied axial field is trapped by the contracting discharge.

Temperatures obtained from the neutron yield agree well with those from spectroscopic measurements. The variation of neutron yield with axial magnetic field shows a peak at that magnetic field which corresponds to the discharge being compressed to one-third of the tube diameter at maximum current. This is to be expected, since the heating of the gas increases with compression, but the discharge becomes unstable if it is compressed too far. Unlike the results obtained with ZETA and Perhapsatron, a maximum with respect to pressure has been found in the neutron yield. Neutrons appear shortly after the discharge has left the wall and the yield rises to a maximum around peak current. Neutrons continue to be emitted into the second half-cycle of the discharge.

Dr. Ware then referred to the comparison of the results with the theoretical predictions of Liley. Results obtained recently have tended to spoil the good agreement reported earlier[1]. The main discrepancies are: the skin-depth is small, a higher temperature is predicted than is observed, there are indications that the electron temperature is less than the ion temperature, and the temperature, as calculated from the neutron yield, does not vary in the right way through the pulse.

Dr. K. W. Allen (Atomic Weapons Research Establishment, Aldermaston) gave an account of work at Aldermaston on straight-tube discharges of short duration, the object of which is to heat the ions directly rather than by way of the electrons. A collapsing current sheath is set up which accelerates radially, the electrons by the pinch effect, and the ions by the electrostatic action between them and the electrons. In this way ions and electrons acquire equal velocities so that the ions get virtually all the energy. Rapid heating requires large sheath velocities and hence minimum circuit inductance. This has been achieved by using an arrangement of parallel spark gaps to discharge the condenser bank so that the inductance is that of a single unit divided by the number of units. A circuit has been devised such that all the gaps can be fired in less than 10^{-8} sec.

Neutrons were first observed at the rate of 10^4–10^5 per pulse on Christmas Eve, 1956. Typical conditions are: bank voltage 9 kV. and pressure 30 μ of mercury in a silica discharge tube 28 cm. long and 15 cm. in diameter. The initial rate of rise of current is 5×10 amp./sec., which is three times faster than that reported by Artsimovich and half that obtained at Los Alamos. Other workers in the field have reported that the neutron yields are very sensitive to impurities and magnetic fields, but this has not been confirmed at Aldermaston, where the yield has been found to be reduced only by an order of magnitude by 5 per cent of nitrogen or by 1,000 gauss axial magnetic field. Artsimovich reported that a few hundredths of a per cent of oxygen, argon or xenon quenched his yield, and Colgate reported that an axial field of 100 gauss reduced his neutron yield by four orders of magnitude. These results suggest that the mechanism responsible for the neutron production in the Atomic Weapons Research Establishment apparatus is different from that proposed by Colgate.

Dr. Allen concluded by saying that a larger condenser bank is under construction. It is hoped that this bank will give rise to a larger neutron yield which will permit a more detailed investigation of the mechanism of neutron emission.

Dr. J. D. Jukes, of Harwell, presented some comments of Dr. R. J. Bickerton and Dr. H. London (Atomic Energy Research Establishment, Harwell) on the scaling laws for stabilized discharges. Dr. Jukes said that, since various groups are seeking to produce thermonuclear temperatures in stabilized pinched discharges, it is desirable to compare similar experiments and to attempt to forecast the requirements of an economical reactor working on this principle by the use of scaling laws.

It can be shown that if I, the total current, and N, the line density, are kept constant, then the characteristic times of the various physical processes which determine the growth and life-time of the pinch, such as ohmic heating, relaxation, field diffusion and radiation cooling[2], are all proportional to R^2, where R is the tube radius. Furthermore, the temperatures are the same at corresponding phases of the life-time of the discharge.

The stable life-time is proportional to R^3, while the neutron yield Y during this time is proportional only to the axial length, and the fraction of nuclear burn-up is independent of size. The radiation flux to the walls per pulse is proportional to R^{-1} and the rate of rise of current required to trap the magnetic field is proportional to R^{-2}. This indicates that there is some engineering advantage in using a large apparatus.

Table 1 compares results of three experiments in the light of these scaling laws. The quantity nt, where n is the density and t the containment-time, is a measure of the efficiency of a reactor, as pointed out by Lawson[3]. This quantity must be increased to 10^{14} at least, and T to 4×10^7 °K. to make a device operating on the deuterium–tritium mixture produce net power. Extrapolating from ZETA this would require a current equal to or greater than 10^6 amp.

Table 1

	ZETA	Sceptre	Perhapsatron $S3$
I (k.amp.)	180	160	200
R (cm.)	50	15	2×5
N (cm.$^{-1}$)	6×10^{16}	8×10^{16}	6×10^{16}
t (sec.)	10^{-3}	10^{-4}	6×10^{-6}
L (cm.)	10^{3}	360	200
Y (neutrons)	10^{6}	10^{5}	2×10^{5}
tR^{-2}	4×10^{-7}	5×10^{-7}	8×10^{-7}
YL^{-1}	10^{3}	3×10^{2}	2×10^{3}
nt	10^{11}	10^{11}	10^{11}

Dr. W. B. Thompson (Atomic Energy Research Establishment, Harwell) gave a theoretical analysis of the operation of ZETA on the assumption that it produces a stable configuration very like that described by Dr. R. J. Tayler[4] later in the discussion, and that most of the heating is Joule heating. The process can be described as occurring in three phases. In phase 1 (0 to 100 μsec.) the gas is ionized, heated and a current skin formed, separating the axial and azimuthal fields; in phase 2 (100 μsec. to 1·5 msec.) the gas is compressed; and in phase 3 (1·5 msec. to end of pulse) the current skin slowly widens, the axial and azimuthal fields interpenetrate and eventually the plasma loses its stability.

Dr. Thompson showed that at the end of phase 1 the current sheath is 5 cm. thick, the temperature is 1·5–2·0 × 10^5 °K., and there is approximate thermal equilibrium. In phase 2 three processes are important: adiabatic compression takes the temperature to about 10^6 °K., Joule heating adds about another 2 × 10^6 °K., and finally shock heating may add a further 5 × 10^5 °K. Thus, at the end of phase 2 the temperature is 3–3·5 × 10^6 °K. During phase 3 there is little further heating and the discharge loses stability. On the basis of Dr. Tayler's calculations (described later in the discussion) the discharge life is 1–2 msec.

Dr. Thompson concluded by saying that the picture he described is not in disagreement with the observations made on ZETA, with the exception of the magnetic-probe measurements. Magnetic probes, however, considerably disturb the discharge and thus may not give a good picture of what happens in their absence.

If the probe results are meaningful and applicable, then some other theoretical model will be needed. An example would be a turbulent but confined plasma, which would make well-mixed fields and high temperatures quite intelligible, but there is little experimental evidence for such a system.

Dr. R. J. Tayler (Atomic Energy Research Establishment, Harwell) spoke of the stability of mixed-field systems. He said that earlier work has shown that there should exist stable configurations of a pinched gas discharge if the currents flow entirely on the plasma surface. Dissipative processes will result in an interpenetration of magnetic fields. An estimate has now been made of the amount of penetration that can occur before stability is lost. A variational method developed at Princeton has been used, and with simplified profiles for the mixed fields, calculations have been made with a succession of trial functions. Results obtained for trial functions with between one and four arbitrary parameters show a change of only 5 per cent in the amount of penetration that can occur. For one initial configuration for which results have been obtained, the field can penetrate through about 15 per cent of the discharge radius. As there is no initial axial magnetic field outside the discharge in this configuration, the estimated duration of stability obtained from it is likely to be optimistic.

These results suggest that a stabilized pinch in ZETA can have a life-time measured in milliseconds. However, it is not clear from the measured magnetic field profiles that a stabilized pinch of this type actually occurs in ZETA.

Dr. Tayler concluded by giving an account of the article on "Co-operative Phenomena in Hot Plasmas" by Prof. L. Spitzer that appeared in *Nature* of January 25, p. 221.

Dr. D. Gabor (Imperial College of Science and Technology) thought that the discrepancy pointed out by Prof. Spitzer is real, and that co-operative processes may well be responsible for the high ion temperatures observed in ZETA and in Sceptre III. It seems necessary to postulate two collective mechanisms: one for transferring energy in a locally ordered form from the electrons to the ions, and one for creating molecular disorder in the ion gas. It is easier to make a guess at the second mechanism, because this may well be essentially similar to that responsible for 'Langmuir's paradox' in low-pressure arcs[5]. In these arcs electrons exchange energy with one another very rapidly, not through collisions but through the intermediary of an oscillating boundary layer. This has a potential distribution and an oscillation frequency such that electrons diving into it and returning to the plasma emerge with a resultant gain, at the expense of those electrons which have dived into the sheath an odd number of half-cycles earlier and have delivered energy to the oscillations. There exists a similar boundary sheath in the pinched discharge, with the difference that—due to the magnetic field—the ions are outside. It is very likely that this sheath is the seat of oscillations with a frequency of about twice the gyromagnetic frequency of the ions, thus creating intense interchange of energy between the ions and an energy distribution which is very nearly Maxwellian.

It is more difficult to guess at co-operative phenomena which may transfer energy from the electron gas to the ions. In the ordinary arc there is no such exchange, as the plasma-frequencies of ions and electrons are widely separated, by a factor of about 60 in the case of deuterons. On the other hand, the Larmor frequency of the electrons in ZETA is of the same order (10^9 cycles/sec.) as the ion-plasma frequency, so that a necessary (but by no means sufficient) condition of co-operative interaction by oscillations appears to be met. Dr. Gabor conjectured that even under conditions when the plasma boundary as a whole is stable, there may be growing helical waves in the electron gas, essentially at right angles to the magnetic field, and weakly coupled to the ion–plasma waves, which are approximately parallel to it. Weak coupling makes the energy pendulate between the two types of waves, but during the periods when the energy is in the ion gas this is converted into disordered, thermal motion by the first-mentioned mechanism, thus preventing its return to the electron gas. To check these hypotheses it may be of interest to look out for strong oscillations in the 1,000-megacycle range.

A. GIBSON

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INTERPRETATION OF SCIENCE TO THE PUBLIC

By Sir LAWRENCE BRAGG, O.B.E., F.R.S.
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SIR ALEXANDER FLECK'S recent address to the general assembly of the British Association, and the editorial in *Nature* of January 4, will be warmly welcomed by all who are interested in the popularization of science. The new plans for enlarging its activities which the British Association has announced focus attention on the need for presenting science in the most effective way to the general public. I am writing about this subject because the experience and traditions of the Royal Institution may afford some useful pointers in our endeavour to interest the public in science. It was founded 160 years ago for the special purpose of interpreting science to the public, and apart from the prosecution of research in its laboratories this has continued to be its primary function. The art of popular lecturing might indeed be said to be its main subject of research.

One of the oldest and most honoured traditions is that a 'Discourse' should be profusely illustrated by experiments and demonstrations. A popular talk to laymen differs in many ways from a lecture to students or an address to a learned society. To a professional scientist the description of an experiment is often quite sufficient because his own experiences in the laboratory enable him to visualize it. But a lay audience has not this advantage. To the layman the difference between the description of an experiment and the actual witnessing of it is as great as the difference between looking at a foreign country on the map and visiting it; we grasp its geography in a far more vivid way when we have been to the place. One is struck again and again by the immense superiority, as judged by the effect on the audience, of a series of experiments and demonstrations explained by a talk over a lecture illustrated by slides. The Christmas Lectures to young people at the Royal Institution afford a good instance. It is surprising how often people in all walks of life own that their interest in science was first aroused by attending one of these courses when they were young, and in recalling their impressions they almost invariably say, not "we were told" but "we were *shown*" this or that. This impact of the witnessed experiment is all the more important because the popular talk is so dependent on emotional reactions. Students take notes, when attending a course, and colleagues listening to an account of research are alive to its bearing on their own work and see the printed account afterwards, so the context is more important to them than the manner of delivery. The final result of the popular talk is measured, however, by the extent to which the audience recalls it afterwards, and this fixation of the image is effected by arousing an emotional response of interest and thrill.

It is perennially surprising to find that it is the simpler experiments which have the warmest reception, especially if they can be done on a spectacular scale. The audience likes to see 'the works'. It is of little help to do something mysterious in a box which makes a pointer move over a scale. The simple experiment is effective because it can be grasped completely, and the members of the audience have the pleasurable feeling that it has become a part of their own experience. Again, there is an art in arranging an experiment so that it shall be æsthetically attractive. We instinctively recognize this when we say after a lecture, "That was a pretty experiment he showed". These may seem small points; but they are important. They may make the difference between a pleased and responsive audience, and one which is bored. If the listeners go away feeling that they have really understood what the lecturer was trying to explain, then they will come again for more. Non-scientists must not be left to feel that all science is too difficult to understand, otherwise they will shut their minds and think that science is for scientists only.

The other guiding principle of the popular lecture is that of starting with something with which the audience is thoroughly familiar in every-day life, and leading them further with that as a basis. The survey of the new country must be tied on to fixed points which are already in their minds. This is one of the most difficult tasks facing the popular lecturer. He may be honestly trying to avoid technical language; but it goes further than that. He has to put himself in the place of the intelligent layman and realize that ideas and experiences so familiar to him are unexplored country to his listener. This may seem to be a stressing of the obvious; but I venture to stress it because I have rather special opportunities to assess the effect of popular scientific talks, and they often pass completely over the heads of the audience because an otherwise excellent talk does not establish an initial *rapport* with the listeners' knowledge and experience.

There is nothing novel in these views, they are merely a recapitulation of the principles which have been preached and practised by all the great exponents of popular lecturing from Faraday onwards. It seems to me, however, that they have an important bearing in planning our strategy for a wider interpretation of science to the public. Merely talking and writing about the wonders of science can be very ineffective because the public is nowadays so bombarded with talks and articles on subjects of all kinds through so many channels. If our message is to be heard above the general noise-level, we must use the most powerful aid we have. The primary way to interest the public in art or music is to show pictures or arrange concerts, and lectures on art or music can only be appreciated when they are related to such first-hand impressions. The primary way to interest the general public in science is to show experiments and demonstrations, and so let them share in the thrill of understanding how things work, which is after all a good popular definition of science.

The staging of a demonstration lecture requires much organization. A simple experiment which takes a few minutes to show in the theatre may demand as many weeks of preparation. There must be a supporting background of technical staff, workshop, and demonstration apparatus of all kinds as well as a suitably fitted theatre, and if a worth-while proportion of the public is to be covered, it means a whole-time use of these facilities which is costly. The Royal Institution is now running a series of demonstration talks for boys and girls throughout the school year, in collaboration with the science teachers, at which large-scale experiments are shown which cannot easily be staged with school resources. An approximate estimate of the cost, based on the proportion of overhead charges allocated to the scheme, is £5,000 a year, which is defrayed by the generous assistance of industrial firms and other bodies which are interested in the venture. Some 16,000 tickets are issued annually. The young people come from an area which includes about one-quarter of the schools in England, and their keenness indicates that this is a very repaying way of using the resources. Some half-dozen such centres operating on a similar whole-time basis would cover most of Great Britain. Certain famous annual lectures sponsored by various bodies are by tradition the occasion for numerous carefully prepared experiments, and these lectures draw enthusiastic audiences. Television can, of course, be a powerful means of transmission ; but the laboratory resources must still be there behind the scenes for providing the programmes. My contention, therefore, is that merely increasing the number of talks and articles about science will not get us very far in interesting the general public, that on the other hand one gets the most rewarding response if one stages shows of experiments for them, and that if their interest is first so aroused, they will be much more able to appreciate the talks and articles.

OBITUARIES

Prof. D. R. Hartree, F.R.S.

Prof. D. R. Hartree, who died suddenly in Cambridge on February 12 at the age of sixty, had been Plummer professor of mathematics in the University since 1946. Before that he had spent fifteen years in Manchester, first as Beyer professor of applied mathematics and later as professor of theoretical physics. He was elected a Fellow of the Royal Society in 1932.

Hartree was born in Cambridge in 1897 and was seventeen years old when the First World War broke out. He served in the Munitions Invention Department and held a commission in the R.N.V.R. When the War ended, he returned to Cambridge to take the Natural Sciences Tripos. He became a Fellow of his own College, St. John's, and later migrated to Christ's College, where he held a fellowship for a short time before going to Manchester.

Some of Hartree's earliest work was on the propagation of radio waves in a magneto-ionic medium, and he wrote several important papers on this subject. His principal contribution to physics, however, was the development of the method of self-consistent fields for the computation of atomic wave functions. Early applications of wave mechanics had been to simple atoms such as those of hydrogen and helium, but Hartree saw a way of obtaining, by numerical means, wave functions for heavier atoms. He exploited this method with great vigour, and a long series of papers appeared in which Hartree and his collaborators presented the results of calculations for a large number of atoms.

Hartree's work on atomic wave functions led him to a more general interest in numerical analysis, and this eventually became his major preoccupation. To him numerical analysis was above all a practical subject and he brought the same kind of enthusiasm to computing as others bring to practical work in a laboratory. He always liked to tackle a new problem, and anyone who brought a problem to him would, as like as not, be given practical help as well as advice.

Although Hartree enjoyed computing—a little while before his death he claimed that he had some 10,000 hours of personal computing to his credit—he appreciated very early the advantages which might be obtained from mechanical aids. He was responsible for introducing the differential analyser into Britain, and the machine which, at his instance, was installed in the University of Manchester in 1935 was used to solve a wide range of problems. During the Second World War the machine was occupied with military problems of various kinds including, notably, an investigation into the mode of operation of the radar magnetron.

When the War ended, Hartree visited the United States to study the developments then going on in automatic digital computers. His practical experience of numerical analysis enabled him to make a distinctive contribution in this field and he rapidly became accepted as an authority. He was much in demand as a lecturer, and a course he delivered at the University of Illinois in the autumn of 1948 was published in book form.

When Hartree arrived in Cambridge in 1946, development work on an electronic digital computer was starting in the Mathematical Laboratory. Hartree associated himself with this project with characteristic enthusiasm and the Laboratory owes much to him for encouragement, advice and practical assistance. He continued his close association with the Laboratory until his death and took a prominent part in the running of successive summer schools in programme design and in the teaching for the diploma in numerical analysis and automatic computing.

Hartree did much to advance the interests of the Cavendish Laboratory, where he had his office. In particular, he was largely instrumental in reorganizing and improving the teaching of mathematics to science students, and in establishing theoretical physics as an optional subject in Part 2 of the Natural Sciences Tripos. In addition to his scientific interests, Hartree was a very keen musician, and played an important part in the founding of the Faculty of Music in the University of Manchester.

Hartree will be greatly missed by his many friends. He was the kindest and most unassuming of men, and endeared himself to all who worked with him.

M. V. Wilkes

Dr. C. J. Davisson

Physicists all over the world, and especially those of the older generation, will have heard with deep regret of the death on February 1 of C. J. Davisson.

Davisson is known best for his work on the diffraction of electrons by metal crystals, which established for the first time the wave character of free electrons and proved L. de Broglie's relation $\lambda = h/p$ between the wave-length λ and the momentum p of an electron. In fact, this work was the outcome of a long series of experiments started for quite a different purpose.

Davisson, who was born in Bloomington, Illinois, on October 22, 1881, took his degree in the University of Chicago in 1908. R. A. Millikan was there at the time and claimed with pride to have directed him towards physics. Davisson then went to Princeton, where he took his Ph.D., and his first published paper appeared in 1909 from Princeton. In 1911, working under O. W. Richardson, then a professor at Princeton, he published another paper on the emission of positive ions from heated salts of the alkali ion and established that they are singly ionized atoms of the metal. In the same year he married one of Richardson's sisters. He then went as instructor to the Carnegie Institute of Technology. His connexion with the laboratory where his life-work was done started as a consequence of the First World War. In 1917 he went to what is now the Bell Telephone Laboratories, then part of the Western Electric Company's organization, to take up a temporary post; he stayed there until 1946.

His war-time work was concerned with the physics of the then new thermionic valves and vacuum technique. After the War he continued to work on the fundamental principles of thermionics and was allowed a free hand in choosing his researches to an extent unusual in those days in an industrial laboratory. He was the first to show experimentally that the variety of Richardson's formula, which in fact makes the electron follow the Fermi–Dirac electron statistics (not then discovered), is preferable to the original form. He also did work which turned out to be of considerable commercial importance on oxide-coated filaments.

Davisson's discovery of electron diffraction arose from a study of the scattering of electrons, and the production of secondary electrons, from metals. The first paper on nickel, with C. H. Kunsman, appeared in *Science* during November 1921. It described surprisingly sharp peaks of reflected electrons which Davisson considered could be explained by scattering (classical, of course) from two shells of electrons. In 1925, after studying some other metals, he returned to nickel. Until then, the experiments had all been on ordinary polycrystallic metals; but by an accident the specimen became oxidized and in restoring the surface by heating was changed into an aggregate of only a few crystals. There was a complete alteration in the pattern of scattering and the former theory had to be abandoned. He was inclined at first to replace it by one of 'transparent directions' of the lattice; but, partly as a result of a visit to the British Association meeting at Oxford, he came to believe that the effect was connected with the new theories of de Broglie and Schroedinger. As a result of a careful search, he and Germer found the first electronic beams in positions which could be explained in this way on January 6, 1927. The consequences of this work of Davisson and Germer are well known, but it is not always realized what a supreme experimental feat these early experiments were. The slow electrons of the order of 150 volts which were used are most difficult to handle, and if the results are to be of any value the vacuum has to be what would still be considered good, and was then quite outstanding. In fact, very few experimenters have since been successful with the method; much faster electrons are used when electron diffraction is employed for the study of surfaces.

In 1937 Davisson shared with me the Nobel Prize in Physics for this discovery.

In the 30's Davisson was interested in electron optics, and with C. J. Calbick could claim the discovery of the principle of the electrostatic lens. During the Second World War he worked on the cavity magnetron. In 1946 he retired from the Bell Telephone Laboratories on reaching retiring age, and was appointed research professor in the University of Virginia and lived at Charlottesville until his death. He leaves a wife, three sons and a daughter. Among many other honours he was awarded the Hughes Medal of the Royal Society.

Davisson was a man of exceptionally lovable character. Slight in build and with a hesitant manner of speaking, which made him seem shyer than he really was, he had a delightful sense of humour and was full of fun. Though he worked most of his life in an industrial laboratory, he was essentially an individualist. Yet he had the reputation of being very accessible in the laboratory and most helpful to all who consulted him. Among those who had close contact with him at the Bell Laboratories are Lee Du Bridge, Merle Tuve, Philip Morse and William Shockley.

GEORGE THOMSON

Mr. J. L. Baker

JULIAN LEVETT BAKER was, when he commenced in 1900, the first chemist appointed to a London brewery. Born in 1873, he had trained at Finsbury Technical College and had worked as a chemist for the Beetroot Sugar Association before brewing became his life-work.

From the first, he energetically studied the many possibilities of improvement in brewing which science could suggest at that time, and in the course of his work he published some fifty papers—a number of them inspired by his original studies on sugars. In 1905, he also published a concise and readable book on "The Brewing Industry".

In 1904 he was joined by Henry Everard Hulton, and the two engaged in the work of the brewery and in numerous scientific studies. It was a memorable collaboration which lasted for thirty-four years until Hulton's death—at which time Baker wrote: "Throughout the long years no shadow was ever cast over an enduring friendship".

Indeed, all Baker's pursuits created something of a record for length. He was an original member at the formation of the Institute of Brewing in 1904 and was a vice-president for forty years (1918–58). He was a scientific editor for forty-two years—first of *The Analyst* (1907–20) and then of the *Journal of the Institute of Brewing* (1920–49); while his service with Watney, Combe, Reid and Co., Ltd., lasted for forty-six years.

His merits were recognized by the award in 1948 of the Horace Brown Medal of the Institute of Brewing.

Baker's interests and energies were not confined to brewing aspects of chemistry, for, besides his editorship of *The Analyst,* he was honorary secretary of the London Section of the Society of Chemical Industry from 1903 until 1909 and its chairman in 1919.

In his retirement, Baker, lovingly tending his garden, outlived his contemporaries to recall to later generations with graciousness and charm something of the marked individuality and wide culture which a band of young London scientists had displayed so outstandingly in the early part of this century.

He died on January 29. He is survived by his two sons and his daughter.

L. R. BISHOP

NEWS and VIEWS

Royal Geographical Society : Medals and Awards, 1958

H.M. THE QUEEN has approved the award of the Royal Medals of the Royal Geographical Society as follows : *Patron's Medal :* Dr. Paul A. Siple, U.S. Antarctic Expedition, scientific leader at the International Geophysical Year's South Pole Base (the "Amundsen–Scott" Base), 1957–58, for contributions to Antarctic exploration and research ; *Founder's Medal :* Sir Edmund Hillary, leader, New Zealand component, Commonwealth Trans-Antarctic Expedition, for Antarctic and Himalayan exploration.

The Council of the Royal Geographical Society has made the following awards : *Special Gold Medal :* Dr. Vivian Fuchs, leader, Commonwealth Trans-Antarctic Expedition ; *Victoria Medal :* Prof. Roberto Almagià, professor of geography, University of Rome, for contributions to geographical research ; *Murchison Grant :* Prof. E. G. Bowen, Gregynog professor of geography and anthropology, University College of Wales, Aberystwyth, for studies on the geography of Wales ; *Back Grant :* Ingénieur-en-Chef Bertrand Imbert, leader of the International Geophysical Year French Antarctic Expedition 1957–58, for contributions to Antarctic exploration and research ; *Cuthbert Peek Grant :* Dr. Peter H. Davis, lecturer in botany, University of Edinburgh, for botanical exploration in south-east Turkey ; *Gill Memorial :* Dr. M. J. Wise, Cassel reader in geography, London School of Economics, for studies in economic geography ; *Mrs. Patrick Ness Award :* Captain A. G. Bomford, R.E., chief surveyor, South Georgia Survey, 1955–56.

The last occasion on which a Special Gold Medal was awarded by the Society was in 1910 when it was given to Robert E. Peary, of the United States Navy, the first man to reach the North Geographical Pole ; previous British recipients were Captain Robert Falcon Scott, R.N. (in 1904), and Sir Ernest Shackleton (in 1909).

Fourth Artificial Earth Satellite (1958β)

As part of the scientific programme of the International Geophysical Year, another artificial Earth satellite was launched by means of a 'Vanguard' rocket of the United States Navy from the testing ground at Cape Canaveral, Florida, on March 17. The new satellite, named 1958β, consisting of an aluminium sphere 6·4 in. in diameter and of mass 3·25 lb., is revolving in an eccentric orbit, varying between 400 and 2,500 miles above the Earth's surface, in a period of 135 minutes. The inclination of the orbit to the ecliptic is at present unknown. The satellite is equipped with two radio transmitters ; one, powered by chemical batteries, broadcasting on a frequency of 108·00 megacycles per second ; the other, powered by solar batteries, operating on 108·30 megacycles per second. The third stage of the 'Vanguard' launching vehicle, a rocket some 4 ft. in length with a mass of about 50 lb., which ejected the sphere from its nose when it attained orbital velocity, is also circling the Earth about a mile from the satellite. It is hoped that this satellite will continue in its orbit for a number of years and afford excellent opportunities for continued observations of value to geophysicists.

Brewing Industry Research Foundation :

Sir Ian Heilbron, D.S.O., F.R.S.

SIR IAN HEILBRON, who is retiring from the post of director of the Brewing Industry Research Foundation, Nutfield, Surrey, has held many distinguished academic appointments. He was professor of organic chemistry in the Imperial College of Science and Technology, London ; and also for some years a member of the Advisory Council of the Department of Scientific and Industrial Research, of which he became chairman in 1953. At the time of his appointment to the Foundation in 1948, the brewing industry had decided to start a central research station, and it fell to Sir Ian to select the site, and to adapt Lyttel Hall, the Victorian property chosen at Nutfield, to meet the requirements of up-to-date research laboratories. This he did with conspicuous success and the Foundation is now a notable example of a modern research station. Sir Ian's reputation as a scientist and in the sphere of research, in which he had rendered distinguished service on a number of departmental and national committees, enabled him to collect around him a band of first-class scientists, who quickly put the Foundation into the top rank of brewing research bodies in Europe, and extended its reputation to the United States. Not the least of Sir Ian's achievements has been that he has succeeded in keeping constantly before his staff, and before the industry, the ultimate practical applications of the fundamental research carried out at the Foundation.

Dr. A. H. Cook, F.R.S.

DR. A. H. COOK has been appointed director of the Brewing Industry Research Foundation at Nutfield at the age of forty-six in succession to Sir Ian Heilbron. Dr. Cook gained the Ph.D. degree for research in organic chemistry at the Imperial College of Science and Technology, London, and after a further period of study at Heidelberg, worked for some time in the field of dyestuff chemistry with Imperial Chemical Industries, Ltd. In 1937 he joined the staff of the Imperial College where, with Sir Ian Heilbron, he did notable work on the chemistry of penicillin. In 1946 he was appointed reader and assistant professor of organic chemistry at the Imperial College, and in 1951 he was elected to Fellowship of the Royal Society. Since 1949 he has been assistant director of the Brewing Industry Research Foundation under Sir Ian Heilbron.

The World and the Observer

IN his broadcast talk, "The World and the Observer", printed in *The Listener* of February 6, Lord Russell investigates the relation between our sensory experiences of material things and the theories of the natural sciences, in particular of physics, concerning the ultimate nature of physical reality. Primary particles such as electrons cannot be perceived, and are quite unlike the sort of objects which we can perceive. Russell's approach to the problem draws on physics, physiology, psychology and logic. His thesis may be summarized in three points. First, the entities dealt with by mathematical physics are "constructions composed of events and taken as units for the convenience of the mathematician". Secondly, everything that is directly perceived is private to the perceiver; it is an occurrence in the brain of an individual. Thirdly, these occurrences are the effects of external causes, the real nature of which cannot be certainly known. As Russell says, these doctrines have not met with great favour from other philosophers. The short space of a broadcast talk is scarcely sufficient to deploy all the arguments and qualifications necessary for a systematic defence of such general and far-reaching theories. One sentence is rendered unintelligible in *The Listener* by the misprint of 'casual' for 'causal', and 'precept' for 'percept'.

The Isaac Newton Telescope and the Navy Estimates

Questioned in Committee of Supply on the Navy Estimates under Vote 6 (Scientific Services) in the House of Commons on February 13 regarding the stoppage of work on the Isaac Newton telescope at the Royal Greenwich Observatory, Herstmonceux, the Civil Lord of the Admiralty, Mr. T. G. D. Galbraith, agreed that the telescope, the purpose of which is to extend the range of astronomical and astrophysical research, is of the greatest importance to the nation. Its cost is being shared between the Admiralty and the Treasury, but after £28,000 had been spent on primary design and study, of which £14,000 had come from the Admiralty, the project has now been suspended in view of the present financial stringency. Mr. Willis said that last year the expenditure was £30,000 and in the previous year £51,000, and he suggested that the stoppage gave point to the recent criticism of the Committee of Public Accounts. Mr. Galbraith said he could not, off-hand, confirm or deny these figures. As regards the International Hydrographic Bureau, while, as stated by Mr. Willis, in the past three or four years sales of charts had increased to 350,000, the 45 per cent increase in income was due partly to increases in price. The reduction in staff was due to the general need to economize. On the expenditure for scientific services generally, in the past two years the numbers of scientific and experimental personnel and of ancillary staff have fallen substantially, and research and development contracts have also generally decreased. The cuts, he said, had not affected important work like the development of nuclear propulsion, on which the Admiralty is working in very close co-operation with the Atomic Energy Authority.

Foundation for Mutual Assistance in Africa South of the Sahara

In a written reply to Colonel T. V. H. Beamish in the House of Commons on March 10, Mr. Ian Harvey, Joint Under-Secretary of State for Foreign Affairs, said that he had represented the United Kingdom at the Conference at Accra on February 19 and 20, when the Foundation for Mutual Assistance in Africa South of the Sahara was inaugurated. The member governments were those of Belgium, France, Portugal, the United Kingdom, the Federation of Rhodesia and Nyasaland, Ghana, Liberia and the Union of South Africa, but other countries and territories in Africa south of the Sahara would be eligible for technical assistance under the scheme. A United States observer had been present at the Conference, but there was no commitment on the part of the United States Government. The technical assistance would take the form of the supply of experts, advisers and instructors to countries in the region, the training of personnel from the region and the supply of equipment for training purposes, and it would be arranged unilaterally following the practice of the Technical Co-operation Scheme under the Colombo Plan. The small secretariat of the Foundation would act as a clearing house between Governments for requests for assistance and offers. The House of Commons would be asked to approve new expenditure of £20,000 by the British Government for such assistance during the next financial year.

Chemical Engineering in a University

Prof. P. V. Danckwerts, recently appointed to the chair of chemical engineering science in the Imperial College of Science and Technology, London, delivered his inaugural lecture entitled "Chemical Engineering in a University" on November 12. He emphasized that a university does not turn out chemical engineers and that its function is to explain to students what a chemical engineer may have to do, to teach them the basic principles on which chemical engineering depends and how to apply them and, above all, to train them to think for themselves. By way of illustration he discussed several chemical engineering processes broken down to show their complicated nature, and the scientific subjects with which it was necessary to be acquainted before trying to build them up. Since, moreover, the practice of chemical engineering is often in advance of the theory, it is imperative for a university to maintain the closest possible contact with industry. Dealing with the difficult question of research, Prof. Danckwerts maintained that, although desirable, research is not an essential part of university training. Certain types of research, such as process development, are, in many cases, unsuited to a university laboratory, owing to the difficulty of working on a sufficiently large scale; but there is a wide and important field in "trying to get a deeper insight into the mechanism of industrial processes by looking at them with a scientist's eye". Examples of possible problems followed, and of particular interest were those dealing with 'scaling up'. Prof. Danckwerts did not venture to tackle the most difficult problem of all: Where is the teaching staff to come from? But perhaps he regards this as outside the scope of his subject. As the first of a series of inaugural lectures to be published by the Imperial College, Prof. Danckwerts's address has now been printed ("Chemical Engineering in a University": Inaugural Lecture by Prof. P. V. Danckwerts. Pp. ii+10+4 plates. London: Imperial College of Science and Technology, 1958. 5*s*.), and will be found illuminating and suggestive by all interested in engineering education and its products.

Palaeontology

Early in 1957, a group of British palæontologists met in London to discuss the formation of an association to further the study of palæontology by the holding of meetings in London and various other centres, and the publication of a journal. The inaugural meeting of the Palæontological Association was held in February 1957, and we now welcome the new journal, *Palæontology*, which made its appearance last November and is to be published half-yearly. The journal is crown quarto in size, and Vol. 1, Part 1, contains eighty-six pages and fourteen collotype plates, the production being of the high standard associated with the Oxford University Press. Contributions will, it is hoped, cover all aspects of palæontology, and included in the first number are articles on the true *Rhynchonella*, Upper Viséan goniatites, the type-species of *Girvanella*, the Cretaceous ammonite *Leymeriella*, *Encrinurus multisegmentatus* and its allies, and descriptions of a new genus of foraminifer and a new Tertiary calcareous alga. The membership subscription is two guineas annually (the price per part of the journal is 35*s*. or 5.20 dollars). The president of the Association is Dr. R. G. S. Hudson, and the treasurer Dr. W. S. McKerrow, University Museum, Oxford.

Evolution

It has been said that the greatest and most enduring monument to the late Dr. O. G. S. Crawford is the journal *Antiquity*, which he inaugurated thirty-one years ago and edited up to the time of his death. He planned his last number, which appeared posthumously in December 1957 (pp. ii + 185–257 + 5 plates. London: Phoenix House, Ltd., 1958. 10*s*. 6*d*. net), as a special evolution number to commemorate the Darwin–Wallace centenary, and it is particularly noteworthy for its frontispiece of a hitherto unpublished sketch of Charles Darwin made in 1855. The number includes a concise and authoritative summary of human evolution by R. Singer, a well-reasoned statement by K. P. Oakley on the evidence for the earliest stages of tool-making, and short articles by the late Prof. Gordon Childe on "The Evolution of Society", and by L. A. White on "Evolution and Diffusion". Another essay, highly appropriate because of its relation to some of Darwin's own studies, is by R. J. C. Atkinson on "Worms and Weathering"; it is the aim of this essay to direct attention to disturbances of the soil produced by worms which, unless taken into careful account, may tempt archæologists to base conclusions on what is really a falsified stratigraphy.

Cleaning Inscriptions

The *Museums Journal* for December 1957 includes an article by Dr. David Smith concerning the cleaning of inscriptions and sculptures in sandstone. The objects comprised altars, military inscriptions, tombstones and sculptures of the Roman and Anglian periods previously housed in the Black Gate Museum in Newcastle upon Tyne. They were cleaned in preparation for exhibition in the new museum erected by the University of Durham. The first step was to remove the surface dirt with a gentle spray of water directed from a rubber hose. For some of the worst cases this was the maximum treatment that the stone could stand. In other cases experiments were conducted with household detergents, dilute hydrochloric acid and fibre scrubbing brushes with hot water; and steel wire scrubbing brushes were also used with much success. This may seem a drastic method, but providing the surface of the stone is sound and the work is done under a constant flow of hot water, it has been found that no harm results. Each stone when completely cleaned was washed and maintained at a fairly constant temperature of 55° F. in another room. After about three months, a colloidal solution of silica in alcohol (ethyl silicate) was applied. This reinforced the natural bond of the stone, hardening it and reducing its porosity without completely sealing it or affecting it in any other way.

Remanent Magnetism

Study of the natural remanent magnetism of rocks is becoming a familiar method for determining the direction of the Earth's magnetic field at past stages in its geological history, and has led to interesting speculations about the wandering of the geomagnetic poles or of the continents themselves. An alternative use for measurements of remanent magnetism, namely, the determination of the temperature of formation of pyroclastic deposits, is described by Shigeo Aramaki and Syun-ito Akimoto in the *American Journal of Science* (255, 619; November 1957). The method depends on the fact that if all the fragments composing a deposit of this kind maintained a temperature above the Curie point of the constituent ferromagnetic minerals during emplacement, and cooled below this point only after coming to rest, their thermo-remanent magnetism must show a uniform orientation parallel to the geomagnetic field at the time and place of cooling. If, on the other hand, the fragments had already fallen below the Curie point before settling, the natural remanent magnetism of the fragments will have random orientations. Using this criterion, the authors have been able to distinguish between *nuée ardente* deposits and mud-flow deposits associated with several Japanese volcanoes and formed at various periods from recent historical to late Pleistocene times.

Wilmot Breeden Fellowships

The Wilmot Breeden Group of Companies, the manufacturing interests of which include motor-vehicles and gas-turbine components, hydraulics and electronics, are sponsoring two fellowships, each worth £1,000 per annum, one at the University of Birmingham and the other at the Birmingham College of Technology. Successful candidates will divide their time between the University or College and the Company. The fellowships will be advertised every year in March, in odd years in association with the University and in even years in association with the College. Each fellowship will normally be held for a period of two years. Candidates, who should have an honours degree of a university in the British Commonwealth, a diploma in technology, or an equivalent qualification, should normally have had two or three years experience of research or industry. An application for a fellowship should outline a two-year programme of research on which the candidate seeks to work. Inquiries can be addressed to the Secretary, Wilmot Breeden (Holdings), Ltd., Amington Road, Birmingham 25.

Society of Analytical Chemistry: Officers

The following officers of the Society for Analytical Chemistry were recently elected for the forthcoming year: *President*, J. H. Hamence; *Past-Presidents serving on the Council*, D. W. Kent-Jones, J. R. Nicholls, G. Taylor and K. A. Williams; *Vice-Presidents*, N. L. Allport, R. C. Chirnside and A. A. Smales; *Honorary Treasurer*, A. J. Amos; *Honorary Secretary*, R. E. Stuckey; *Honorary Assistant Secretary*, S. A. Price; *Ex-Officio Members of Council* (chairmen of Sections): A. N. Leather (North of England Section), Magnus A. Pyke (Scottish Section), S. Dixon (Western Section), R. Belcher (Midlands Section), D. F. Phillips (Microchemistry Group), R. A. C. Isbell (Physical Methods Group) and S. K. Kon (Biological Methods Group).

American Phytopathological Society

The American Phytopathological Society is celebrating its fiftieth anniversary this year, and a series of outstanding symposia by internationally-known scientists is being presented at the meeting of the Society with the American Institute of Biological Sciences in August. A book of approximately 1,000 pages entitled "Plant Pathology—Problems and Progress 1908–1958", containing more than sixty symposium papers, will be published by the American Phytopathological Society in the winter of 1958. The papers in this volume are primarily basic in content and apply to many phases of the biological and physical sciences. Further information can be obtained from the American Phytopathological Society, P.O. Drawer 1106, New Haven 4, Conn.

University News :

Birmingham

Prof. F. H. Garner's tenure as professor of chemical engineering and head of the Department of Chemical Engineering has been extended for two years to 1960. The title of reader in mechanical engineering has been conferred on Dr. B. N. Cole, senior lecturer in mechanical engineering; and the following appointments have been made: Dr. R. D. Peacock and Dr. J. Burdon, to be lecturers in chemistry; T. R. Bott, to be lecturer in chemical engineering; D. I. Rees, to be J. Lyons research fellow in analytical chemistry; Dr. D. A. Heath, to be lecturer in pathology; and W. Marsh, to be lecturer in orthodontics.

The new Chemistry Block (the first stage of which should be completed in 1960) is to be named the Haworth Building to commemorate the late Sir Norman Haworth, who was Mason professor and director of the Department of Chemistry in the University during 1925–48.

London

Dr. S. R. Sparkes, reader in civil engineering at the Imperial College of Science and Technology, has been appointed to the chair of engineering structures tenable at that College; and Mr. G. R. Hall, acting principal scientific officer at the Atomic Energy Research Establishment, Harwell, has been appointed to the readership in nuclear technology tenable at the Imperial College.

Announcements

Prof. C. A. Coulson, Rouse Ball professor of applied mathematics in the University of Oxford, will deliver the 1958 Eddington Memorial Lecture in Cambridge, at the Arts School Lecture Theatre, Bene't Street, on April 21 at 5 p.m.; his subject will be "Science and the Idea of God".

A symposium on Molecular Structure and Spectroscopy will be held in the Department of Physics and Astronomy, Ohio State University, during June 16–20. There will be discussions of the interpretation of molecular spectroscopic data as well as methods for obtaining such information. Accommodation will be available for those who wish to reside on the campus during the meeting. Further details can be obtained from Prof. R. A. Oetjen, Department of Physics and Astronomy, Ohio State University, Columbus 10, Ohio.

The 1958 Microscopy Symposium, the fifth of these symposia, will be held in Chicago during June 9–12 and will include sessions on instrumentation, electron microscopy, X-ray microscopy, autoradiography, medical and biological applications, fibres and plastics, forensic microscopy and structural materials. Exchange of ideas and techniques are encouraged in an informal atmosphere. Further information can be obtained from W. C. McCrone, jun., Walter C. McCrone Associates, 500 East 33rd Street, Chicago 16, Illinois.

The Postal and Telecommunications Group of the Brussels Universal and International Exhibition is organizing an international conference on "Solid State Phenomena in Electronics and Telecommunications" to be held in the University of Brussels during June 2–7. Three major subjects will be treated at this conference: semi-conductors, magnetic materials and photo-sensitive and luminescent materials. Prospective authors of papers in those fields are invited to notify the organizers as soon as possible. Further information can be obtained from the Hon. General Secretary, Société Belge de Physique, Loverval, Belgium.

A conference on "Noise", with particular reference to industry, organized by the British Occupational Hygiene Society, will be held at the Canterbury Hall, Cartwright Gardens, London, W.C.1, on April 1. The conference is open to non-members of the Society on payment of a registration fee of one guinea. Mr. T. E. Cawthorne (King's College Hospital) will discuss the physical disturbances produced by excessive noise; Dr. T. S. Littler (Wernher Research Unit on Deafness) will describe the techniques of measuring noise; Dr. A. E. Carpenter (Applied Psychology Research Unit of the Medical Research Council) will deal with the disturbance of mental performance caused by noise; and the suppression of noise will be dealt with by Mr. N. Fleming and Mr. W. C. Copeland (National Physical Laboratory). Further details can be obtained from the hon. scientific secretary, Dr. D. Turner, Associated Ethyl Co., Ltd., Ellesmere Port, Cheshire.

The Non-destructive Testing Group of the Institute of Physics has organized a joint conference with the Société Française de Métallurgie, to be held in Paris during June 16–20. The theme is to be the utilization of physical properties for studying the relationships between the constitution, structure and service behaviour of metals, and there will be both French and English chairmen at each discussion session. The conference, for which there is no fee, is primarily intended for members of the Institute of Physics, but there will be limited accommodation for non-members. A parallel programme, including visits to Malmaison and St. Germain, is being arranged by the French Metallurgical Society, and members' ladies are expressly invited on this occasion. Those who wish to attend should apply, before March 24, on forms obtainable from Mr. L. Lawrence, Institute of Physics, 47 Belgrave Square, London, S.W.1, to whom all inquiries should be addressed.

Erratum. In the article by Dr. E. B. Kraus entitled "Recent Climatic Changes" in *Nature* of March 8, p. 666, the formula in the second paragraph is incorrect; for $y(n) = 100 \sum_{l=1881}^{n} \left(\frac{r_l}{\bar{r}-1}\right)$ read $y(n) = 100 \sum_{l=1881}^{n} \left(\frac{r_l}{\bar{r}} - 1\right)$.

TECHNOLOGICAL EDUCATION IN BRITAIN

THE development, up to July 1957, of courses leading to the new Diploma in Technology is recorded in the first report of the National Council for Technological Awards, which was published on November 21*. At that date there were 965 students in thirty-seven courses leading to the new award. The report gives a full list of the courses now in progress which have been approved; these include applied chemistry, applied physics, applicable mathematics, applied pharmacology, applied biochemistry, aeronautical engineering, mechanical engineering, civil engineering, electrical engineering, and production engineering. Of 123 applications which had been received, 83 had been considered by July 31, 1957, and of these 49 were accepted and 34 rejected. The 49 accepted comprised 29 existing courses and 20 proposed new courses.

The report opens with a brief review of the events leading up to the establishment of the National Council, with its two boards of studies, one for engineering and one for technologies other than engineering. The constitution of the subject panels which deal with individual technologies is then mentioned and the procedure for the consideration of courses is described. The written submission from a college is considered by the appropriate subject panel, and, generally, the college is visited by members of the Council, the object of the visit being to inform the Council of the setting in which the course would be conducted, to meet the principal of the college and his staff, to see the equipment and accommodation available, and in general to enable the Council to form a better assessment of the position than could be done on the basis of the written application alone.

Several of the important features of the scheme receive comment in individual paragraphs of the report. Recalling that the standard of admission to courses is either five subjects in the General Certificate of Education, of which two appropriate to the course must be at Advanced Level, or a 'good' Ordinary National Certificate, the comment is made that the Council has not attempted to establish a definition of 'good' for this purpose, but has considered individually the proposals put forward by colleges. It is pointed out that there is also provision for the entry of students not possessing these qualifications but who have completed successfully a course of preliminary training.

Dealing with syllabuses, the report reiterates that, in all courses approved, the study of fundamental science and technology and their application provides a course of disciplined study fully equivalent to that leading to a university honours degree. The interesting comment is made in this section that in relation to some of the courses which the Council has rejected the weakness has been one, not of inadequate syllabus content, but of overcrowding the syllabus, resulting in an excessive number of hours in the week assigned to formal classes.

The importance of providing a reasonable amount of time for private study is emphasized and it is remarked that few colleges have adequate space available for this purpose. This, it is implied, is associated with inadequate library facilities—a situation which is being rectified.

Specific reference is made to the 'project' as an important part of the work of the course in the final year, and it is suggested that the project may well serve as a link between the industrial training and the subjects studied. Liberal studies which might serve to give the student some appreciation of the social and economic significance of the technology he is studying are expected to form part of the curriculum and should constitute subjects which are examined. It is recognized that the best methods of incorporating such liberal studies are still very much a matter of experiment, and an appreciative reference is made to the serious way in which colleges are tackling the pioneer work to be done in this matter.

In regard to staff, special reference is made to the report of the Special Committee on the Supply and Training of Teachers for Technical Colleges. Of particular urgency are the matters of reducing the excessive teaching load carried by many teachers in technical colleges, the provision of adequate research facilities and of adequate research assistance and clerical assistance. Associated with these are several other recommendations from the report, among which may be mentioned the proposal that "senior members of industrial staffs should be given a special status in colleges permitting them to be closely identified with all the academic activities of the college" and the "appointment of representatives of industry and commerce to college Governing Bodies as a means of ensuring the effectiveness of the college's work and of helping to secure part-time staff from industry".

Another of the fundamental principles upon which the Diploma in Technology is based is restated in the report in the words: "The Council regard a course leading to the Diploma in Technology as a complete entity, the industrial training being just as much a part of the course as the academic study". Full and wholehearted co-operation between college and industrial firm is essential if works experience and academic studies are to be genuinely complementary. The view is expressed that such close and effective association may well be difficult to achieve when a number of small firms are involved, but its attainment is of the utmost importance as it constitutes one of the most valuable—and indeed unique—features of the scheme. Associated with this is the problem of maintaining an appropriate amount of study during the works periods.

The Council is confident that the substantial building programme now in progress will remove the majority of the many deficiencies in accommodation found in colleges. These deficiencies have in the main concerned amenities for student social activities, libraries, accommodation for project work and private study, and for research by staff. Residential accommodation for students is regarded as essential, but the initial absence of such facilities has not prevented the recognition of courses.

The main body of the report concludes with a statement that the Council has set up a special committee to make recommendations as to what postgraduate award the Council should offer. Six appendixes provide information concerning the governing body, boards of study, courses in progress which have been recognized and new proposed courses, together with notes about the subjects of courses approved and rejected. The last two appendixes state the examination arrangements and give the decisions of the Council concerning the minimum length of a sandwich course, and conditions for exemption from the first year of the course.

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* National Council for Technological Awards. Report for the period December 1955 to July 1957. Pp. 20. (London: National Council for Technological Awards. 1957.)

It is evident from the report that the response of technical colleges to the institution of the new award has been excellent. The relatively high rate of rejection for courses offered has been due to the insistence of the Council on the maintenance of fully adequate standards, a matter of paramount importance in the establishment of the standing of the new award.

Enrolment of approximately one thousand students in the courses recognized up to July of last year represents a substantial and encouraging start to a project which should make a great contribution to meeting the need of Britain for additional technologists. Although the appendixes to the report give considerable detailed information about the position, one vital factor is absent, namely, the distribution of students in relation to their method of satisfying the entrance requirements. In assessing the net gain, the real criterion is that of the sources from which the men are drawn, and it is to be hoped that in future reports this information will be presented.

SCIENCE EDUCATION IN MALTA

DURING Malta's tenth education week, which was organized by the Malta Union of Teachers during May 4–11, 1957, Prof. G. P. Xuereb, dean of the faculty of medicine and surgery in the Royal University of Malta, discussed the place of science in the Maltese educational system.

There is in Malta an acute realization of the fact that changes are necessary in the educational system. The social environment has changed, and educational methods have become unrelated to the social background. There must be an intimate and indissoluble connexion between the pattern of an educational system and the social order for which it is preparing the citizens.

One of the principal causes of the maladjustment between Maltese education and the country's needs lies in the fact that the new scientific knowledge, from which social changes have sprung, is incorporated very imperfectly in the educational system.

The majority of Maltese educated men and women are unaware of the way scientific discovery has shaped society in the past and of the way in which it might change it in the future. Inadequacy of science teachers is imperilling the introduction of the sixth forms in school. The Civil servant is having to face the administration of industry, trade development, public health, statistics, technical education, labour and social services created by forces that his education did nothing to lead him to understand. Everywhere there are improvized methods, because education has given no training.

Scientific studies are not providing the social stimulus and the intellectual training which they should. Judged by the actual hours of teaching, science is still a minor subject in general education. Many teachers still believe that science should not be taught as part of a general education—a belief disguised laconically by the statement that they wish to avoid "premature specialization".

The content of the science courses also leaves much to be desired: the course must be coherent so that everybody realizes the connexion between the successive parts of his science work. Instead of coherence there is a strong bias towards physics—and physics in its most arid form. Chemistry is not yet established. Biology, far from being taught as the natural history of animals and plants, is 'nature study' and is hurriedly jostled out of the curriculum when it arouses the inborn curiosity of youth. Science is being taught as a collection of laws and facts rather than as a constantly growing body of knowledge with social implications of vital importance. The social repercussions of science are relegated to a few isolated industrial applications. Briefly, science is presented as a dead body of facts, rather than as a living cultural and social force.

When these boys go to the Royal University, a course in general science is quickly prescribed for the lawyers, legal procurators and theologians of to-morrow. In this course the lecturers ensure that the students learn to believe the authority of the master or text-book and to reproduce the text when asked. These students are confined to the lecture room and are never referred to the laboratories.

The science courses are not much better themselves. Science students spend two years at the University acquiring the basic theoretical and practical knowledge which they should have more appropriately gathered in the secondary schools. Then, when they are ready to absorb some scientific method, they are passed on to the intermediate course in medicine, pharmacy, architecture and engineering. In medicine considerable time is devoted to introducing them to the sequence of hypothesis followed by experiment or observation and then analysis. Is it surprising that nearly 70 per cent of science students fall by the wayside and that only 30 per cent obtain a medical qualification ?

In the past three years the University has taken certain steps to ensure that science is brought into closer relationship with the needs of life. A four-year course for Civil servants has been instituted leading to a diploma in social and political administration. Scholarships in biology, chemistry and physics have been provided, and three Maltese graduates are now at Oxford and London taking the honours school in these specialities before appointment to lectureships in science. The University of Malta will shortly be requiring matriculation in chemistry and in physics or biology from prospective science students. The University has drawn up plans for reform in the course of pharmacy. The libraries have been put on a scientific basis, science laboratories are now completed and funds have been secured for the building of a medical school. These measures are a beginning: they will contribute greatly towards bringing the Maltese educational system into line with a changing social environment.

MANAGEMENT DEVELOPMENT

At a conference organized by the British Institute of Management at Harrogate during January 22–24, more than a hundred representatives from leading industrial organizations in Britain discussed the finding and development of managers for industry.

To open the conference, Mr. E. F. L. Brech, of Urwick, Orr and Partners, examined the motives which cause young men to choose a managerial career. The goal could be money, the idea of power, prestige, or a wish to cover up the man's sense of inferiority. Mr. Brech suggested that these reasons are inadequate. The essence of management is responsibility for a social task, and the better educated mind should be attracted to management with the offer of a satisfying social job rather than for the financial return.

He wondered whether the advertisements selling the idea of a big and lucrative future in management were carrots to draw in bright young men who would not be given a chance to get ahead. Many men now in top managerial posts should not be there, and firms should keep their eyes open and remove incompetent men before they got too far. The responsibility of management is to do the job efficiently and economically. Good human relations lead to good morale and so help to achieve this end.

Here, Mr. A. Brown, administration and personnel director, Mars, Ltd., suggested that all companies should adopt an appraisal system to ensure that all human resources in the company are looked at systematically at least once a year. The right man, the best man for the job, should be sought within and without the company.

If the company needs a 'go-getter', then he should be sought. If the company needs a systematic, conservative type, he should be looked for. Small and medium-sized firms must often rely on large firms to train managers who will either find inadequate or too distant scope in those firms and seek work in the smaller company with its close relationships and opportunity for wide experience.

When selecting men as managers there must be not only a job specification but also a full definition of the requirements of the job in relation to the organization, its personnel and future planned development. It is desirable to know who the man will work with. Is a systematic or intuitive approach required in the job as envisaged? These are the kind of facts which should be known but rarely are.

If the company has a natural successor for an appointment, it should dispense with elaborate selection methods. If the company is satisfied that it has the right man after examining all information and records, the selection should be made there and then.

Mr. W. W. Ferguson, of James Williamson and Son, Ltd., suggested that, to find the right man, the old Army custom of making men into acting temporary unpaid lance-corporals should be tried on the shop floor. In this way, argued Ferguson, it could be discovered whether the prospective foreman was a good leader and, by letting him work with a carefully chosen foreman, he could be seen in action. If he were satisfactory, all would be well; if not, he could be returned to his previous job.

This assumption was not generally accepted. One or two delegates supported Mr. Ferguson, but many others rejected his plan as impractical. Most of the delegates felt that in industry it was no easy thing to lower a man's status after raising it, and that the temporary foreman would suffer as he could have no real authority during his trial period.

In an informal discussion, the conference considered a suggestion that the end of National Service would be the end of an interlude which did much useful work in disciplining the nation's industrial recruits. More than one speaker claimed that industry could get along quite well without this service, and that it could undertake its own teaching of discipline and training of apprentices.

One of the general conclusions emerging from the conference was that management development is supported only by a representative, sincere and progressive slice of British industry. More than once voices were raised to ask whether top management—the policy makers and leaders of industry—was yet sufficiently convinced of its practical value.

Examples were given of firms with comprehensive management development programmes sympathetically encouraged by the men at the top: so were more cynical views that top management thought such programmes a waste of their valuable time.

T. H. Hawkins

ELECTRON MICROSCOPISTS

At the fifteenth annual meeting of the Electron Microscope Society of America, which was held at the Massachusetts Institute of Technology on September 11, 1957, the president, Dr. J. H. L. Watson, head of the physics department of the Edsel B. Ford Institute for Medical Research (Henry Ford Hospital, Detroit 2, Michigan), gave a summary of the results and conclusions of a survey which he had recently conducted on the subject of what was expected professionally of a trained electron microscopist. The survey was made by questionnaire and letter addressed to two hundred electron microscopists and directors or supervisors of laboratories in which electron microscopy is used. One hundred and thirty-nine answers and opinions were received, but despite the diverse fields of application in the various institutions the replies showed a surprising unanimity.

A good laboratory attitude, a co-operative personality, scientific imagination, and patience, were the particular personal qualities required. Familiarity with the particular field of application, in addition to electron microscopy, was stressed, as was also the importance of ability to inform others clearly and concisely of the work in progress. No desire was expressed by the biologists or non-biologists for a difference in training of scientists for electron microscopy in their respective spheres, except that the non-biological institutions mentioned that especial emphasis should be given to optical microscopy. The replies included eleven from sources outside the United States, but their requirements were almost identical with those from the industrial non-biological institutions, differing only in that 'skill in photography' was asked for in preference to 'knowledge of allied instruments'.

In almost all cases the duties expected of a trained electron microscopist were expected in a high order of perfection—not just to maintain the instrument, but to maintain it 'at its peak'—thus demanding a maximum of experience and training in the field and indicating a preference for postgraduate training.

Dr. Watson referred to the great shortage of research electron microscopists in the United States of America and stated that a strong plea could be made for graduate university courses in electron microscopy where men from diverse fields could be trained in the fundamentals of the subject and conduct electron microscopical research in their respective fields leading to postgraduate degrees.

S. WEINTROUB

FREEZING FISH AT SEA

A PRIMARY aim of the work at the Torry Research Station of the Department of Scientific and Industrial Research is the improvement in quality of fish as sold to the consumer. Particular attention has been paid to the problem of fish, principally cod, caught in Arctic waters, since the earlier part of the catch may be some twelve days old when it is landed. During the voyage the fish are stowed in holds in crushed ice, and it is obvious that the quality at landing could be markedly improved if the fish were quick-frozen soon after catching. "Report on an Experiment into the Freezing of Fish at Sea" (pp. 65+6 plates. London: White Fish Authority, 1957. 5*s.*) is a record of an extensive and impressive large-scale experiment to examine the practical feasibility of such a scheme of quick-freezing at sea. The technical developments were undertaken by the Department of Scientific and Industrial Research, and in the field work the White Fish Authority and the trawler owners gave full co-operation.

Five main phases of the technical work are fully described: (1) the experimental development in the Torry engineering laboratories of a suitable type of freezer for whole cod; (2) the sea-trials of a prototype freezer in the Station's motor fishing vessel; (3) collection and analysis of operational data on fourteen typical trawler trips to northern waters, to provide a design basis for a full-scale plant; (4) the construction and shore testing of the full-scale freezing plant and the conversion of a typical trawler, *Northern Wave*, to take the installation; (5) the results of the eight experimental voyages with the freezing plant in action.

The freezing plant has a capacity of about 8 tons of fish per day and roughly 23 per cent of all fish caught was quick-frozen. Freezing was effected by direct-contact plates through which refrigerant at − 40° F. was circulated, and the frozen blocks were stored at − 20° F. in a specially installed cold store.

Details are given of the marketing experience and reaction to the product, and the financial and economic implications are summarized. The scale of the experiment was not large enough to permit of firm conclusions on all these points, but the findings should be of marked assistance to trawler owners contemplating the adoption of freezing at sea. The outstanding feature of the experiment was the successful performance of the freezing equipment under all weather conditions, and the technical feasibility of the project was amply demonstrated.

CARTOGRAPHY

THE first volume of the official records of the first United Nations Regional Cartographic Conference for Asia and the Far East consisted of the report of the Conference. This has now been supplemented by a second volume*. Of this, the first 22 pages, or about one-sixth, consists of summary records of the discussions, which took as their starting point a recognition that "accurate maps are a prerequisite to the proper development of the world resources which in many cases lie in relatively unexplored regions", and that topographical mapping must necessarily precede geological or other specialized surveys. Delegates were concerned largely with the need of the less-developed countries for technical assistance in both survey and map compilation; and with the means by which publication of further sheets of the International Map of the World on the Millionth Scale might be encouraged. The "Technical Papers" follow and vary from an account of the status of publication of the International Map accompanied by communications on its future from various interested parties to descriptions of some of the most recent developments in survey methods.

The report on the "International Map of the World on the Millionth Scale"* is, except to the cartographically well informed, a most misleading document. It misleads particularly by its index map, which conveys the impression that the Map itself is well on the way to completion. This is far from being the case, and since it is important that scientists generally should be aware of the realities of the situation regarding this basic map of the world, it is well to recall the history of this project.

The original proposal for an international map of the world on a scale of 1 : 1 million (about 16 miles to 1 in.) was made by Prof. A. Penck at the International Geographical Congress in Berne in 1891. It

* United Nations Regional Cartographic Conference for Asia and the Far East, 15–25 February, 1955, Mussoorie, India. Vol. 2: Proceedings of the Conference and Technical Papers. Pp. x+133+2 maps. (New York: United Nations; London: H.M. Stationery Office, 1957.) 1.50 dollars; 11*s.*; 6.50 Swiss francs.

* International Map of the World on the Millionth Scale: Report for 1955 prepared by the Secretariat. Pp. iii+84+1 map. (New York: United Nations; London: H.M. Stationery Office, 1957.) 0.80 dollars; 5*s.* 6*d.*; 3.50 Swiss francs.

was recognized from the outset that the standard of the surveys from which it would be compiled varied greatly in different parts of the world, but it was felt that if the sheets were published in a uniform style and those features which had only been roughly explored were clearly distinguished, a very useful map would result. It was discussed at succeeding (4-yearly) conferences and by 1910 detailed specifications for projection, sheet lines, conventional signs and layer colouring had been drawn up, with the object of ensuring that sheets published by different countries should be as much a part of a uniform series as if they had been issued by the same publisher. By 1914 about a dozen sheets had been published. During the War several sheets were issued in styles closely approximating to that specified, but the Paris Conference of 1913 had ruled that sheets not completely conforming could not be regarded as part of the International Map, and in the first report of the Central Bureau of the Carte International du Monde (1921) two index diagrams were printed—one showing international sheets and the other sheets sufficiently similar to be conveniently used to supplement them. This distinction was confirmed by the conference of 1928 and firmly adhered to in the period between the Wars. Some of the most important contributions, including the American Geographical Society's series of sheets of Hispanic America, which was commenced in 1922 and completed in 1945, fall in the latter category, though they closely resemble International sheets.

In 1939 a map on this scale was again found to be most useful, and many sheets were prepared by military establishments. As time went on, they departed more and more from the specifications for the International Map and by the end of the War the position was very confused. In September 1953 the functions of the Central Bureau at Southampton were transferred to the United Nations Cartographic Office and an attempt was made to find out what had been published. The first result was an index diagram in World Cartography, Vol. 3. The report of the regional cartographic conference referred to above contains a reproduction of this diagram, which bears the date January 1957, though World Cartography, Vol. 4, which was published in the first half of 1956, and was devoted entirely to the International Map, contains a later diagram showing many more sheets, particularly in Asiatic Russia and Australia. It also contains most useful reproductions of the resolutions of 1913 and 1928.

The report for 1955 on the International Map of the World on the Millionth Scale (published in 1957) again shows more sheets, this time mostly of China. In both cases it is explained that the additional sheets are not necessarily newly published, but that their existence had not previously been reported to the United Nations. However, an inspection of the tabulated list of sheets reveals the fact that a great many, particularly of these additional sheets, are published by either the Geographical Section of the General Staff of Great Britain, or the Army Map Service of the United States, and are for "official use only, and not for sale or distribution". What is not revealed is the equally important fact that in general they depart considerably from the specifications for the International Map, though it is made clear that many of those of China are in black-and-white only and in the Chinese language. In fact, almost no reference is made to the distinction so carefully drawn in the years before 1939 between International and other sheets. Since the latter have become so very heterogeneous, some of them having little except projection and sheet lines in common with the International Map, the report is of little value as a guide to the present state of what used to be known as the Carte International du Monde. It would be a great pity if the challenging but very desirable and, one hopes, not unattainable objective of a homogeneous series of maps covering the whole world which for so long received the support of many distinguished geographers and surveyors should become obscured by a welter of second-rate publications, not all of which are even on public sale. A. M. FERRAR

INSECTS OF MICRONESIA

THE attention of students of the terrestrial Arthropoda in general is directed to a series of publications by the Bernice P. Bishop Museum, Honolulu, Hawaii, entitled "Insects of Micronesia". The geographical area covered includes practically all the oceanic islands of the north-western Pacific Ocean west of the 180th meridian and north of the equator. The chief island groups are the Marianas, Carolines, Marshalls and Gilberts, and the isolated islands are Ocean, Nauru, Wake, Marcus, the Bonins and the Volcano Islands. Altogether, Micronesia comprises some 2,400 islands under the administration of the United States, the United Kingdom and Australia. The former Japanese possessions, the Bonin Islands, Volcano Islands and Marcus, are now under United States mandate.

This series is based largely on the collections made between 1947 and 1953 by the Pacific Science Board (U.S. National Research Council) with the financial support of the U.S. Office of Naval Research, but much material was collected during the Second World War by American Service-men and previously by Japanese workers headed by Prof. Teiso Esaki, of the University of Kyushu. Since 1953 the work has been financed by the U.S. National Science Foundation, which has also assisted in the publication of the series.

"Insects of Micronesia" is planned to appear in twenty volumes which will be published at irregular intervals when ready. Vol. 1, which explains the scope and aims of the series as well as discussing the environment and natural history, was published in 1954 and is by Dr. J. Linsley Gressitt, entomologist at the Bishop Museum and leading spirit in this ambitious project. Vol. 2, published in 1955, is a comprehensive bibliography together with a subject index and is by Prof. Teiso Esaki, E. H. Bryan, jun., and J. L. Gressitt. Vol. 3 will be devoted to the Arachnida, Vol. 4 to the Crustacea, and Vols. 5–19 to the insect orders, followed by a summary in Vol. 20. Although none of these volumes has been completed, twenty-two parts have been issued to date.

This work is being undertaken by 115 specialist authors representing about fifty institutions in some thirteen countries, and is an example of the international effort required to deal with the vast assemblage of insects. Some idea can be gained of the increase in knowledge resulting from this publication by reference to the most recent issue, Vol. 7, No. 3, Heteroptera Aradidae, by Ryuichi Matsuda and Robert L. Usinger, in which the number of known species of this obscure family of fungus-feeding bugs is raised from thirteen to forty.

It is to be hoped that "Insects of Micronesia" will be successfully concluded in the not too distant future. W. E. China

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A TRAP FOR INSECTS BITING SMALL VERTEBRATES

By Dr. W. H. R. LUMSDEN

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In estimating the biting insect attack on man the bait may be made to perform the work of catching, as in the 24-hr. catch system with human catchers[1], and so confusing factors are minimized. In the case of other animals, however, a difficulty arises. If men are used for catching the insects alighting to feed on an animal bait, it remains in doubt whether the insects are primarily attracted to the animal or to the men, only biting the animal secondarily. Conversely, some of the insects biting the men might be expected to bite the animal if it was alone. Previous attempts to resolve this difficulty with unattended traps baited with animals have employed traps with restricted inlets[2,3]. Such traps are very successful for some species of mosquito, less so for others, perhaps because species vary widely in their readiness to enter. Further, these traps do not retain all the insects entering them; a certain, probably variable, proportion escapes[3]. The essentials of an improved design appeared to be that access to the bait should be as open as possible and that insects attracted to the bait, and captured, should not be able to escape afterwards. Some reconciliation of these apparently mutually exclusive characteristics has been accomplished in the trap to be described, which samples at regular intervals the flying insects in the vicinity of a bait which is as nearly as possible freely exposed.

A first design of trap[4] employed a horizontal flow of air over the bait. Although it was successful its efficiency was considered likely to vary with changes in wind direction and velocity, and so it has been superseded by a vertical design (Fig. 1). A 'Vent-Axia' 12-in. fan is mounted on a framework of iron strip and rod over the centre of a platform of hardboard. The trap is quite open around the platform for a height of 15 cm. Above this, and up to the base of the fan assembly, a conical space is partially enclosed by truncated sectorial pieces of transparent cellulose acetate sheet between the edges of which are spaces about a centimetre wide. The bait, in the middle of the platform, is thus visible from all directions above the horizon except from directly and nearly directly overhead, and access of insects to it is practically unimpeded. Above the fan a metal cylinder carries a wire gauze funnel which leads laterally to a small chamber fitted with a collecting bottle; the bottle contains a killing agent—potassium cyanide or pyrethrum.

The switching of the fan motor is performed by a 'Sunvic' hot-wire vacuum switch, using as a control an ordinary alarm clock the minute hand of which trails a piece of hair-spring over a surface of aluminium foil out of which are cut sectorial pieces to correspond with the desired 'off' periods.

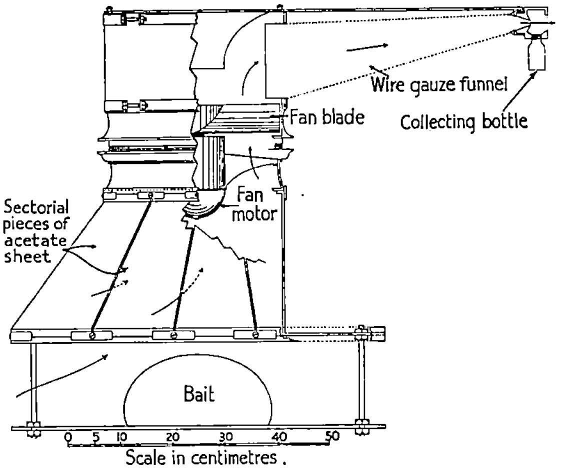

Fig. 1

Comparisons of the performance of the first design of trap on various cycles of operation—continuous running and 'on' and 'off' periods, respectively, and 2 and 3 min., 5 and 5 min., and 2 and 8 min.—led to the selection of 'on' 2½ and 'off' 5 min. periods giving eight complete cycles per hour. This cycle has been retained in the larger trap with, so far, no further experimentation. Other pilot studies with the first design of trap concerned the effect of different animal baits, the periodicity of activity and the effects of different environments and levels. All these studies gave promising results although the numbers caught were only moderate; for example, in sixteen nights at ground-level in the compound of the Institute, 940 mosquitoes were taken on four guinea pigs as bait—an average of 59 per night. The new design appears much more effective; under approximately similar conditions both with regard to trap operation and expected mosquito density the new design took 2,449 mosquitoes on one rabbit in five nights, an average of 490 mosquitoes per night.

Some first results to indicate the efficiency of the new design are as follows:

(*a*) The effect of the bait; 10 all-night runs, alternately with and without a grey rabbit; ground-level, East African Virus Research Institute compound (see Table 1).

The occurrence of small numbers of mosquitoes in the trap in the absence of bait is to be expected as the trap will catch mosquitoes entering it by chance at the appropriate time. However, in this particular case a cage which, fouled by the animal, may have some attractive power, was present in both series.

Table 1

Mosquito species	Arithmetic mean number of females caught per night	
	With rabbit	Without rabbit
Taeniorhynchus metallicus	1·0	0·6
fuscopennatus	475·8	57·6
africanus	9·0	2·0
uniformis	1·4	0·0
Culex spp. indet.	2·6	0·0
Total—mean	2,449—489·8	301—60·2

(*b*) The effect of position; 12 all-night runs, alternately at ground-level and 3 m. above it, in a tree; bait, one grey rabbit; East African Virus Research Institute compound (see Table 2).

Transference of the catching position into the tree is associated with a reduction in attack by some species and an increase by others.

Most of the mosquitoes caught are unfed and therefore may be assumed to be caught when exploring the bait preparatory to biting.

In conclusion, it may be pointed out that, besides the uses indicated above, the trap has possibilities for the investigation of the potency of attractants other than those emitted by the bodies of animals.

Table 2

Mosquito species	Arithmetic mean number of females caught per night	
	Ground	Tree
Uranotaenia sp.	0·0	0·2
Ficalbia plumosa	0·2	0·0
Taeniorhynchus metallicus	0·5	3·2
maculipennis	0·0	0·2
fuscopennatus	269·5	26·7
aurites gp.	0·7	4·7
africanus	10·8	0·0
uniformis	0·8	0·0
Aēdes africanus	0·2	0·2
Culex annulioris	0·0	0·2
spp. indet.	1·8	11·8
Total—mean	1,704—284·0	282—47·0

[1] Haddow, A. J., *Bull. Ent. Res.*, **45**, 199 (1954).

[2] Magoon, E. H., *Bull. Ent. Res.*, **26**, 363 (1935).

[3] Bellamy, R. E., and Reeves, W. C., *Mosquito News*, **12**, 256 (1952).

[4] Lumsden, W. H. R., E.A.V.R.I. Ann. Rep., No. 6 (Governmen Printer, Nairobi, 1956).

ELECTRON MOBILITY IN BIOLOGICAL SYSTEMS AND ITS RELATION TO CARCINOGENESIS

By DR. R. MASON

Department of Chemical Crystallography, University College, London, W.C.1

IN 1941, Szent-Györgyi[1] suggested that some biochemical processes could be better understood if protein molecules and extended systems of proteins were imagined to possess common energy bands similar to those which are derived from the collective-electron model of crystals; the conductivities of dyed protein films were later cited[2] as evidence for the usefulness of such an approach, although such limited data were scarcely conclusive. A good deal of other suggestive, but still not conclusive, evidence led Evans and Gergely[3] to examine theoretically the possibility of bands of energy-levels in proteins as a consequence of electronic conjugation through the π-orbitals in a protein structure represented by the scheme shown in Fig. 1.

These authors concluded that a banded structure was possible and indeed would actually confer a small extra stability on the system; their results, with nitrogen assumed to be trigonal planar (the most likely stereochemistry), are given in Table 1, which lists the range of energy bands in eV. relative to the lowest filled level, together with the electronic population of the bands.

Table 1. RANGE OF ENERGY BANDS (eV.)

Band 1	0·00–0·13	Doubly filled
Band 2	3·17–3·43	Doubly filled
Band 3	6·48–6·60	Unfilled

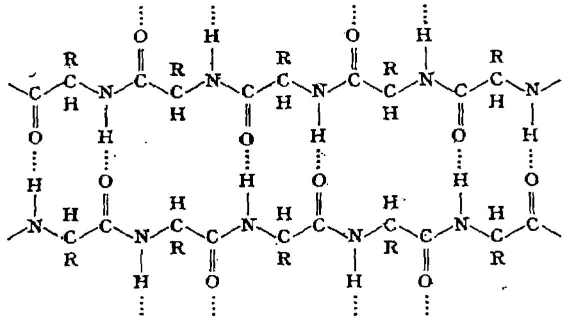

Fig. 1

Three main conclusions were discussed by Evans and Gergely: a protein structure is non-conducting in the ground-state and can assume conducting properties only on excitation; the width of the forbidden zone (∼ 3 eV.) is such that conduction can never be realized by thermal excitation, but can take place by the absorption of photons of suitable energy; finally, the narrowness of the bands, as compared with a metal or graphite structure, suggests "that in order to transfer electrons to or from empty or full levels of another system, the energy levels of the structures must be closely matched".

The calculations received, perhaps unexpectedly, excellent confirmation from the measurements of Eley *et al.*[4] of the semiconductivity of proteins. Plasma albumin, fibrinogen and edestin were shown to possess conducting properties which are consistent with a band structure having an energy gap of 2·1–2·6 eV. Later work[5] described dry hæmoglobin as having a semiconductivity with an energy gap of 2·7 eV., while separation into globin and hæm gave observed gaps of 3·0 and 1·8 eV., respectively; it was also suggested that while these experiments had been carried out on denatured proteins, similar results were indicated for natural hæmoglobin.

The importance of the conclusion reached by Evans and Gergely regarding the requirement for close matching of energy-levels if charge transfer is to

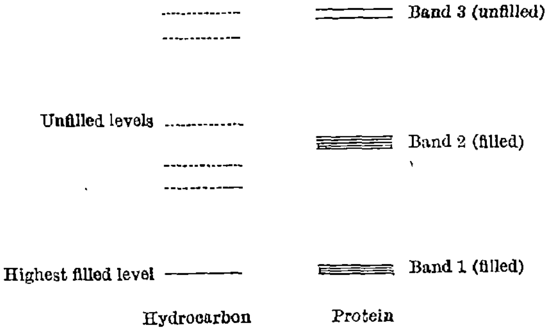

Fig. 2

take place can be discussed from the point of view of a molecular complex formed from a protein and an aromatic hydrocarbon (the latter is chosen because of the availability of data from quantum-mechanical methods concerning energy-levels, etc.). The conditions which must be satisfied in such a complex, if electrons are to be transferred from one molecule to the other, have been pointed out by various authors (see, for example, ref. 6), and may be written in the form

$$h\nu = I_D - E_A - \Delta$$

where $h\nu$ is the energy required to bring about charge transfer, I_D the ionization potential of the donor, E_A the electron affinity of the acceptor and Δ the stabilization of the ion pair. Let us assume that the electronic condition of the complex before any charge transfer takes place can be represented as in Fig. 2, that is, the highest filled level of the hydrocarbon coincides with the lowest filled band of the protein. This assumption, implying that

$$I_D \text{ (band 1)} = E_A + \Delta$$

cannot, unfortunately, be examined in any rigorous fashion so far as we know and its only justification is the results which follow its adoption. Our object—to alter the electron population of the highest filled band in the protein in such a way that conduction can take place—will now be achieved when an unfilled level of the hydrocarbon occurs with an energy which is within the energy range of the highest filled band in the protein, that is, when the energy separation between the highest filled and the *n*th unfilled level of the hydrocarbon

$$\Delta E_n = 3{\cdot}23 \pm 0{\cdot}19 \text{ eV}.$$

If this condition is fulfilled, the hydrocarbon may be regarded as 'active', and this activity, which therefore corresponds to the induction of electron mobility in the protein, will afterwards be considered to be an essential prerequisite in the process of carcinogenesis by these molecules.

Table 2 gives the energy difference between the highest filled and successive unfilled levels, in units of β (the resonance integral), as calculated by the simple molecular orbital method; these values have been calculated from the "Dictionary of Values of Molecular Constants"[7], and Prof. B. Pullman has generously provided energy-level schemes for a number of molecules which do not appear in those tables. The carcinogenic indices are taken, in most part, from Hartwell's[8] and Pullman's[9] surveys. 'Activity' can be seen to correspond approximately to the range

$$1{\cdot}10 \leqslant \Delta E_n \leqslant 1{\cdot}18$$

with the unit of energy on this scale, therefore, approximately 2·8 eV., a value in not unreasonable agreement with spectroscopic data. The relation suggests that the matching of energy-levels may be even more critical than is indicated by Evans and Gergely's calculated band-widths, but this must not, perhaps, be considered too seriously when the shortcomings of the theoretical method are remembered. It can also be seen from Table 2 that the molecules which satisfy this energy criterion possess, with the exception of 3,4-benzophenanthrene, one or more unfilled levels which lie below those coming into coincidence with the highest filled band in the protein; once electron mobility has been induced in the protein, these lower unfilled levels of the hydrocarbon must be imagined to act as further 'sinks' for electrons from the protein. The result of forming a complex of an 'active' hydrocarbon and a protein is therefore to induce positive-hole conduction in the hitherto completely-filled band and also to transfer electrons to a state of lower energy.

Of the 34 hydrocarbons tabulated, five are known, with some certainty, to be carcinogens of varying potency, namely, 3,4-benzophenanthrene, 1,2 : 5,6- and 1,2 : 7,8-dibenzanthracene, 3,4-benzpyrene and 3,4 : 8,9-dibenzopyrene, while 1,2-benzanthracene is now also thought to be active. All these molecules satisfy the stipulated criterion for ΔE_n, the remaining molecules falling outside the range with the exception of anthanthrene, which theory predicts should be active (very limited experimental results suggest that it is inactive), and 1,2 : 7,8-dibenzofluorene, which should be inactive but is found to be carcinogenic (although there appears to be some doubt here also). 1–12-benzoperylene and 2,3 : 6,7-dibenzofluorene come within the 'active' range but no data on their physiopathological properties are available.

Several molecules appear in Table 2 in which intramolecular overcrowding is known to exist; the

Table 2

Molecule	ΔE_1	ΔE_2	ΔE_3	ΔE_4	Activity
Benzene	2·0000	2·0000	3·0000		−
Naphthalene	1·2361	1·6180	1·9208	2·2361	−
Anthracene	0·8284	1·4142	1·4142	1·8284	−
Naphthacene	0·5899	1·0724	1·2950	1·4885	−
Pentacene	0·4394	0·8377	1·2197	1·2197	−
Phenanthrene	1·2105	1·3743	1·7476	1·9110	∓
3,4-Benzophenanthrene	1·1352	1·2297	1·5676	1·6910	+
Chrysene	1·0402	1·3124	1·3954	1·7365	−
1,2-Benzanthracene	0·9046	1·1673	1·4523	1·6179	+ ?.
Pyrene	0·8901	1·3244	1·4450	1·6920	−
Triphenylene	1·3681	1·5634	1·9696	2·0313	−
Pentaphene	0·8743	0·9580	1·4372	1·4372	−
Picene	1·0038	1·1822	1·3614	1·5019	−
Perylene	0·6946	1·3473	1·3473	1·3473	−
1,2 : 3,4-Dibenzanthracene	0·9982	1·2131	1·2899	1·5940	−
1,2 : 5,6-Dibenzanthracene	0·9470	1·1578	1·2601	1·5431	+ +
1,2 : 7,8-Dibenzanthracene	0·9834	1·1097	1·3652	1·4917	+
3,4 : 5,6-Dibenzophenanthrene	1·0709	1·1922	1·3227	1·6027	−
3,4-Benzpyrene	0·7425	1·1730	1·3712	1·3712	+ + + +
3,4 : 8,9-Dibenzopyrene	0·6054	1·0960	1·1314	1·3027	+ + + +
1–12-Benzoperylene	0·8784	1·1235	1·4329	1·4392	?
Coronene	1·0784	1·0784	1·5392	1·5392	−
Anthanthrene	0·5818	1·0409	1·1657	1·3944	−
Diphenyl	1·4092	1·7046	1·7046	2·0221	−
p-Diphenylbenzene	1·1853	1·5926	1·5926	1·5926	−
m-Diphenylbenzene	1·3243	1·4275	1·6622	1·6622	−
o-Diphenylbenzene	1·2206	1·4346	1·6103	1·6103	−
1,3,5-Triphenylbenzene	1·3243	1·5681	1·6622	1·6622	−
Styrene	1·3242	1·6622	2·0764	2·7979	−
Stilbene	1·0086	1·5043	1·5043	1·6577	−
Biphenylene	0·8901	1·3244	1·6920	1·7923	?
2,3 : 6,7-Dibenzofluorene	0·9687	1·0107	1·1518	1·6211	?
3,4 : 5,6-Dibenzofluorene	0·7466	1·2002	1·2151	1·4433	−
1,2 : 7,8-Dibenzofluorene	0·8326	1·1848	1·3793	1·5207	+ ?

calculations of the energy-levels for these compounds can scarcely have any reliability placed upon them and this may account for the exception which 3,4-benzophenanthrene makes to the other carcinogens in not having an unfilled level below that level which coincides with the highest filled band in the protein.

When electrons from the highest filled band fall to lower unfilled levels in the hydrocarbon component of the complex, work (possibly in the form of some synthesis) may be done on the system, and Szent-Györgi's suggestions as to "why catabolic processes prevail over anabolic ones in damaged tissues (and cancer ?) . . ." are, perhaps, now more readily understood for the particular example of chemical carcinogenesis. It is therefore tempting to suggest that the relative potency of the carcinogen is related to the energy gap through which electrons from the highest filled band fall to reach unfilled levels in the hydrocarbon (and the data of Table 2 suggest that this may not be a completely misleading concept), but here again we must recognize the inadequacies of the theoretical methods and the present paucity of data.

The banded electronic model of a protein suggests, also, that radiation carcinogenesis may be interpreted as the result of electron promotion from the highest filled band to the conduction band proper of the protein. It follows that the overall result is one of inducing positive-hole conduction in the highest filled band and afterwards performing work on the system when the electrons promoted by photon absorption fall back to their ground state. If oxygen adsorption leads to impurity-levels close to the filled band, electron promotion will be facilitated and we may thus be able to understand the increase in radiation sensitivity, which malignant cells show on adsorption of oxygen, in this way.

The theory of the mechanism of chemical carcinogenesis which has been outlined here suggests experiments by which its usefulness may be judged. If induction of conducting properties in the protein is a necessary stage in carcinogenesis, such related effects as the diamagnetism and electrical conductivity of an 'active' complex should be quite different from the sum of the effects due to each component of the complex when they are not involved in charge-transfer processes. It is therefore hoped to extend recent crystallographic studies of carcinogen–purine complexes[10] to X-ray and diamagnetic investigations of complexes formed from carcinogens and nucleic acids or proteins, in addition to further theoretical consideration of these molecules.

Finally, it should be pointed out that the electronic structure of a protein ion in an active complex will be quite different from that usually assumed for protein ions in solution. In the latter case, the net charge is due to ionization in the side-chains of the protein, and it is unlikely that such perturbations can conjugate through these chains to the electronic system in which we have been interested.

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CONTRIBUTION OF DEOXYMETHYLPENTOSES TO THE SEROLOGICAL SPECIFICITY OF SOME BACTERIAL POLYSACCHARIDES, AND THE RECOGNITION OF A NEW SUGAR, PARATOSE

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TWO different deoxymethylpentoses have been found in specific polysaccharides extracted from various species of *Salmonella*, tyvelose in the products of group *D* strains (*S. typhosa*[1-3] and *S. enteritidis*[2]) and abequose in the products of group *B* strains (*S. abortus-equi*, *S. paratyphi B*[2-4] and *S. typhimurium*[4]). These sugars are very rapidly liberated from the polysaccharides on acid hydrolysis, which suggested that they might occupy terminal positions in the polymer chains and contribute to the specificity of groups *D* and *B*. Analyses of polysaccharides extracted from other species of *Salmonella* confirmed the presence of tyvelose in other group *D* strains and of abequose in other group *B* strains[5] (Table 1), but the presence of sugars having similar chromatographic behaviour to tyvelose and abequose was revealed in members of other groups (*S. paratyphi A* in group *A*; *S. Kottbus* and *S. newport* in group C_2)[5].

It has been shown that specific reactions of immune sera with homologous polysaccharides can be inhibited by single sugars[6]. In the *Salmonellae*, abequose inhibits the precipitation of an anti-*S. paratyphi B* serum by the homologous polysaccharide and tyvelose inhibits precipitation of an anti-*S. typhosa* serum by the homologous polysaccharide. Neither abequose nor ascarylose inhibits the latter system[7] although ascarylose, a deoxymethylpentose extracted from

Table 1. COMPOSITION OF THE SPECIFIC POLYSACCHARIDES OF GROUPS *A*, *B* AND *D* *Salmonellae*

Group	Species	'O' antigen (Kauffman–White)	Galactose	Glucose	Mannose	Rhamnose	Abequose	Paratose	Tyvelose
A	*S. paratyphi A*	1 2 12	+	+	+	+		+	
B	*S. paratyphi B*	1 4 5 12	+	+	+	+	+		
	S. typhimurium	1 4 5 12	+	+	+	+	+		
	S. abortus-equi	4 12	+	+	+	+	+		
	S. budapest	1 4 12	+	+	+	+	+		
	S. stanley	4 5 12	+	+	+	+	+		
	S. salinatis	4 12	+	+	+	+	+		
D	*S. typhosa*	9 12	+	+	+	+			+
	S. enteritidis	1 9 12	+	+	+	+			+
	S. gallinarum	1 9 12	+	+	+	+			+
	S. dar-es-salaam	1 9 12	+	+	+	+			+

Parascaris equorum, cannot be distinguished chromatographically from tyvelose[8]. These results indicated that tyvelose and abequose do contribute to the specificity of groups *D* and *B Salmonellae* and suggested that the specificities on which the Kauffman–White scheme is based are related, at least in part, to their content of the respective deoxymethylpentose. It could also be visualized that sugars present in the polysaccharides of *Salmonellae* of groups other than *D* and *B*, which could not be distinguished chromatographically from tyvelose and abequose, might in fact be isomers with closely similar properties. A re-examination of the composition of *S. paratyphi A* specific polysaccharide, previously reported to contain tyvelose, is recorded here, and the presence of a deoxymethylpentose has been established which is not tyvelose, nor is it identical with any sugar of this series previously recorded.

Cells of *S. paratyphi A* were extracted by the phenol/water method and the lipopolysaccharide component recovered in purified form by high-speed centrifugation[3]. After hydrolysis with *N* sulphuric acid, analysis on paper chromatograms, using authentic sugar samples for comparison, revealed the following sugars: galactose, glucose, mannose, rhamnose and a sugar which migrated faster than rhamnose and had an R_F value close to that of tyvelose. When hydrolysates of lipopolysaccharides obtained from *S. paratyphi A*, *S. typhosa* and *S. abortus-equi* were examined chromatographically side by side it became clear that the fast-running component of *S. paratyphi A* ('Paratose') was not identical either with tyvelose or abequose; the $R_{\text{rham.}}$ values were abequose 1·16, tyvelose 1·29 and paratose 1·25 (pyridine–butanol–water, 4 : 6 : 3). Like tyvelose and abequose, paratose is the first sugar to be released from its polysaccharide on acid hydrolysis. A sample of paratose was isolated by elution from paper chromatograms; it contains one oxidizable aldehyde group determinable quantitatively by the Willstätter–Schudel method. Oxidation with 1 mole of periodate produced, besides formic acid, a breakdown product which gave a strongly positive Webb reaction[9]; this is an intense red colour which develops on heating with *p*-nitrophenylhydrazine in trichloracetic acid, followed by the addition of strong alkali. The reaction is characteristic of 2-deoxysugars which have at least a C_6 straight chain; 2-deoxytetroses do not react[10]. A strongly positive reaction has also been obtained with the C_5 periodate breakdown products of tyvelose and abequose. It therefore seems probable that, like tyvelose and abequose, paratose belongs to the group of naturally occurring deoxymethylpentose sugars, recently characterized fully as 3.6-*bis*deoxy-aldohexoses[11].

From Table 1 it will be seen that galactose, glucose, mannose and rhamnose are present in all the *Salmonella* polysaccharides investigated, which include representatives of groups *A*, *B* and *D*. Group specificity, however, is clearly associated with the presence of paratose, abequose and tyvelose.

Although deoxymethylpentoses have been isolated thus far only from one group of bacteria (*Salmonellae*)[2,3] and from one animal source[8], it is clear that they are more widely distributed, at least among bacteria. In the 'O' antigens of some *Escherichia coli* strains (O 55 and O 111) deoxymethylpentoses have been found[3] which behave chromatographically like abequose; studies of their chemical identity and immunological role are in progress. In the *Pasteurellae*, smooth forms of *P. pseudotuberculosis* yield lipopolysaccharides containing a number of different sugars[12], and from each of the five serological groups[13] the lipopolysaccharide possesses a different specificity. In two instances (groups IV and V), one component could not be distinguished chromatographically from tyvelose; it is noteworthy that a serological cross-reaction has been recorded between *P. pseudotuberculosis* and *Salmonellae* of group *D* [14,15], the latter containing tyvelose. Hydrolysates of *P. pseudotuberculosis* group II lipopolysaccharide revealed on chromatographic analysis a sugar indistinguishable from abequose. Erythrocytes sensitized with the group II lipopolysaccharide can be agglutinated by *Salmonella* group *B* antisera, and erythrocytes sensitized with *Salmonella* group *B* lipopolysaccharide (for example, *S. salinatis*), which contain abequose, are agglutinated by *P. pseudotuberculosis* group II antisera.

In the remaining *P. pseudotuberculosis* groups (I and III) not all the sugars have been identified but fast running components appear to be present. However, in all instances isolation of the sugars will be necessary for a satisfactory identification.

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HAPTOGLOBIN TYPES IN BRITISH, SPANISH BASQUE AND NIGERIAN AFRICAN POPULATIONS

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SMITHIES[1,2] found that the patterns obtained by starch gel electrophoresis of sera from different human subjects fell into three groups. The determinant proteins combine with hæmoglobin and appear to be identical with the haptoglobins previously studied by Jayle and his colleagues[3,4]. It has therefore been suggested by Smithies and Walker[5] that the groups should be named haptoglobin types 1–1, 1–2 and 2–2 (formerly types I, *IIA* and *IIB*, respectively). Preliminary genetical analysis[6] indicated that the groups correspond to the three genotypes produced by a single pair of allelomorphic genes. In fact, our unpublished observations suggest that the genetical control of the haptoglobin types is more complex. A detailed discussion of the evidence will shortly be submitted for publication. In the meantime results can be expressed in the nomenclature of Smithies and Walker, with the addition of a fourth group of subjects in which no haptoglobin at all can be detected, for which the designation type O–O is suggested.

Table 1. Haptoglobin Types in Various Populations

Population	No. tested	0—0		1—1		1—2		2 2		Authors
		No.	(Per cent)	No.	(Per cent)	No.	(Per cent)	No.	(Per cent)	
Canadian	49	0	0	10	21·1	25	50·5	14	28·4	Smithies
American	54	0	0	6	11·1	29	53·7	19	35·2	Sutton *et al.*
British	218	6	2·7	22	10·1	121	55·5	69	31·7	Allison *et al.*
Basque	107	1	0·9	15	14·0	49	45·7	42	39·3	Allison *et al.*
Liberian and Ivory Coast (African)	142	0	0	69	48·7	60	42·3	13	9·1	Sutton *et al.*
Nigerian (African)	99	32	32·3	53	53·5	11	11·1	3	3·0	Allison *et al.*

The frequency of the haptoglobin types in different populations is of anthropological and genetical interest. It may also provide a clue to the way in which this remarkable polymorphism is maintained. The only published population studies of which we are aware are those of Smithies[2] on Canadians and of Sutton *et al.*[7] on Americans and on West Africans from Liberia and the Ivory Coast. In this article the results of haptoglobin type analyses of 218 British subjects, 107 Spanish Basques and 99 Nigerian Africans are presented.

The British sera were taken from unselected laboratory staff and blood donors in the Oxford region. The Basque bloods were collected as described elsewhere[8]. The African sera were taken from Yoruba of Ilobi, Western Nigeria.

Fresh oxyhæmoglobin was added to all sera to give a final concentration of the order of 100–120 mgm. per 100 ml. before electrophoresis in starch gels[2]. Each gel was then cut horizontally and one half stained with benzidine, as described by Allison and ap Rees[9]. The addition of enough hæmoglobin nearly to saturate the haptoglobins, but not much more nor less, and benzidine staining of the gels after electrophoresis, greatly facilitates the identification of the haptoglobin types, which may not otherwise be easy. As will be mentioned below, the discrepancy between our results and those of Sutton *et al.* on West Africans may be attributable to differences in technique.

The results of our three surveys, together with those of Smithies on Canadians and Sutton *et al.* on Americans and Africans from Liberia and the Ivory Coast, are summarized in Table 1. The frequencies of the various haptoglobin types in the British series are not significantly different from those in the small Canadian and American series, although the former includes six subjects of type O–O, none of which was described by Smithies or by Sutton *et al.* The frequencies in the Basque series also are not significantly different from those in the British, Canadian and American series. Thus the uniqueness of the Basques, shown in their low *B* and Fy^a and high *Rh*-negative frequencies[8,10], is not reflected in their haptoglobin types.

The haptoglobin frequencies of the Africans are, however, quite different. One-third of the Nigerian Africans lack haptoglobins altogether, and most of the remainder are of type 1–1. The discrepancy between these results and those of Sutton *et al.* may represent a difference between Africans from Nigeria on one hand and from Liberia and the Ivory Coast on the other; but it is probably attributable to the inclusion by Sutton *et al.* of a number of subjects of group O–O in their group 1–1. The distinction between these two groups is difficult without specific staining of hæmoglobin.

The high frequency of Nigerians without haptoglobins raises a physiological point. It has been shown that the 'renal threshold' for hæmoglobin is due to binding of the pigment by haptoglobins in the serum[9,11]. In subjects without haptoglobins most hæmoglobin liberated into the blood stream passes into the urine. Since hæmoglobinaemia must frequently occur after malarial attacks as well as after vigorous exercise[9], it might be expected that some degree of hæmoglobinuria and loss of iron in the urine would be common among Africans. To our knowledge, this point has not been investigated.

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The fact that several haptoglobin types exist side by side in a number of different populations indicates that it is a true polymorphism. This may have been maintained, like those of the blood groups and abnormal hæmoglobins, by a balance of selective forces related to susceptibility to disease[12]. The absence of haptoglobins might be disadvantageous, particularly in regions where there is a deficiency of iron in the diet. The fact that so many Nigerians lack haptoglobins is presumably due to a compensatory advantage in persons heterozygous for the factor concerned. The low frequency of type 2–2 in the tropics suggests that it may confer protection against one or more conditions common in temperate, but not in tropical, climates.

Dr. F. Alberdi kindly co-operated in the collection of the Basque blood specimens and Drs. Jean Grant and H. Preston in the collection of British bloods. The Nigerian specimens were collected by one of us (B. S. B.) as part of the work carried out on an expedition supported by the Wenner Gren Foundation, Inc., and grant No. *H*-3161 from the National Heart Institute, U.S. Public Health Service. The help of Prof. B. G. T. Elmes, Ibadan, is gratefully acknowledged.

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ONE-ELECTRON *VERSUS* TWO-ELECTRON TRANSFER PROCESSES IN THE MECHANISM OF OXIDATION-REDUCTION REACTIONS IN SOLUTION

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IN recent years there has been some discussion regarding the question of one-electron *versus* two-electron transfer processes in the mechanism of oxidation-reduction processes in solution. The concept of one-electron transfer processes, in its general form, was first put forward by Haber[1], and it has been confirmed by a large body of experimental evidence. The assumption of single electron transfer also leads directly to free radical intermediates which play such an important part in the mechanism of chemical reactions.

One-electron transfer processes also constitute an essential step in many photochemical (ref. 2*a*) and photosensitized reactions (ref. 2*b*) in solution. Moreover, it has been suggested that the formation of many of the so-called 'molecular complexes' is also due essentially to an electron transfer between the two components (ref. 2*c*).

In general, it is to be expected that one-electron transfer processes should predominate over two-electron transfers, as the latter are only likely to occur when there is a strong coupling between the electrons.

Although it is now generally accepted that in the majority of cases one deals with one-electron transfer processes, it is believed that there are certain oxidation reactions where two-electron transfer predominates[3]. In the latter cases, this assumption is mainly derived from the apparent inability to detect free radicals, and from the appearance of oxygen from the oxidizing reagent in the molecule which has been oxidized (as demonstrated by means of compounds labelled with oxygen-18).

In the following, an attempt has been made to show that all the relevant experimental facts are fully compatible with, and can be easily explained by, one-electron transfer processes.

From the theory of electron-transfer processes it follows (ref. 4*a*, *b*) that one of the significant features is that electron transfer leads to a more or less strongly bound primary (ionic) complex between the reacting partners; thus, in the case of two uncharged reactants: $A + B \rightarrow (A^{+}.B^{-})$. In general, the energy of interaction gained in the formation of the primary complex also makes an important contribution towards the 'driving force' of the electron transfer. The ionic complexes primarily formed will have a certain minimum life-time. An estimate of the probable life-time of such a complex in solution can be obtained from the time which is required for the water dipoles to interact with an ionic complex; this cannot be less than the time of relaxation of water dipoles in liquid water, which is of the order of 10^{-10}–10^{-11} sec. This will, however, only be a lower limit, because in the interaction of water molecules with an ion, the time of relaxation in the immediate neighbourhood of the ion will have to be considered. According to the work of Kozyrev[5] and others, these relaxation times can be considerably greater than those measured for the pure solvent and in certain cases they can be as long as 10^{-7} sec.

This may have the consequences, first, that the primary complex could be long lived enough to react as a separate entity with another reactant present in the solution, and secondly that the possibility of intramolecular changes within the complex must be taken into account. This follows from the consideration that the jump frequency for atoms (or ions) is given by $\nu = \nu_0 \exp(-E/kT)$, where E is the activation energy and ν_0 (frequency coefficient) is of the order of 10^{13}–10^{14} sec.$^{-1}$ for a typical atom (or ion) transfer. Moreover, such changes should have a negligible or only a very small energy of activation, as both the reacting species have free-radical character.

Thus, for example, even in a primary complex of the relatively short life-time of 10^{-10} sec., about $10^{-10} \times 10^{14} = 10^{4}$ jumps can take place if the process goes without appreciable energy of activation, and even up to activation energies of about 4 kcal. there would still be a high probability for an intramolecular transfer of a heavy particle; in the case of longer lived intermediates the situation is, of course, more favourable.

There is, therefore, a considerable probability that, during the life-time of the primary complex, intramolecular transfer of atoms or radicals will take place without any appreciable participation of the solvent.

A case where the primary complex is probably long lived enough to react with another molecule is found in the oxidation of ferrous ions by oxygen in acid solution[6], where presumably the primarily formed electron transfer complex, namely, $Fe^{2}+ + O_2 \rightarrow (Fe^{3}+ . O_2^{-})$, reacts with another ferrous ion giving $[Fe^{3}+ . O_2^{-} . Fe^{2}+]$, and this dinuclear complex then breaks up to give ferric ions and hydrogen peroxide. Additional support for this type of intermediate comes from the autoxidation of cobaltous amine ions where complexes of the structure $[Co^{3}+(NH_3)_5 . O_2^{2-} . Co^{3}+(NH_3)_5]^{4}+$ have actually been isolated.

Examples of supposedly two-electron transfer processes which can be explained on the basis of one-electron transfers are the following.

The reaction between hydrogen peroxide and iodide ions (ref. 7*a*). The first step is expected to be electron transfer according to the reaction

$$I^{-} + H_2O_2 \rightarrow (I . H_2O_2^{-}) \tag{1a}$$

followed by association of the iodine atom and OH radical within the primary complex:

$$(I . H_2O_2^{-}) \rightarrow I . OH + OH^{-} \tag{1b}$$

Oxidation of sulphite by chlorate. From the kinetics of this reaction it follows that the first step is a reaction between chlorate ion and sulphurous acid, and it has been shown by means of chlorate labelled with oxygen-18 that transfer of (about 2·3) oxygen atoms from the chlorate to the sulphite takes place (ref. 7*b*). On the basis of the theory given above, this reaction can be represented as follows:

$$ClO_3^{-} + SO_2 \rightarrow (ClO_3^{2-} . SO_2+) \tag{2a}$$

$$(ClO_3^{2-} . SO_2+) \rightarrow (ClO_2^{-} . SO_3) \tag{2b}$$

$$(ClO_2^{-} . SO_3) \xrightarrow{H_2O} ClO_2^{-} + H_2SO_4 \tag{2c}$$

with the corresponding reactions between the intermediately formed ClO_2^{-} and ClO^{-} (or HClO) with SO_2. Thus, one has single electron transfer processes followed by O^{-} transfers within the complex, possibly with some solvent interaction in the last stage.

Oxidation of sulphite by hydrogen peroxide (ref. 7*b*). This is a particularly interesting case because one now has an explanation of a hitherto unexplained fact that, whereas in the oxidation of sulphurous acid in acid solution two oxygen atoms from the hydrogen peroxide are transferred, in alkaline solutions, only one of the oxygen atoms of the hydrogen peroxide appears in the resulting sulphate[8]. According to the theory outlined here the reactions can be formulated as:

In acid solution:

$$H_2O_2 + SO_2 \rightarrow (H_2O_2^{-} . SO_2+) \tag{3a}$$

$$(H_2O_2^{-} . SO_2+) \rightarrow (HO . SO_3H) \tag{3b}$$

At higher pH:

$$H_2O_2 + HSO_3^{-} \rightarrow (H_2O_2^{-} . HSO_3) \tag{3c}$$

$$(H_2O_2^{-} . HSO_3) \rightarrow HO.SO_3H + OH^{-} \tag{3d}$$

Thus, in acid solutions, an OH^{-} and an OH radical may be transferred within the primary ionic complex, whereas the radical ions (HSO_3 or SO_3^{-}) formed from the sulphite anions should only associate with the OH radical but not with the OH^{-}.

Biological oxidation-reduction processes. The interesting results of Vennesland and Westheimer[9] concerning the reaction between deuterated ethanol ($CH_3.CD_2OH$) and diphosphopyridine nucleotide, catalysed by alcohol dehydrogenase, are fully in agreement with the general theory given above. (Proviso must be made here, of course, with regard to any possible role of the enzyme in the actual reaction mechanism which is, as yet, unknown.) If the reaction is assumed to take place directly between the two reactants, it could be represented by a one-electron transfer followed by a deuterium (or hydrogen) atom transfer, within the primary complex, from the alcohol radical ion to the monovalently reduced nucleotide. In the cases of hydrogen or deuterium atom transfer, there would also be an increased probability of transfer by a tunnel effect. As all such processes would take place during the life-time of the primary complex, it is not at all surprising that they proceed without hydrogen exchange with the solvent, as found experimentally.

Formation of free radicals. It is known that in the majority of oxidation-reduction processes free radicals do, in fact, appear as more or less stable intermediates. The occurrence of these can often be predicted on plausible physical grounds. For example, in the reaction (ref. 1*b*)

$$Fe^{2}+ + H_2O_2 \rightarrow (Fe^{3}+ . H_2O_2^{-})$$

the primary complex would be expected to break up by interaction with the solvent according to the equation

$$(Fe^{3}+ . H_2O_2^{-}) \rightarrow Fe^{3}+OH^{-} . aq + OH$$

giving OH radicals. Similarly, in the reaction between oxalate ions ($C_2O_4^{2-}$) and iodine atoms, the primary complex should break up to give the radical ion $C_2O_4^{-}$ thus

$$(C_2O_4^{-}. I^{-}) \rightarrow C_2O_4^{-} . aq + I^{-}$$

One may conclude, therefore, that in general the appearance of a free radical as a reacting entity depends on the intrinsic behaviour of the primarily formed one-electron transfer complex. This complex may release into the medium either a free radical or a valence-saturated species[10], the latter arising from a rearrangement within the complex prior to its break-up by the solvent (water).

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INDUCED GENE UNSTABILIZATION

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A GENE may acquire a hereditary high mutability-rate either by its own mutation to an unstable form or as a result of the influence of another gene (which in turn is changed by a mutation or is introduced *de novo* into the genome). Whatever the cause, the resulting gene unstabilization might be of importance for evolution.

In this report, the observable phenomenon of unstability rather than the precise mechanism will be discussed. The experiments were performed on strains of *Escherichia coli* which have not been reported to recombine sexually; therefore, it is assumed that in this case the unstabilization is caused solely by a mutation (and not *de novo* introduction of another gene). In such strains, the site of the mutation (nuclear or cytoplasmic) cannot be unequivocally established; however, in the cases of induced unstabilization studied here, the effects were a result of the known interference with the structure of deoxyribonucleic acid molecules, and this points to this acid as the site of these changes.

The 'unstable gene' will be arbitrarily designated as the one with a spontaneous mutation-rate higher than 1 per 1,000 cells per generation. Studies of such high mutabilities were avoided in the past, partially because of the lack of proper techniques.

The cells of *Escherichia coli* can replace up to half the thymine in their deoxyribonucleic acid[1-3] by 5-bromouracil without losing the ability for subsequent division[4]. This replacement is reversible[5]. It occurred to us[4] that such a drastic (though temporary) change in the structure of deoxyribonucleic acid, which is believed to be the hereditary determinant[6], may result in a change in genotype: the recent findings that the replacement can occur without apparent cell division[3,5] and that the precursor is a nucleotide[7] (which may imply breakages in the sugar–phosphate chain of deoxyribonucleic acid) suggest the possibilities of faults during the replication of deoxyribonucleic acid even though 5-bromouracil afterwards disappears from the acid upon cultivation on normal medium.

We have reported that the spontaneous mutation-rate of strain *I* to the 5-bromouracil resistant strain *I/Br* was not changed by the introduction (and subsequent removal) of 5-bromouracil into and from deoxyribonucleic acid[4]. We now find that the spontaneous and ultra-violet-induced mutation-rates (both to prototrophy and to auxotrophy) of eight different markers in four different strains, tested in various media, with various concentrations of 5-bromouracil, and with and without intermediate cultivation, were also not changed. (Purine − mutant of strain *W*: mutation to purine +. Strain *I*: mutation to thymine +, streptomycin resistance, total auxotroph count. Strain A.T.C.C. 11887: mutation to lactose −. Uracil − mutant of strain A.T.C.C. 11887: mutation to uracil +, lactose +, total auxotroph count.) It must be concluded that the introduction (and subsequent removal) of 5-bromouracil to (and from) deoxyribonucleic acid is not a process that unstabilizes all the genes. It was of interest to study whether some genes can be unstabilized by such a process.

In a previous publication[4] we have reported that during the experiments on introduction of 5-bromouracil into deoxyribonucleic acid there appear 'pinpoint' or small colonies: because of their eventual disappearance after 140 generations we were not sure that they could be classified as typical mutations.

These changes have now been studied in more detail. The materials and the methods used were those described previously[1,3,4].

(1) *The nature of the changes.* It appears now that most of these changes to pinpoint colonies are typical mutations, with a varying degree of stability, that is, varying mutation-rate back to large colonies. For convenience in explaining experimental results, these mutations can be divided into three classes:

A. Typical mutations to stable 'pinpoints'. The back mutation of the latter has never been observed. The mutant 'pinpoint' strains can be maintained indefinitely by transferring from nutrient broth or nutrient agar as infrequently as every 24 hr.

B. Typical mutation to unstable 'pinpoint'. The latter back-mutate to normals which have a strong selective advantage over the 'pinpoint'; thus, any repeated transfer may eventually result in loss of the 'pinpoint' strain. It was found that the transfer of 14-hr. old (37°) pinpoint colonies containing approximately 10^6 cells still allows for the indefinite maintenance (tested for 150 generations or seven transfers) of the 'pinpoint' strain, thus proving that one deals here with a typical mutation.

We now find that 'pinpoints' of similar behaviour occur also in the spontaneously unstable Harvard strain[8] (A.T.C.C. 11887).

C. Change to 'pinpoints' so unstable that any attempt to transfer, even as early as 12 hr., results in a loss of the pinpoint 'strain'. This 'strain' may still be a typical mutant with an exceptionally high mutation-rate back to normal. If the back-'mutation'-rate approaches 1 per cell per generation, the change will usually be called a non-hereditary phenotypical change; perhaps there is no sharp dividing line between the two types of change.

The present techniques do not permit one to determine whether in each of these cases the descendants of a single cell all have only one single mutation-rate or a *whole range* of mutation-rates.

(2) *The mutation-rates.* After having established that the changes, at least in cases *A* and *B*, are hereditary, it seemed of interest to determine the rate of their occurrence (mutation-rate). The results are given in Table 1. In most cases only the lower or the higher limits of mutation-rates can be estimated from the mumber of colonies because of the selective advantage of the normal over the 'pinpoints'. As can be seen from Table 1, some mutation-rates for types *A* and *B* are higher than 3 per cent.

The highly unstable strain *I/Br* is of interest. Fifteen single large colonies of this strain were tested and *all* were found to produce 'pinpoints'. To ascertain that the change was indeed hereditary, three large colonies were carried through seven transfers

Table 1. MUTATION-RATES

Parent strain*	I			I'	I/Br
Unstabilizing or mutagenic agent*	5-bromouracil ?	5-bromouracil deoxyriboside		5-bromouracil	none
Type of mutant*	I/Br	A_1–A_3	B_1	A_4	B_2
Forward mutation-rate, per cell per generation†	4×10^{-10}	$> 10^{-3}$	$> 5 \times 10^{-3}$	$> 3 \times 10^{-3}$	$> 3 \times 10^{-2}$
Back mutation-rate, per cell per generation†		$< 5 \times 10^{-5}$	1×10^{-2}‡	$< 5 \times 10^{-5}$	

* See text; the subscripts denote different mutants.

† Where the actual mutation-rate cannot be determined, the upper or the lower limits were calculated from the frequency of mutants.

‡ Determined by early restreaking.

(180 generations); after these transfers, the cells still showed unchanged unstability.

(3) *Gene unstabilization.* It appeared first of interest to study the origin of gene unstabilization in strain I/Br. This strain was isolated as a mutant of strain I grown on medium containing 5-bromouracil in the conditions of incorporation of this analogue into deoxyribonucleic acid[4]. Two other 5-bromouracil resistant mutants isolated under similar conditions proved to be as unstable as strain I/Br. On mutation back to 5-bromouracil sensitivity (strain I'), the unstability is lost. Thus, the feature of gene unstability seems to be linked with the gene for resistance to 5-bromouracil. The nature of this linkage is not clear. To date we have not succeeded in isolating a I/Br strain without contact with 5-bromouracil; it is therefore not known whether this gene unstabilization is a result of incorporation of 5-bromouracil into deoxyribonucleic acid (see below) or merely a selection of a spontaneous unstable mutant I/Br. That this latter mechanism may be operative is indicated by the fact that the mutation-rate to I/Br (and therefore unstability) is not increased by the presence of 5-bromouracil[4]. It is of interest that the 2-thiothymine resistant strain I/TT[4], which exhibits cross-resistance to 5-bromouracil, is also as unstable as I/Br. This strain was isolated in the presence of 2-thiothymine, which is not incorporated into deoxyribonucleic acid, but increases the content of 6-methylaminopurine in deoxyribonucleic acid (see below).

In contrast to the above, the unstabilization in strain I could be demonstrated only in the conditions of incorporation of 5-bromouracil into deoxyribonucleic acid (Table 1). In recent years, hypotheses have been put forward that the only action of a mutagen is gene unstabilization and that the actual mutation of such an unstabilized gene may occur automatically at some later time, without the action of a mutagen[9]. If this be applied to the case under study, one may contend that 5-bromouracil acting on strain I produces unstable genes at a very high rate, recognizable by the subsequent high mutation-rate (types A and B). In the mutation of type A, this high mutability is lost at mutation; this situation occurs often in unstable genes. On the other hand, in the mutation of type B (B_1), the high mutability (high back mutation-rate) persists indefinitely (tested for at least seven transfers or 150 generations). This represents, therefore, a case of induced permanent gene unstabilization.

(4) *The inducing agents.* As mentioned above, the mutations occur spontaneously in unstable strains I/Br and I/TT. It appears that the stable strains I and I' can produce frequent mutants or become unstabilized or both, under the influence of agents (Table 1) which interfere with the structure of deoxyribonucleic acid.

A. Replacement of thymine by 5-bromouracil. The 'pinpoints' (I_8 and I'_8, respectively) of type A and B can be obtained in strain I and I' (back mutant of I/Br to 5-bromouracil sensitivity) when grown in broth containing 100 μgm. 5-bromouracil per ml. or 125 μgm. 5-bromouracil deoxyriboside[1] per ml., and then streaked on nutrient agar. No stable 'pinpoint' colonies were observed among 5,000 colonies (strain I') or 50,000 colonies (strain I) when 5-bromouracil or 5-bromouracil deoxyriboside was omitted.

It is of interest to note that a striking increase of mutation-rates in bacteriophage in the conditions of incorporation of 5-bromouracil into phage deoxyribonucleic acid has also been reported[10].

B. Replacement of thymine by 6-methylaminopurine[11]. This condition has been induced by growing the thymine-requiring strain I in basal broth containing a limited amount of thymine[1] (0·2–1 μgm. per ml.) or containing inhibiting amounts of 2-thiothymine (50 μgm. per ml.) and then streaking as usual on nutrient agar. It must be added that while 5-bromouracil produced stable (type A) and unstable (type B) 'pinpoints', the 2-thiothymine, which is not incorporated into deoxyribonucleic acid, produced only unstable 'pinpoints' (types B and C); the conditions of limited thymine produced only unstable 'pinpoints' of type C which cannot be as yet proved to be a typical mutation.

Two interesting cases of increase (up to 100-fold) in the spontaneous mutation-rate (to histidine independence or to streptomycin resistance) under conditions of thymine deficiency have been reported recently[12,13]; in both cases, however, the increased mutant frequencies ($2 \cdot 5 \times 10^{-6}$ or $2 \cdot 5 \times 10^{-9}$) still remained low.

The 6-methylaminopurine content has been reported to increase from 2 per cent (of thymine) up to 30 per cent, under conditions where an analogue inhibits the synthesis of deoxyribonucleic acid, but is not incorporated into it[11]. It was of interest to study whether this content increases also under conditions where the inhibitory analogue is incorporated into deoxyribonucleic acid, as in the case of 5-bromouracil. A preparation of deoxyribonucleic acid containing 42 per cent of 5-bromouracil (as referred to thymine) and a control preparation of the acid containing no 5-bromouracil were isolated and analysed as described previously[3]. The content of 6-methylaminopurine in the acid containing 5-bromouracil was not significantly higher (2·7 per cent) than that of control acid (2·0 per cent). It is concluded that when the cell can partially counteract the inhibition by building the analogue into deoxyribonucleic acid, it may do so in preference to increasing the content of 6-methylaminopurine, especially if there is no lack of thymine or thymidine (enriched nutrient broth). Thus, the genetic phenomena observed here when growing cells on 5-bromouracil seem to be due to the effect of this compound rather than to 6-methylaminopurine.

(5) *The nature of 'pinpoint' colonies.* The occasional appearance of hereditary 'G type', 'small' or 'pin-

point' colonies in many bacterial species has been frequently reported in the past. Such colonies occurred spontaneously or as a result of treatment with agents such as barium chloride, lithium chloride, Cu++, dyes, antibiotics or just ageing. In a few recent reports where a genetic analysis was made[14,15], it was found that the 'small' mutants were present in natural populations in proportions of the order of one cell per 50,000, but were selected for by the particular agent used and therefore appeared in high proportion after treatment with this agent. However, it would be premature to say that this is true of all the agents used, that is, that indeed none of them is a mutagenic agent.

The present study was thus far made primarily with strains *I* and *I'* and their stable 'pinpoint' mutants (type *A*): the unstable pinpoints (types *B* and *C*) are difficult to study because of the high mutation-rate to 'large'.

In the case of strains *I/Br* and *I/TT* the mutation to 'pinpoint' colonies is spontaneous and therefore no selective agent is involved; on the other hand, in the case of 'pinpoint' colonies produced in strain *I'* and *I* by the action of 5-bromouracil and 5-bromouracil deoxyriboside, it was first important to ascertain that the appearance of a high proportion of 'pinpoint' colonies is not due to selection by these agents. This was indicated by the 'reconstruction experiments' in which mixtures of 'pinpoint' and normal cells (containing approximately equal proportions of each) were used as inocula. In the case of strain *I'*, the cells were allowed to multiply 10^5-fold in the presence of 100 μgm. of 5-bromouracil per ml. After 24 hr., the proportion of 'pinpoints' decreased to 3 per cent, which is of the same order of magnitude as the proportion obtained by the action of 5-bromouracil itself when no 'pinpoints' were in the inoculum. In strain *I*, the cells were grown 24 hr. in unmodified enriched medium whereupon a 4-fold volume of fresh medium containing 200 μgm. of 5-bromouracil deoxyriboside per ml. was added and the incubation continued for another 24 hr. Under these conditions, there was merely a 2-fold increase in the number of cells; this, as checked by a 'reconstruction experiment', did not change the proportion of added 'pinpoints'. Both experiments (strain *I* and *I'*) were also repeated with the 'pinpoint'-free inocula, and in this case the 'pinpoints' appeared as mentioned before.

These results indicate that in both strains the appearance of 'pinpoints' is a result of the mutagenic or unstabilizing action of 5-bromouracil or 5-bromouracil deoxyriboside and not selection.

By direct observation of dividing cells on nutrient agar and by actual cell counts in nutrient broth it was found that the lag period of stable 'pinpoint' cells (from strain *I'*) was not longer than 2 hr.; the main factor responsible for the smaller size of the colony was the 1·4 times longer division time during the logarithmic growth.

A preliminary study of the nature of the difference between the two types of cells has been made. In the case of yeast, the thorough study of Ephrussi *et al.*[16] revealed that his "petit" mutants are deficient in certain respiratory enzymes. In our case, the study of the stable 'pinpoint' mutants from strains *I* and *I'* of *E. coli* revealed that it is unlikely that the mutation is of the respiratory nature: contrary to the results of Ephrussi *et al.*, the growth of the 'pinpoint' mutants of *E. coli* is just as depressed by the lack of oxygen (Brewer's agar under anaerobic conditions) as is the growth of the normal strain. It occurred to us that the poor growth of these mutants on regular nutrient agar ('Difco') may signify that they represent various complete or partial auxotrophs for substances present in this medium in sub-optimal quantities. That various types, rather than one type, of auxotroph occur can be expected if the inducing agent (5-bromouracil) enters a variety of molecules of deoxyribonucleic acid. As mentioned above, an unstable 'Harvard' strain studied by Goldstein and Smoot[8], which is known to produce a high proportion of mixed auxotrophs, also forms a high proportion of colonies of smaller size on nutrient agar. When our 'pinpoint' mutants from strain *I'* were tested in several media, the results obtained (Table 2) indeed clearly indicated that, at least in this case, we are dealing with a nutritional mutant having perhaps multiple and/or partial growth requirements. The required additional nutrients seem to be present in yeast supplement *A* ('Difco') and are partially destroyed by boiling (½ hr.). In tryptone–peptone–yeast extract ('Difco') strain *I'* cannot be distinguished from normal.

Table 2. STUDY OF ADDITIONAL GROWTH REQUIREMENTS OF THE STABLE 'PINPOINT' MUTANT I'_s AS COMPARED WITH ITS PARENT STRAIN I'

Strain			I'	I'_s
Differential count*, per cent			75–97	0–25
Agar	Colony diam., mm., 24 hr.	Nutrient	1·5–1·6	0·3–0·6
		Nutrient + yeast suppl.†	1·5–1·6	0·8–1·2
Broth	Cell ratio‡ 24 hr.	Nutrient	0·61	
		Basal§	0·61	
		Basal + fresh yeast suppl.†	0·98	
		Basal + boiled yeast suppl.†	0·89	
		TPY‖	1·08	

* Number of colonies appearing on basal agar (ref. 17) as a percentage of those on nutrient agar ('Difco').

† Supplement *A* from yeast cells ('Difco').

‡ Ratio of cell number in a 'pinpoint' mutant culture I'_s to that in a corresponding parent strain of the same age.

§ Basal broth (ref. 17).

‖ Tryptone, peptone and yeast extract ('Difco').

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LETTERS TO THE EDITORS

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Remanent Magnetism of the Rajmahal Traps of North-Eastern India

Following a palæomagnetic survey of the Deccan Traps of India[1-3], we have extended our investigations of Indian rock formation to other geological ages. In particular we have made rock magnetic measurements on samples of lavas from the Rajmahal Traps of eastern Bihar. These lavas, which consist mainly of basaltic and pitchstone trap flows, overlie the Upper Gondwana shales and sandstones. They are most probably Jurassic in age, and according to Hobson[4] they represent the earliest part of the volcanic activity that afterwards, during the late Cretaceous and early Eocene periods, gave rise to the Deccan Traps.

During January 1957 we collected samples of the rocks from five localities spaced about 20 miles apart. Approximately ten samples were taken from each site, usually over a distance of several hundred yards. In two of the localities the material was found in the beds of streams, while in the remaining three the blocks were obtained from freshly exposed rock in quarries. The samples were analysed in Bombay and London.

The specimens taken from the three quarries (33 blocks in all) were found to be consistently magnetized along an axis directed towards the west of north with a steep upward dip. A total of 16 blocks from the two stream beds, on the other hand, were badly weathered and showed widely scattered directions of magnetization, and the results for these particular samples have been rejected.

The magnetic direction for the samples from the quarry sites are plotted in Fig. 1 and details of the measurements are given in Table 1. The steep upward dip (−64°) is consistent with the assumption that the Indian land mass occupied a position south of the equator at the time when the rocks acquired their magnetization, and if the mean direction of magnetization is taken to correspond to that of a geomagnetic axial dipole field at the time when the rocks were formed, we must suppose that the Rajmahal area had a southern latitude of 46° at that time. The corresponding ancient position of the north geographical pole, computed on the polar wandering hypothesis, lies in the southern Carribbean at lat. 13° N., long. 70° W., as shown by point IX in Fig. 2.

It is interesting to compare this result with those published previously[1-3,6] for the lavas of the Deccan Trap series. The north pole positions obtained from measurements made on rocks from eight different sites in the Deccan formation are also shown in Fig. 2. They fall into three categories :

(1) Sites V–VIII, which belong to the Lower Traps, give pole positions farthest to the south. The rocks are all reversely magnetized (that is, in south-easterly directions) with rather steep downward dips.

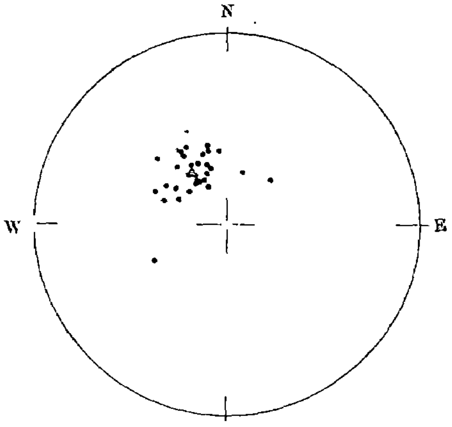

Fig. 1. Rajmahal area : ●, upward dips. Equal area projection

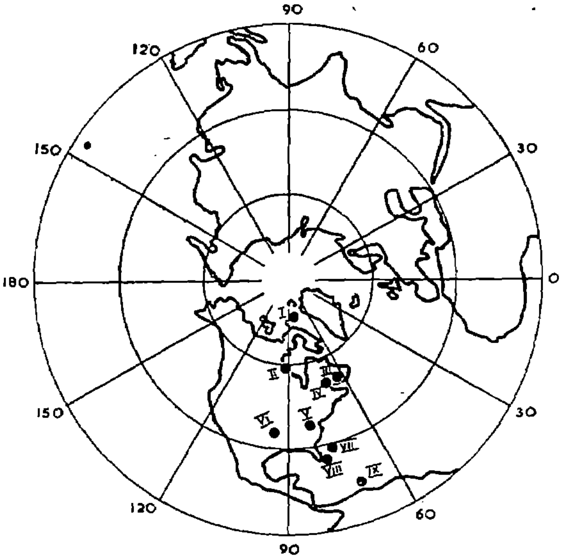

Fig. 2. Ancient pole positions for various sites : I, Pavagadh (upper) ; II, Pavagadh (lower) ; III, Amba (upper) ; IV, Nipani (upper) ; V, Linga ; VI, Nipani (lower) ; VII, Amba (lower) ; VIII, Khandala ; IX, Rajmahal

(2) Sites II–IV are all close to the tops of the Western Ghats, and give pole positions closer to the present geographical pole. The samples from these sites have normal magnetization (that is, towards the west of north), with considerably shallower upward dips.

(3) Site I is close to the top of Mount Pavagadh, and the rocks are acid tuffs believed to be more recent than the lavas of the main Trap sequence. Again the magnetic directions are normal, but the dips are almost zero.

It has been pointed out that this continuous decrease of dip with altitude above sea-level may be due to any one of three causes, namely :

(*a*) It may have occurred as a result of some mechanical effect associated with different depths of burial, such as that described by Graham[7].

Table 1. Rajmahal Rocks

Mean latitude of area	Mean longitude of area	No. of blocks	Mean intensity (c.g.s.u.)	Mean azimuth	Mean dip	Radius of 50 per cent circle of confidence*
25° 0′ N.	87° 51′ E.	33	$8{\cdot}85 \times 10^{-3}$	N. 328° E.	− 64° up	2°

* Measured by Fisher's method (ref. 5)

(*b*) It may be indicative of partial magnetic instability which would cause a pulling of the magnetic directions towards that of the present Earth's field. This would tend to increase the magnetic dips of the reversely magnetized rocks (1) and to decrease those of the normally polarized ones (2) and (3).

(*c*) It may represent a continuous northward movement of India relative to the equator during the time when the Deccan Traps were being erupted.

The Rajmahal lavas discussed in this communication are older than the Deccan Traps. They have steeper magnetic dips, and give a pole position (IX) farther from the present pole than any of the Deccan rocks. Considering this steeper dip in relation to postulates (*a*), (*b*) and (*c*) above, it appears that: (*a*) it is unlikely to have been caused by compressional forces associated with deep burial, since all the specimens collected came from the uppermost 250 ft. of the Rajmahal series, and it is improbable that they have ever been overlain by any substantial thickness of material[4]; (*b*) it cannot have been increased by magnetic instability in the present Earth's field, as the Rajmahal rocks are normally magnetized, and this effect would tend to reduce rather than to increase their magnetic dips.

It seems, therefore, that the combined results for the Rajmahal and Deccan Traps conform best with the postulate (*c*) and are compatible with the supposition that there was a continuous northward drift of the Indian land mass extending from the Jurassic to the Eocene.

This conclusion must be regarded as tentative pending a more detailed survey of the areas concerned. The work is continuing, and a full account will be given elsewhere.

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The Triple Point of Argon as a Thermometric Fixed Point

IN connexion with experimental work on the thermodynamic properties of binary mixtures of condensed gases, it was necessary to know accurately the triple point of argon on the absolute scale. Michels, Wassenaar, Sluyters and De Graaff[1] have recently made a careful determination of this temperature using a platinum resistance thermometer. They suggested that it should be used as a fixed point for thermometer calibrations, and since this proposal has much to recommend it, it is desirable that there should be an independent estimate of the triple point.

Using cylinder gases of the highest purity obtainable, further purified by fractional distillation, we have measured the vapour pressure of oxygen at the triple point of argon, the liquid oxygen being contained in a small bulb surrounded by argon which had just started to melt. The manometer used was that described by Lambert and Phillips[2], and individual measurements of the oxygen vapour pressure at the argon triple point were constant to ± 0·01 mm. The average value was 368·69 int. mm. of mercury with an estimated absolute uncertainty of ± 0·05 mm. Hoge[3] has given values of the vapour pressure of oxygen on a temperature scale based on a helium gas thermometer on which the oxygen boiling point is taken as 90·190° K. (with 0° C. $\equiv$ 273·160° K.). In the range involved, Hoge gives oxygen vapour pressures accurate to 0·1–0·2 mm., corresponding to temperatures accurate to 0·003–0·006°. From his data and the above figure for the oxygen vapour pressure, the triple point of argon is 83·819 ± 0·006° K. This is in good agreement with the value of Michels *et al.* of 83·819 ± 0·001° K.

Aston and Moessen[4] have recently carefully determined the normal oxygen boiling point and obtained a value of 90·154° K., which is 0·036° lower than the figure of the 1948 International Temperature Scale. With their value of the oxygen boiling point, our value for the argon triple point is 83·783 ± 0·006° K.

We have also made repeated measurements of the triple point pressure of argon, obtaining an average value of 516·82 ± 0·04 mm. The figure of 515·7 mm. given by Clark, Din and Robb[5] and used by them to obtain the triple point is undoubtedly too low.

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Raman Spectrum of Tetrakistrifluorophosphine-nickel

WE have observed the Raman spectrum of liquid tetrakistrifluorophosphine-nickel, $Ni(PF_3)_4$, prepared as described by Wilkinson[1]. As required for the point group T_d, all the lines of the spectrum are found to be depolarized except three, which are highly polarized ($\rho \sim 0$). This observation provides strong evidence that the arrangement of the four attached phosphorus trifluoride molecules around the nickel atom is regular tetrahedral (cf. nickel tetracarbonyl).

The Raman frequencies of the three polarized lines are 954, 534 and 195 cm.$^{-1}$. They are clearly to be assigned respectively to ν_1 (mainly P–F stretching), ν_2 (mainly symmetrical 'umbrella' PF_3 deformation) and ν_3 (mainly Ni–P stretching). For comparison, the values of ν_1 and ν_2 for the phosphorus trifluoride molecule[2] are respectively 890 and 531 cm.$^{-1}$. Assuming a simple valency force field, the three polarized frequencies of $Ni(PF_3)_4$ may be used for deriving the two bond-stretching force constants $k_{\text{P–F}}$ and $k_{\text{Ni–P}}$ and the deformation force constant k_δ/l^2. The values thus obtained are $k_{\text{P–F}} = 7{\cdot}73$, $k_\delta/l^2 = 0{\cdot}53$ and $k_{\text{Ni–P}} = 2{\cdot}71$ (all in units of 10^5 dynes per cm.). The first two may be compared with the corresponding values for the phosphorus trifluoride molecule, $k_{\text{P–F}} = 5{\cdot}38$ and $k_\delta/l^2 = 1{\cdot}15$, as calculated from ν_1 and ν_2 assuming simple valency forces. The force constant of stretching of the bond between the central nickel atom and each of the attached phosphorus atoms is of particular interest. The corresponding value of $k_{\text{Ni-C}}$ for nickel tetracarbonyl, likewise calculated[3] on the basis of a simple valency force field, is 2·52. Both $k_{\text{Ni-P}}$ and $k_{\text{Ni-C}}$ are in the range normally expected for single bonds, and are thus remarkably low in view of the other evidence which has led to the conclusion[1,4] that nickel–ligand bonds of this kind have appreciable double-bond character.

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Retinal Type of Photovoltaic Cell

IT is known that the retina of the animal is a photovoltaic mosaic composed of countless minute individual light receptors. The gradual development of multiple electrode photovoltaic cells may perhaps lead to an actual working model of the retina.

Previously constructed multiple-electrode photovoltaic cells have the seat of their photopotential within each single electrode unit. A typical example of a wet multiple photovoltaic cell is the telephotographic system of Ruben[1], which utilizes the copper/cuprous oxide barrier-layer in each individual receptor unit. Photoemissive mosaic cells such as the television iconoscope, etc., obviously do not approach the retina in principle.

The cell described here is unlike previous multiple-electrode wet photovoltaic cells in that the individual electrodes are completely inert; the seat of the photopotential is apparently in the space charge formed in the volume around the point electrode during irradiation[2]. Certain organic structures when irradiated in solution produce photopotentials with respect to the unirradiated solution, a development from the Becquerel effect. The point electrode here is a potential probe.

The construction of the multiple cell, together with the irradiation box, is shown in Fig. 1. The cell can have as many points as desired on any shape of surface, and only one common dark electrode is required. In Fig. 1, nine point electrodes are shown mounted in a piece of cylindrical 'Bakelite' coil form which is cemented to a glass slide. The bottom electrode is made the common dark electrode. Platinum wire 0·02 in. in diameter is used for all the electrodes. The exposed platinum wire ends inside the compartment are about 0·05 in. long and can be assumed to be points. The cell is cemented together with an epoxy adhesive. A small strip of black electrical or masking tape hides the bottom point from light. The cell is filled with about 0·25 c.c. of a 1 per cent solution of benzoin in 95 per cent ethyl alcohol as one of a series of photoactive solutions[3]. A photopotential as high as 0·15 V. may be generated by each irradiated point with this solution; but in general, sensitivity of the point electrode to the space charge surrounding it during irradiation is more important than the magnitude of photopotential if an analogy to the retina is to be drawn. The wave-length response of the cell is dependent on the photo-active solute used.

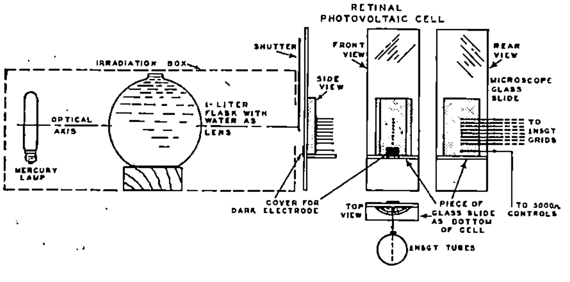

Fig. 1. Retinal photovoltaic cell and irradiation box

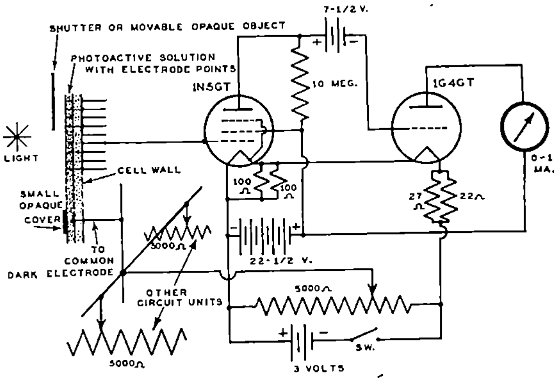

Fig. 2. Amplifier 'brain' unit attached to one electrode point

The cell obviously requires an auxiliary apparatus to indicate that the cell is actually seeing light and a moving object. Fig. 2 shows a simple battery-operated electronic amplifier actually used for each irradiated electrode point. Each milliammeter indicates what its respective point is seeing—light or darkness.

The analogy between the rods and cones of the retina and the point electrodes of this photovoltaic cell, the roles of visual purple and the photo-active solution, and the requirement of a common dark electrode or 'ground' are accented with discretion.

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Contrast in the Electron Microscope Image

THE detail seen in a highly magnified electron micrograph is to-day limited more by a lack of contrast in the image than by any lack of resolution in the microscope, which is now usually capable of resolving objects at least as small as 15 A., that is, only a few atoms in diameter. Contrast may be increased either by metal-shadowing the surface of the specimen or by treatment with various reagents. By analogy with the use of stains in light microscopy this latter technique has come to be known as 'electron staining' (perhaps this is an unfortunate, if convenient, term since the analogy is not very close). However, it is still not quite clear what physical property makes a substance likely to be useful for increasing contrast. Published statements say variously that high density, high atomic number, high atomic weight or the presence of atoms of a metal are required. Even the extreme claim that all substances are almost equally efficient in increasing electron density has been argued.

It is unfortunate that exact measurements of contrast in the electron image are not easy to make, and subjective judgments are unreliable except in the rare cases of obviously intense staining. A simple theoretical approach to the problem of contrast has recently been made by Zeitler and Bahr[1], and since this is in reasonable agreement with the few satisfactory measurements that have so far been published[2,3] it seems worth deducing from their formulæ the conditions for a just appreciable increase in contrast in the image of any part of a specimen. If the part considered covers an area S cm.^{2} at right angles to the beam, then we may deduce that a distinct increase in contrast requires the addition of N atoms of atomic number Z uniformly over or through the object where $NZ^{4/3}/S = 5 \cdot 5 \times 10^{17}$ when the microscope works with a high-tension voltage of 60 kV. ($4 \cdot 7 \times 10^{17}$ for 50 kV.; $8 \cdot 25 \times 10^{17}$ for 100 kV.). A reasonably contrasting photographic recording of the image and a small objective aperture have been assumed. This simple formula allows one to predict the effect of adding various amounts of different substances to the specimen and also, in a measure, to reconcile some of the conflicting views on the requirements for contrast.

There are three useful bases on which to compare contrast, and it is important to distinguish which is relevant in any particular case.

(1) Contrast compared on the basis of equal thickness. This is particularly relevant when selecting a material for shadowing the specimen where an adequate increase in contrast with the minimum thickness of deposit is required. If d cm. is the thickness of the thinnest film of material that gives increased contrast, ρ gm.cm.$^{-3}$ the density of the film, A its atomic weight and L Avogadro's number ($6 \cdot 02 \times 10^{23}$), then $NZ^{4/3}/S = \rho d L Z^{4/3}/A = 5 \cdot 5 \times 10^{17}$, that is, $d = 0 \cdot 915 \times 10^{-6} (A/Z^{4/3})(1/\rho)$. Now $A/Z^{4/3}$ is nearly unity for all elements (it varies from 0·57 for uranium to 1·6 for lithium), so that, judged on the basis of equal thickness, the maximum contrast is given by the material with the greatest density. In the particular case of platinum ($A/Z^{4/3} = 0 \cdot 59$, $\rho = 21 \cdot 5$), $d = 2 \cdot 5$ A., which agrees well with practice, where an estimated 5 A. is found to be a suitable thickness for the film of metal-shadowing. This calculation also shows that a useful histochemical technique for the electron microscope might be that of forming small deposits of some dense substance specifically in the tissue; indeed, the few successful techniques so far have been mostly of this type[4,5].

(2) Contrast compared on the basis of equal weight. If an object d cm. thick of density ρ gm.cm.$^{-3}$ can bind p per cent by weight of an added substance, then a detectable increase of contrast requires p to have a value of not less than that given by $(p/100) \rho d L Z^{4/3}/A = 5 \cdot 5 \times 10^{17}$, that is (taking $Z^{4/3}/A$ and the density of the specimen as unity), $p = 9 \times 10^{-5}/d$.

We thus obtain the unexpected result that for a specimen of given thickness the percentage uptake of stain required for contrast is almost independent of the nature of the stain used. For an object about $0 \cdot 5 \mu$ thick (say, a bacterium) a 2 per cent uptake of any stain should increase contrast, and it might be worth trying the usual light microscope stains on such objects viewed with the electron microscope. On the other hand, for a thin section (200 A.) 45 per cent of stain is required. A similar calculation has led Ornstein[6] to claim that, since osmium is only taken up to the extent of about 10 per cent, osmium staining of thin sections must be a fiction. As shown later this conclusion may not be altogether justified, and it certainly conflicts with a deep-set belief of many electron microscopists.

(3) Contrast compared on the basis of equal numbers of molecules. If the object to be stained is d cm. thick and can bind n molecules of stain per cm.^{3}, then for increased contrast $nd(\Sigma Z^{4/3}) = 5 \cdot 5 \times 10^{17}$ where $(\Sigma Z^{4/3})$ is obtained by adding up the values of $Z^{4/3}$ for each atom in the molecule of stain. It is on this basis that different stains would normally be compared. If, as may often be the case, the molecules of stain are bound to the surface of membranes and not uniformly distributed throughout the tissue as has been assumed above, then if n molecules are bound per cm.^{2} of membrane surface, the normal to which makes an angle θ with the beam at any point, contrast results when $n(\Sigma Z^{4/3}) \sec \theta = 5 \cdot 5 \times 10^{17}$. If the tissue is fixed with osmium tetroxide and this is bound on the membranes as the lower oxide $OsO_2(\Sigma Z^{4/3} = 353)$, then when $\theta = 89°$ (that is, in a section where part of a membrane runs almost at right angles to the surface) $n = 2 \cdot 5 \times 10^{13}$ cm.$^{-2}$, or one atom of osmium bound per 400 A.^{2} of the membrane surface will increase its contrast. This is a very plausible figure, so that both in theory and in practice osmium staining of the surface of membranes may well be a fact.

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Sintering of Tin Powder

MOST powdered metals will sinter together appreciably when heated to a temperature which, in the absence of extraneous factors, is about three-quarters of their absolute melting point; metals of low melting point tend to be exceptions, however, to this generalization in that they can be heated nearly to their melting point before sintering takes place. There is no evidence, in fact, that tin has ever been observed to sinter[1]. Tin powder is usually made by the atomization of the molten metal and particles of the powder become coated with a film of stannic oxide; this oxide cannot be reduced below the melting point of tin by any atmosphere normally used in sintering. It has already been found[2] that sintering previously pressed powder leads to no further densification of the compact and confers no beneficial properties on it. The inability of tin to undergo sintering has been generally assumed, but never shown, to be due to the presence of unreduced oxide films.

It was decided to test this assumption by attempting to sinter loose oxide-free powder. To obtain such powder, massive white tin was transformed to the grey allotrope at −40° C. in an evacuated and 'gettered' glass tube. Considerable volume changes occur during transformation, and the grey tin formed as a more or less granular powder. This loose powder was re-transformed to white tin at room temperature and shaken to one end of the tube. It was then heated at 220° C., for 48 hr.

The powder had formed a coherent, but friable, mass, which was removed from the tube in one piece. Specimens from this were prepared for micro-examination, which showed much evidence of growth across particle boundaries, indicating that sintering had taken place. It is, of course, to be expected that sintering would take place much more rapidly and completely if the powder were first compacted, but it may be concluded that, in the absence of oxide films, tin powder will sinter when heated.

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Thermoelectric Properties of Bismuth Telluride and its Alloys

Previous publications from this Laboratory have described the progress made with bismuth telluride in connexion with thermoelectric refrigeration or generation. With a thermo-junction between *p*-type bismuth telluride and bismuth the maximum temperature difference obtained[1] was 26° C., and between *p*- and *n*-type bismuth telluride[2] 40° C. This corresponded with a figure of merit $\eta\sqrt{\sigma/K}$ of 0·0335 degree$^{-1/2}$. Here η is the thermoelectric power, σ the electrical conductivity, and K the thermal conductivity.

In our work on this compound in 1956 we were able to make *p*- and *n*-type bismuth telluride with greater uniformity and to realize more exactly the optimum thermoelectric power, which is near 200 μV./deg. C. The outcome of this was a maximum temperature difference of 65 deg. C. at a mean temperature of 17° C. The physical properties of the material are consistent with those reported by me at the Garmisch conference in September 1956[3], except that Hall electron mobilities as high as 300 cm.^{2} volt^{-1} sec.$^{-1}$ have been obtained in more recent material.

A temperature difference of 65 deg. C. has been quoted recently by Shilliday[4], of the Battelle Laboratories. In Russian work, Sinani and Gordyakova[5] have quoted a figure of merit of 0·049 for one component of a junction. This was *n*-type, and consisted of an alloy of 80 per cent bismuth telluride and 20 per cent bismuth selenide. The highest temperature difference quoted in Russian work[6] appears to be 70 deg. C., indicating that their *p*-type material is inferior to the *n*-type quoted, since if both components of a junction have a figure of merit of 0·049, the maximum temperature difference is larger than 70 deg. C., as indicated later.

It is to be expected, as discussed by Joffe[7], that in alloys the thermal conductivity will be less than that of either single component, because the substituted atom causes phonon scattering. In favourable circumstances this can be achieved without appreciably increasing the electron scattering. In accordance with this, we have recently studied alloys of bismuth telluride – bismuth selenide, bismuth telluride – antimony telluride, bismuth telluride – bismuth sulphide and also alloys of bismuth telluride – antimony telluride containing either selenium or sulphur. With some compositions both *p*- and *n*-type material with the optimum thermoelectric power has not yet been obtained, and in fact this is the case with alloys giving the lowest thermal conductivity. Taking the most favourable *n*- and *p*-type alloys so far prepared, we have been able to obtain a mean figure of merit of 0·049 for the junction, corresponding with a maximum temperature difference of 80 deg. C. for a mean temperature of 17° C. This results primarily from the fact that substitution of antimony for bismuth lowers the lattice component of the thermal conductivity, K_0, from 0·0157 for bismuth telluride to a minimum of 0·010 ohm. cm.$^{-1}$ deg. C.$^{-1}$ at about 50 atomic per cent of antimony, while the electron mobility is not reduced. Substitution of sulphur or selenium for tellurium in any $(Sb–Bi)_2–Te_3$ alloy causes a further small reduction in K_0, but the amount which can usefully be substituted is restricted because of electron scattering.

Our work on the optical properties[8] indicates that on substituting selenium for tellurium in bismuth telluride, there is a change in band structure near the composition Bi_2Te_2Se, which may be associated with the decrease in mobility on adding selenium because of an increase in inter-valley scattering. We have not so far been able to obtain infra-red transmission through $(Bi–Sb)_2–Te_3$.

I would like to acknowledge the collaboration of several scientists working as a team on this subject. A. R. Sheard is responsible for preparing the material, H. J. Goldsmid for studying thermal conductivity and thermoelectric power, J. R. Drabble for investigating the galvanomagnetic effects, and I. G. Austin for examining the optical properties. P. A. Walker and B. Yates are extending the measurements down to liquid-helium temperatures. In addition to the papers referred to above, some of the more recent work has been published[9], and other papers are in preparation[10].

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Mechano-Chemical Anodic Dissolution

Hoar and Hines[1–5] have studied the transgranular stress-corrosion cracking of 18–8 type stainless steels in aerated aqueous magnesium chloride solution (42 wt.-per cent of magnesium chloride) at temperatures of 120–154° C., using thin wires directly stressed in tension. They found rates of crack propagation in the range 0·5–2 mm./hr., similar to those found in other work using much thicker material, and several orders of magnitude smaller than the rate of cracking in mechanical brittle fracture. They suggested that a crack is propagated by the selective anodic dissolution of the highly stressed metal forming its advancing edge, the unstressed sides of the crack remaining relatively unattacked.

By measurements of the electrode potential of cracking wires, and of potential and current density on unstressed wires polarized cathodically with impressed e.m.f., they estimated the current flowing from the surface oxide-film cathode into each crack as of the order of 0·5 μamp.; this, together with the anodic current-density at the advancing edge necessary to give the observed rate of crack propagation by metal dissolution to Fe^{II}, Cr^{III} and Ni^{II}, say 0·4–1·6 A./cm.², leads to reasonable values of the width of the advancing edge, some tens or hundreds of angstroms. The potential measurements also showed that the postulated anodic dissolution of stressed metal at high current density must take place, if it in fact occurs, with only a few millivolts polarization of the anode above its zero-current potential of about −0·15 V. (*N*-hydrogen scale). While there are no grounds for supposing that stressed or even strained metal is, *per se*, much more easily dissolved anodically than unstressed metal, it seemed possible that metal in the act of yielding under stress might be so. Measurements of the overall extension of wires during cracking suggested that the actual strain-rate at the advancing edge of each crack may well be of the order of 10–100 per cent/sec., and it was thus of interest to see whether a macroscopic area of 18–8 type stainless steel yielding at a comparable rate could sustain a high anodic current density of the order of 1 amp./cm.², leading to equivalent metal dissolution, at very small polarization.

We have modified the apparatus of Hoar and Hines[1–5] so that in it a wire may be extended very rapidly while it undergoes anodic polarization in a hot aqueous solution. Arrangements for the simultaneous measurement of extension-rate, electrode potential and current are included, and for the rapid flow of the solution past the wire if required.

When an unstressed wire of 18–8 steel (carbon, 0·09; silicon, 1·00; manganese, 0·78: chromium, 17·1; nickel, 9·2; molybdenum, 0·18; copper, 0·2; nitrogen, 0·06; niobium + tantalum, titanium, $<0{\cdot}05$ wt.-per cent) was polarized anodically in stagnant 42 wt.-per cent aqueous magnesium chloride solution at 154° C. so that the current density was 0·5 amp./cm.², the potential was +0·52 V. and the wire dissolved uniformly over its whole surface to Fe^{II}, Cr^{III} and Ni^{II} with about 100 per cent current efficiency. When a similar wire was treated similarly during its extension at 5 per cent/sec., the potential was + 0·35 V. and similar uniform dissolution occurred. The rapid macroscopic dissolution produced, however, considerable concentration polarization caused by the accumulation of dissolved metal ions in the liquid adjacent to the wire. To reduce this, further experiments, in which similar wires were extended at 5 per cent/sec. while dissolving at 0·5 amp./cm.², were made with the solution forced at 50 cm./sec. past the wire (which was held in the axis of a 1-cm.-diam. glass tube): the potential was now − 0·15 V., very close to the zero-current potential of unstressed 18–8 steel anodes and slightly more negative than the potentials observed during stress-corrosion cracking[1–5], the wire again dissolving uniformly.

These experiments demonstrate that 18–8 steels can dissolve anodically at high current density with very small polarization provided that the surface is yielding rapidly in a direction normal to the direction of dissolution. They provide strong confirmation for the hypothesis of Hoar and Hines for the mechanism of crack propagation; as we shall show in a full report of this work elsewhere, concentration polarization at a very small anode at the advancing edge of a yawning crack is likely to be very small. The experiments also provide an example, on the macroscopic scale, of a mechano-chemical effect: an anodic dissolution that is highly stimulated by the mechanically induced movement of the surface metal atoms.

Similar experiments on pure nickel gave no indication of mechanical stimulation of its anodic dissolution in hot aqueous magnesium chloride solution; significantly, nickel does not suffer stress-corrosion cracking under these conditions. Although 18–8 steel and nickel both have face-centred cubic lattices, the number, distribution and mobility of dislocations and other zones of disarray are clearly different in the alloy and in the pure metal, which may well account for the difference in their behaviour when they undergo simultaneous yielding and dissolution.

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Electronic Configuration of Cations in some Distorted Spinels

Two apparently different approaches have been used for explaining the distortion to tetragonal symmetry of some spinels. Both, however, rely on the behaviour of cations having 3*d* electrons. Thus in one the origin of distortion is attributed to the ability of these cations (for example, Mn^{3+}) to form the appropriate covalent bonds with the overlapping oxygen orbitals[1–3]. On the other hand, the second approach relates it to the crystal field effects and Jahn–Teller distortions[4] of ligands around such cations[5].

In what follows the observed electronic configuration of cations in a few cases is examined in the light of these schemes. The analysis of the available magnetic data for $Mn^{2+}[Mn^{3+}_2]O^{2-}_4$ and for the γ-oxide $(Mn^{3+}_2O^{2-}_3)$ showed that Mn^{3+} (d^4) ions at octahedral sites in both the substances have four unpaired *d*-electrons. However, the tetrahedrally situated cations, that is Mn^{2+} (d^5) in the former and

Mn^{3+} (d^4) in the latter had only one and two unpaired electrons respectively[2]. This distribution satisfies the requirement of Mn^{3+} ions at octahedral sites which in virtue of one empty d-orbital would take part in dsp^2 square bonds to produce the appropriate distortion of each elementary octahedron ($c/a > 1$). Furthermore, the cations at tetrahedral sites which have two empty d-orbitals would seem to form d^2sp hybrid (irregular tetrahedral) bonds[2]. This is also in accord with the geometrical requirements where in both the substances the MeO_4 tetrahedra are also distorted and can be described as tetragonal sphenoids[6] with $\alpha_1 = \alpha_2 = 102° 30'$ and $\beta = 113° 34'$, the central cation being equidistant from oxygen ions.

The above electronic distribution of $3d$ electrons in the tetrahedrally situated cations, which seems to be in violation of Hund's rule, can also be justified from the point of view of crystal field theory.

According to this approach[5], the $(t_{2g})^3$ (e_g) configuration of octahedrally situated Mn^{3+} (d^4) ions, having degeneracy with respect to e_g orbitals, gives rise to a Jahn–Teller distortion whereby $c/a > 1$. This is in agreement with observation. However, configurations with highest permissible multiplicity for tetrahedral cations are $(e)^2$ $(t_2)^3$ for Mn^{2+} in $Mn^{2+}[Mn_2^{3+}]O_4$ and $(e)^2$ $(t_2)^2$ for Mn^{3+} in γ-$Mn_2^{3+}O_3$. For the former the Jahn–Teller distortion is zero and for the latter $c/a < 1$. In fact, this distortion of tetrahedral groups will oppose that of octahedral groups. This would conflict with the observed situation where in both the substances $c/a = 1{\cdot}16$. A distortion of the tetrahedral group consistent with $c/a > 1$ is expected from a configuration where there is, in these ions, a single electron in the t_2 orbital (in effect T_2 state). Thus the modified configuration for such ions would be $(e)^4$ (t_2) for d^5 and $(e)^3$ (t_2) for d^4. This distribution is in agreement with the total spin values derived from the magnetic data.

Actually, the distortion of MeO_6 octahedra to give $c/a > 1$ and the corresponding distortion of MeO_4 tetrahedra amounts to the production of a strong crystal field which would favour the low spin-states.

It is expected that a molecular orbital approach which takes into account the essential features of the Jahn–Teller effects would lead to a more consistent picture.

I am grateful to Prof. M. H. L. Pryce for discussions.

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Murexide Test in Paper Chromatography

MICHEL[1] found that the purines on a moist filter paper, when treated with chlorine gas for 3 min., dried at 80–90° C. and left in an ammonia atmosphere for a few minutes form compounds which are detectable by their fluorescence in ultra-violet light. A true murexide test, with development of a pink coloration, can be carried out without using chlorine directly, by lightly spraying the paper first with a 10 per cent solution of chloramine *T* (B.P.) and then with *N* hydrochloric acid, followed by heating it in a steam-oven (96–98° C.) until there is no smell of chlorine. The dried paper is then passed slowly over the open mouth of a bottle of concentrated ammonia and heated in the steam-oven for 5–10 min., when the purines will show up as pink spots. It is sometimes necessary to repeat the ammonia treatment and subsequent heating to make the spot visible. Morgan[2] used chloramine *T* as an oxidizing agent for detection of caffeine in the conventional way by the murexide test.

This method will detect uric acid, caffeine, theophylline, theobromine and xanthine in approximately microgram quantities of 1·5, 18, 38, 1 and 7 respectively. When viewed in ultra-violet light the spots show violet fluorescence, and the minimum detectable quantities are reduced to approximately one-third of those quoted above.

We wish to thank the Indian Tea Association for permission to publish this communication.

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Acidity of Sprays used in detecting Ketohexoses on Paper Chromatograms

SEVERAL spray reagents are available for the specific detection of ketoses and ketose-containing sugars on paper chromatograms. Probably the most widely used are resorcinol and naphthoresorcinol, originally prepared as sprays in 2 *N* hydrochloric acid by Forsyth[1]. Afterwards, Partridge[2] replaced the hydrochloric acid with trichloracetic acid in order to minimize attack on the filter paper. Heyrovsky[3] has recently reported that β-indolyl acetic acid in trichloracetic acid is also a very sensitive ketose-specific reagent. In work in this laboratory on two fructose-containing disaccharides it has been found that all three of the above reagents, when prepared in trichloracetic acid, failed completely to detect these sugars on paper chromatograms. When the trichloracetic acid was replaced with 2 *N* hydrochloric acid strong positive tests were obtained. The results are listed in Table 1.

Disaccharide *A* was obtained from red clover (*Trifolium pratense*) and yielded fructose only on hydrolysis. Disaccharide *B* was isolated from cultures of *Streptococcus bovis*[4] and yielded both glucose and fructose on hydrolysis. Both sugars were somewhat resistant to acid hydrolysis and required 4 hr. at 100° in 1·5 *N* sulphuric acid for complete hydrolysis. The two disaccharides were applied to

Table 1

Reagent	Acid	Disaccharide *A*	Disaccharide *B*
Resorcinol	Trichloracetic	nil	nil
	2 *N* hydrochloric	bright red	bright red
Naphtho-resorcinol	Trichloracetic	nil	nil
	2 *N* hydrochloric	deep red	deep red
β-Indolyl-acetic acid	Trichloracetic	nil	nil
	2 *N* hydrochloric	strong violet	strong violet

papers as spots containing 20–25 μgm. of sugar, and the sprayed papers heated according to the methods employed by Forsyth[1], Partridge[2] and Heyrovsky[3]. No reaction was obtained with the trichloracetic acid reagents even with prolonged heating times. Fructose and sucrose, under these conditions, reacted readily with all three reagents in either acid, while glucose gave no reaction.

All three reagents appear to have been developed with fructose and oligosaccharides containing the easily hydrolysed sucrose linkage (sucrose and raffinose) as reference sugars. From the results just reported it appears that either free ketose only can react with the reagents or else a specific part of the ketose molecule may be involved in the reaction. In this latter case a stable glycosidic linkage involving this specific portion of the ketose molecule would prevent reaction with the reagents. In either case preliminary hydrolysis would be necessary. The results described suggest that trichloracetic acid, under the recommended conditions, is unable to hydrolyse the more stable glycosidic linkages and thus the stronger hydrochloric acid is necessary.

It is evident that in testing an unknown oligosaccharide for ketoses on a paper chromatogram the stronger acid sprays are necessary. A positive reaction with only the stronger acid reagent may be a useful indication of the strength and possible nature of the glycosidic linkage involved.

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Quantitative Determination of Hydroxyproline by Paper Chromatography

RECENTLY, we showed that the quantitative analysis of amino-acids using the maximum colour density method could be accomplished with low errors and good reproducibility[1]. As regards the analysis of hydroxyproline, the accuracy can be considerably improved if the colour development is effected using a ninhydrin–isatin–triethylamine reagent[2] rather than isatin[1].

A solution containing 46·8 mgm. of hydroxyproline in 100 ml. of 10 per cent *iso*propanol was assayed by the paper chromatographic procedure[1]. This procedure employs strips of Whatman No. 1 filter paper, 23 cm. × 57 cm., buffered at *p*H 8·4 and a 40-hr. descending development in the solvent system *m*-cresol buffered at *p*H 8·4.

Eighteen quantitative chromatograms were prepared. Following solvent development and drying at 60° C. for 1 hr., nine of the chromatograms were dipped in 0·4 per cent isatin in water-saturated *n*-butanol containing 4 per cent acetic acid (reagent *A*). The blue colour of the hydroxyproline spots was developed by heating the dipped chromatograms for 10 min. at 100° C. and then storing at room temperature for 24 hr. The maximum densities of the spots were read using a 'Densichron' transmission densitometer (Model 3835*B*, W. M. Welch Scientific Co., Chicago), the red built-in filter, and a 3-mm. aperture.

Table 1. ACCURACY AND PRECISION OF PAPER CHROMATOGRAPHIC DETERMINATION OF HYDROXYPROLINE

Chromatogram	Calculated concentration (mgm./100 ml.)	
	Reagent *A*	Reagent *B*
1	44·9	45·9
2	44·0	47·7
3	47·7	44·9
4	44·9	44·9
5	44·0	44·9
6	49·6	48·7
7	43·1	45·9
8	45·9	46·8
9	43·1	47·7
Average	45·2	46·4
Standard deviation*	2·18	1·41
Deviation from theory†	3·4%	0·9%

* Standard deviation $= \sqrt{\dfrac{N\Sigma X^2 - (\Sigma X)^2}{N(N-1)}}$

† Theoretical value = 46·8 mgm./100 ml.

The remaining nine chromatograms were dipped in a reagent composed of 270 mgm. of ninhydrin, 130 mgm. of isatin and 2 ml. of triethylamine made up to 100 ml. with water-saturated *n*-butanol (reagent *B*)[2]. After heating for 15 min. at 60° C., the maximum densities of the red-purple hydroxyproline spots were read using the 'Densichron' transmission densitometer and no filter.

The results of this comparative quantitative study are given in Table 1. In addition to a marked improvement in the accuracy and precision of the analysis, the use of reagent *B* (the new ninhydrin–isatin–triethylamine reagent) offers a number of other distinct advantages: (1) It is specific for hydroxyproline[2]. (2) It is more sensitive than isatin. The concentration of the standard and unknown solutions spotted on the filter paper are one-half the concentration required when using isatin[1]. (3) The maximum densities of the hydroxyproline spots are greater and can be read immediately after colour development, thus eliminating the 24-hr. colour development period necessary when using isatin.

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Iron Content of Hæmoglobin in Iron Deficiency

IN iron-deficiency anæmia insufficient iron is available for hæmoglobin synthesis to proceed at a normal rate. Presumably the primary difficulty is in the synthesis of the prosthetic groups of hæmoglobin, hæm. Since the usual methods of estimating hæmoglobin (spectrophotometry, iron analysis, oxygen capacity) depend upon the hæm group, it appeared possible that the decrease in 'hæmoglobin' observed in this deficiency state might be one of hæm rather than hæmoglobin. Thus, unless globin synthesis was restrained by the absence of hæm, globin molecules with less than the normal four hæm groups might be produced. The studies reported here were undertaken to determine whether appreciable quantities of such a hypothetical incomplete pigment were present.

Table 1

Sample	No. of aliquots	Iron content as average per cent of dry weight ± standard error of the mean
Mother liquor from first crystallization of hæmoglobin from normal rats	2	0·312
Mother liquor from first crystallization of hæmoglobin from iron-deficient rats	2	0·298
Purified (twice crystallized) hæmoglobin from normal rats	5	0·3488 ± 0·0027
Purified (twice crystallized) hæmoglobin from iron-deficient rats	5	0·3364 ± 0·0053
Purified (once crystallized) hæmoglobin from normal human	4	0·3260 ± 0·0017
Purified (once crystallized) hæmoglobin from iron-deficient human	4	0·3173 ± 0·0020
Purified (twice crystallized) hæmoglobin	4	0·3328 ± 0·0028
Purified (twice crystallized) hæmoglobin from iron-deficient human	5	0·3496 ± 0·0028

Rat hæmoglobin was isolated from the heparinized blood of animals rendered iron-deficient by feeding them a mild diet supplemented with an iron-free salt and vitamin mixture. Control animals were fed an identical diet to which ferrous sulphate had been added. The hæmoglobin was crystallized by shaking an alkalinized hæmolysate with toluene, centrifuging, filtering and adjusting the *p*H to 6·8. The crystals were redissolved with the aid of dilute ammonia, and recrystallization was achieved by dialysis against large volumes of iron-free water. Prior to drying for analysis, the crystals were dissolved in iron-free water with the aid of dilute ammonia and the resultant hæmoglobin solution was filtered.

Human hæmoglobin was isolated from the blood of a normal young man and from the blood of a woman with long-standing uncomplicated iron-deficiency anæmia. Crystalline human hæmoglobin was prepared according to Drabkin's method[1]. It was washed briefly in 2·8 *M* phosphate buffer at *p*H 6·8 and was then redissolved in iron-free distilled water, filtered, and dialysed against large volumes of iron-free water. An aliquot of the hæmoglobin was recrystallized by further dialysis against 2·8 *M* phosphate buffer, *p*H 6·8, and was washed overnight in the buffer. The crystals were redissolved in 2·0 *M* phosphate buffer *p*H 6·8, filtered, and dialysed against several large volumes of iron-free water.

2–5 aliquots of each hæmoglobin solution were dried to a constant weight at 110° C. and were then wet-ashed with concentrated sulphuric acid and hydrogen peroxide. In the case of human hæmoglobin solutions, residual potassium phosphate represented less than 1 per cent of the dry weight as estimated by phosphorus analysis. A correction for the weight of this salt was made. Iron determinations were carried out colorimetrically with *o*-phenanthrolene, using a modification of the method of Barkan and Walker[2]. The iron content of the hæmoglobin samples is presented in Table 1.

Assuming that the pigment in the destromatized hæmolysate is representative of the pigment inside the intact red cell, the results of these studies demonstrate that most, if not all, of the pigment in iron-deficient red cells has a normal iron content. It is apparent that the nearly identical iron content of the purified hæmoglobin solutions from normal and iron-deficient subjects cannot be due merely to failure of an incomplete hæmoglobin to crystallize, since there was very little difference in the iron content of the mother liquors from the first crystallizations of the rat hæmoglobin. Thus in iron deficiency a defect in the hæm synthesis appears to limit somehow the synthesis of globin.

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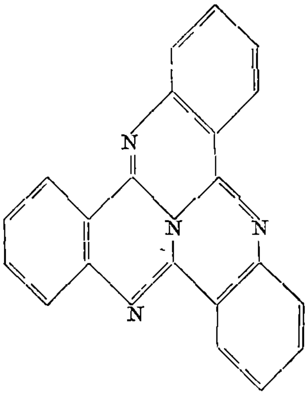
Carcinogenicity of Tricycloquinazoline

Tricycloquinazoline (I) has hitherto been prepared from indazole and copper powder[1,2], from *o*-aminobenzaldehyde and ammonium chloride[3] and from *o*-cyanoanilinium toluene-*p*-sulphonate[2]. We now find that it is readily formed in simple pyrolytic reactions. For example, methyl anthranilate was refluxed into a red-hot tube; a benzene solution of the resulting tar, after removal of its constituent acidic and basic fractions including methyl anthranilate, furnished 0·053 per cent of pure tricycloquinazoline by chromatography on alumina.



(I)

It was also produced, in the yields given, by the action of heat on the following compounds or mixtures: ammonium anthranilate (0·083 per cent), anthranilamide (0·73 per cent), anthraniloylanthranilamide (5 per cent), anthranilamide toluene-*p*-sulphonate (20–25 per cent), methyl anthranilate and ammonium benzenesulphonate (5–16 per cent), ammonium anthranilate and ammonium benzenesulphonate (0·11 per cent), anthranilic acid and ammonium benzenesulphonate (0·086 per cent), anthranilamide and ammonium benzenesulphonate (12 per cent). In each instance the product was authenticated by its melting-point and mixed melting-point, by its characteristic ultra-violet light absorption and by its R_F value.

Tricycloquinazoline can be sublimed unchanged at red heat at atmospheric pressure and is resistant to oxidation. This substance is a representative of a class of polyazapolycyclic hydrocarbons which have not previously been tested for carcinogenic properties, and so the activity has been examined following subcutaneous injection in the rat.

The compound was injected subcutaneously as a suspension in olive oil (10 mgm./ml.) into 30 Wistar

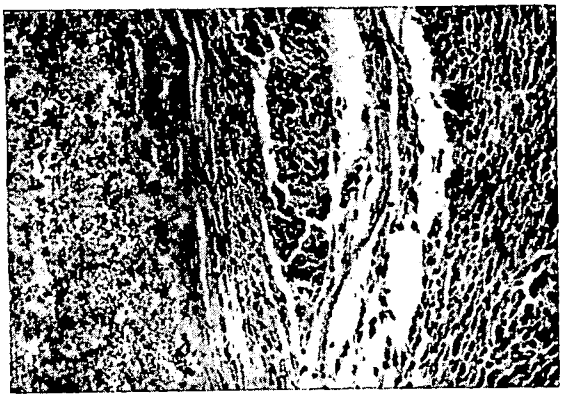


Fig. 1. Photomicrograph showing relation of neoplastic tissue to injected tricycloquinazoline. (× *c.* 90)

rats, 7–11 weeks old and equally divided with respect to sex. Because of the persistence of the material at the site of injection, rats received only four monthly injections, representing a total dosage of 40 mgm., and were then observed for 26 months.

The injected tricycloquinazoline proved to be extremely resistant to metabolism, and subcutaneous cysts containing the compound remained at the site of injection during the whole period of the experiment (22–26 months). In two experiments where attempts were made to recover tricycloquinazoline from injected rats after 22 months, in each case a total of 36 mgm. out of 40 mgm. injected was recovered from the local lesion in an unchanged form.

Tumours were observed in 27 per cent of treated rats during the period of the experiment and the tumour-induction period was relatively high. The first tumour appeared 14 months after the first injection, while the majority of the tumours developed between the sixteenth and twenty-fourth months. All these tumours were undifferentiated spindle-cell sarcomata which had arisen at the site of injection. Tricycloquinazoline causes a low-grade inflammatory reaction in the surrounding connective tissue, with ultimate formation of a cystic space surrounded by fibrous tissue. The inactivity of the compound is indicated by its demonstration by fluorescence microscopy as long as 26 months after injection. Histological studies enabled the close relation of the tumours to be seen (Fig. 1).

The latent period for tumour induction with tricycloquinazoline is considerably greater than that observed with polycyclic hydrocarbons[5]. This may be due to the extreme inertness of the compound, and it is interesting that similar latent periods have been observed for tumour induction by implants of synthetic polymers, which are also chemically unreactive[6].

Although it is not suggested that the carcinogenic activity of these various substances is due to a common mechanism, it would appear that, by virtue of its chemical inertness, the carcinogenic response produced by tricycloquinazoline more closely resembles that caused by plastics[6] and metals[7] and cannot be directly compared with the activity of the more readily metabolizable polycyclic hydrocarbons.

In view of the wide occurrence of methyl anthranilate in plants[4], and the fact that tricycloquinazoline can be readily prepared from it by the action of heat, the products of pyrolysis of plant material are now being examined for the presence of tricycloquinazoline. Further studies are also in progress to determine the carcinogenic activity of the compound administered by several routes in mice and rats.

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A Micro-electrophoretic Method

A MICRO-ELECTROPHORETIC technique has been developed which is sensitive, simple and rapid and does not require any elaborate apparatus. Very clear results can be obtained with samples of the order of fractions of a micro-litre with a protein content of 10 μgm. and even less. The technique is a combination of the membrane filter electrophoresis[1] and, in particular, of the small-scale technique[2], with the use of a very sensitive stain—'Nigrosin'[3]. All details of the membrane-filter electrophoresis apply as well to the micro-technique.

A horizontal electrophoretic tank for small-scale membrane-filter electrophoresis, with a bridge gap of 8 cm. is used. The buffer compartments run through the whole length of this tank, convection currents are considerably reduced and more efficient vapour saturation and cooling are provided.

The supporting medium consists of cellulose acetate-membrane filter strips (Oxo, Ltd., 16 Southwark Bridge Road, London) 10–12 cm. × 2·5 cm., with strip-holders lined with filter paper acting as wicks. Longer or wider strips can be used (and may be easier to handle). 120 V. applied for about two hours provides a pattern length of approximately 5–6 cm.

The sample is applied by means of a very fine calibrated capillary, micro-pipette or micro-syringe, about 2 cm. from the cathode end. The position of the sample is important and partly determines the pattern. The size of the sample can vary from 0·0001 ml. to about 0·008 ml. (0·1–8 μl.). Staining is carried out in very dilute 'Nigrosin' solution (0·005 per cent in 2 per cent acetic acid) for about one hour, the time being judged best by experience. The strip is washed in 2 per cent acetic acid, blotted and dried. 'Nigrosin' is more suitable for small samples. For samples containing more than 70 μgm. of protein conventional stains are to be preferred.

Patterns obtained with the method described are shown in Fig. 1. Clear separation patterns were still obtained on serum samples not exceeding 0·0001 ml. containing about 5–10 μgm. of protein. Two pre-albumin fractions could be clearly demonstrated in human serum (Fig. 1*b*). An important feature of this technique is that with small quantities of protein used some minor protein fractions become unmasked.

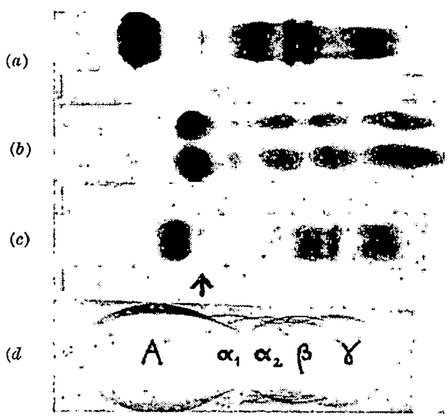

Fig. 1. Human serum, veronal buffer *p*H 8·6, *a*, *b*, *c*, 'Nigrosin' stain, *d*, azocarmin. Contact prints from uncleared strips. (*a*) 0·5 μl. 30 μgm. protein; (*b*) two pre-albumin fractions, 30 and 40 μgm. protein; (*c*) small post-albumin fraction (indicated by arrow) 10 μgm. protein; (*d*) micro-immuno-electrophoresis on 0·0025 ml. serum (180 μgm. protein)

A post-albumin fraction, for example, has been found in most of the human sera investigated (Fig. 1*c*).

The micro-technique described above can also be applied to immuno-electrophoresis (Fig. 1*d*). This is performed in a manner similar to that reported in a previous paper[4], taking into account the smaller size of the strip. The thickness of the agar layer should not exceed 1–2 mm., and the distance between the electrophoretic and antiserum strips is reduced to 3–5 mm., the width of the antiserum strip being about 1 mm.

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Formation of Lactulose and Tagatose from Lactose in strongly heated Milk

In recent years it has been shown that reductones, furfurals and other related substances formed in heated milk are sugar fission products[1,2]. The mechanism by which lactose is degraded to these products has interested food chemists, but nothing is known of the transformation of carbohydrates in heated milk, in spite of considerable attention paid to them in normal cow's milk[3-5].

In order to confirm the secondary formation of carbohydrates in heated milk, the browning whey from autoclaved milk (120° C., 10 hr.), from which the curds had been removed, was chromatographed on Tōyō No. 50 filter paper by the ascending technique using the mixture *iso*propanol/pyridine/acetic acid/water (8 : 8 : 1 : 4)[6], and phenol saturated with water as solvent systems. The chromatogram was coloured by spraying with resorcine and aniline hydrogenphthalate reagents. The control sample was prepared from raw milk by a method essentially similar to that described by Sasaki and Taniguchi[5]. In the case of heated milk the chromatograms gave two new spots corresponding to tagatose and lactulose, and the intensity of the galactose spot was greater than that of raw milk. The lactose and glucose spots were less intense than in raw milk. These results are not sufficient to identify the newly formed carbohydrates. However, they indicate clearly that the same carbohydrates are formed secondarily from lactose in milk during heating in the autoclave.

The isolation and identification of these carbohydrates were carried out by Whistler and Durso's[7] and Samuelson and Sjoström's[8] methods. The sample from autoclaved milk (120° C., 8 hr.), desalted by passing it successively through columns of the ion exchange resin 'Amberlite-*IRA* 410' (OH^- form) and 'Amberlite-*IR* 120' (H^+ form), was poured into a column packed with a mixture of equal weights of 'Sagi' activated charcoal and 'Celite No. 535' filter aid. It was then developed with water followed by 5 per cent ethanol. These eluting fractions were passed separately through a column of 'Amberlite-*IRA* 410' (HSO_3^- form) and evaporated under reduced pressure. The crystalline carbohydrates isolated from the resultant syrups by methods given in the literature[9,10] were identified, by the determination of physical constants in conjunction with the results of the formation of characteristic derivatives, as *d*-tagatose and lactulose, from the water and ethanol fractions, respectively. These results are shown in Table 1. Galactose was identified in the water fraction as *p*-tolylhydrazone.

On the basis of these results, it seems reasonable to assume that the successive transformation of lactose to lactulose, galactose and tagatose in heated milk occurs not only in accordance with the Amadori rearrangement (as shown in previous papers[11]) but also *via* the de Bruyn and van Ekenstein reaction in the milk protein–lactose system. These findings are supported by the facts that tagatose was not formed while lactulose and galactose were, from *p*-tolyl–*iso*lactosylamine, the Amadori rearrangement product of *p*-tolyl–lactosylamine[12], under the conditions described above. Tagatose is doubtless the de Bruyn and van Ekenstein reaction product of galactose. Since lactulose has not been hitherto reported as a constituent of any natural product, while naturally occurring tagatose has recently been discovered in the gum

Table 1. Identification Data of Crystalline Ketoses eluted from Carbon Column

Sample	M.P. (° C.)	$[\alpha]_D^{20}$ (24 hr., in water)	Phenylosazone			M.P. mixed with corresponding synthetic sugar
			M.P. (° C.)	Nitrogen (per cent) Found	Nitrogen (per cent) Calculated	
Carbohydrate obtained from water fraction	132–133	—	186	15·48	For $C_{18}H_{22}O_4N_4$ 15·64	With tagatose 132–133° C.
Carbohydrate obtained from 5 per cent ethanol fraction	156–157	−50·7	200	10·80	For $C_{24}H_{32}O_8N_4$ 10·89	With lactulose 156–157° C.
d-Tagatose	132–133	− 2·8	186	15·55	For $C_{18}H_{22}O_4N_4$ 15·64	—
Lactulose	156–157	−51·0	200	10·85	For $C_{24}H_{32}O_8N_4$ 10·89	—

exudate of *Sterculia setigera*[13], the presence of these ketoses in heated milk is of particular interest. These results may be applied to the transformation of the carbohydrates in evaporated milk[14] and other related dairy products.

A more detailed account of these experiments will be published elsewhere. I wish to thank Prof. T. Nakanishi for his guidance and encouragement in the course of this work.

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Synthesis of Phlorin and other Phenolic Glucosides by Plant Tissues

ALTHOUGH phloroglucinol itself seldom occurs in plants it has been implicated in the biosynthesis of ring *A* of the flavonoid compounds[1,2]. In the course of a study of the metabolism of the glucoside, phloridzin, in *Malus*, leaf disks were fed phloroglucinol together with glucose labelled with carbon-14, and although phloridzin synthesis was unaffected a new compound was detected in chromatograms which has been tentatively identified as phlorin[3], the glucoside of phloroglucinol.

The methods used were as follows: 4 or 5 leaf disks, 1·2 cm. diam., obtained with a Ganong leaf punch, were infiltrated under vacuum with tap water, blotted and placed in 0·6 ml. of a solution of 600 μgm. phloroglucinol and 50 μgm. (1 μc.) labelled glucose contained in a small Petri dish. The dish was covered and placed in the light at room temperature. After 24 hr. the disks were removed, washed thoroughly with water and extracted for ½ hr. with boiling 80 per cent ethanol. The ethanolic extract was reduced in volume by means of an air jet at room temperature and applied, without further purification, to Whatman No. 1 paper for chromatography. The solvents were phenol saturated with water for the first direction and butanol/acetic acid/water (4 : 1 : 5 v/v) for the second.

Phlorin was detected on chromatograms by colour reactions with vanillin in concentrated hydrochloric acid[4], diazotized sulphanilic acid[5] and diazotized *p*-nitroaniline[6]. Radioactive phlorin was eluted from chromatograms with hot ethanol and hydrolysed with either 2 *N* hydrochloric acid or emulsin after removal of the ethanol. Chromatography of the hydrolysis products gave phloroglucinol and labelled glucose. Successful hydrolysis with emulsin showed that the compound was a β-glucoside. When phloroglucinol labelled with carbon-14 and inactive glucose were fed to disks, a radioactive spot, identical with the one obtained from phloroglucinol and labelled glucose, was obtained.

Table 1. DISTRIBUTION OF CARBON-14 IN 80 PER CENT ETHANOL-SOLUBLE FRACTION OF LEAF DISKS OR SEGMENTS FED LABELLED GLUCOSE AND PHLOROGLUCINOL

Leaf disks or segments	Per cent radioactivity of 80 per cent ethanol-soluble fraction				
	Phlorin	Glucose	Fructose	Sucrose	Glucitol
Adiantum macrophyllum	11	<1	<1	82	—
Pinus resinosa	62	1	—	37	—
Briza media	27	1	—	64	—
Pelargonium hortorum	76	3	—	1	—
Kalanchoë punctata	3	46	42	9	—
*Gerbera jamesonii**	82	1	—	5	—
Malus sylvestris	29	1	—	5	64

* When leaf disks of this plant were fed phloroglucinol labelled with carbon-14 and inactive glucose under the same conditions, 90 per cent of the radioactivity of the 80 per cent ethanol-soluble fraction was in phlorin.

That this ability to synthesize phlorin is not peculiar to apple-leaf tissue is shown in Table 1. It was found that phlorin synthesis occurred not only in the margins but also in the central regions of the disks, and, moreover, light was not necessary to effect this synthesis. Except for *Adiantum*, free phloroglucinol was not detected in any of the other plant extracts. When starved leaves, that is, leaves on plants maintained in the dark for 48 hr., of *Pelargonium hortorum* or *Gerbera jamesonii* were used, however, phlorin synthesis was found to decrease, and free phloroglucinol accumulated in the tissues. This occurred even in the presence of exogenous glucose.

Although other sugars such as fructose, galactose, rhamnose, arabinose or xylose were substituted for glucose, no glycoside other than phlorin was detected on chromatograms.

Other phenols, including orcinol, resorcinol, hydroquinone, salicyl alcohol, *p*-hydroxybenzaldehyde and vanillin were similarly fed with labelled glucose to leaf disks of *Malus* and *Gerbera*. Each phenol gave rise to what appeared to be the respective glucoside regardless of whether it occurred naturally in the plant, and appeared as a distinct, intensely radioactive spot on the chromatogram.

So far as we know, this ready synthesis of phenolic glucosides by plant tissues has not been described, although Dr. A. E. Schwarting of the University of Connecticut (private communication) has found that salicyl alcohol, when fed to twigs of *Salix nigra*, gives increased amounts of salicin in the bark.

Phenols have been prominent in theories of disease resistance in plants[7–13]. Disease resistance has been attributed to either an increased production of phenols in healthy tissue adjacent to regions invaded by the parasite or to a naturally high phenol content of the host. The increase in free phenols often observed in healthy tissue of parasitized plants may be due to an inability to 'detoxify' phenols liberated by enzymic hydrolysis of the natural glycosides of the plant. The inability to 'detoxify' phenols may be caused by glucose depletion as a result of metabolic activity of the pathogen. These phenols permeate both host and parasite tissues. The extent to which pathogenic bacteria and fungi either metabolize or 'detoxify' phenols is not clear. Recently, certain phenolic acids, hitherto considered to be characteristic of higher plants, have been detected in a bound form (possibly as glycosides) in uredospores of wheat stem rust[14]. It is possible that these compounds are formed in the fungus through glycosidation subsequent to the absorption of phenolic acids. If phenols are to be implicated in theories of disease resistance it would appear that studies of the metabolism of these compounds in both host and parasite may be of the greatest importance.

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Effects of Clipping and Spraying on Various Homœothermic Responses of Rabbits at an Elevated Environmental Temperature

The relative effects of clipping and spraying on evaporative and non-evaporative cooling have been measured on rabbits at an elevated air- and body-temperature. Under such conditions most of the heat loss is by evaporative cooling.

Rabbits were maintained in individual cages in the alley of the University of Missouri Climatic Laboratory at 103° F. and 15 per cent relative humidity, in an air velocity of 50 ft./min. Drinking water and rabbit feed (pellets) were available *ad libitum* from hopper-type feeders and waterers. However, at 103° F. air-temperature the rabbits consumed no food, except occasionally after spraying.

Before exposure to an air-temperature of 103° F., four of the eight experimental rabbits were sheared as closely as possible with small animal clippers. After being at 103° F. for 4–5 hr., the animals were sprayed manually with an atomizer (15 lb./in.^{2} air pressure), using water at room-temperature (103° F.). Each rabbit was sprayed for 5 min. using only enough water to produce a fine mist. Conduction between the skin and (spray) water was thus not likely to be an appreciable factor in loss of heat.

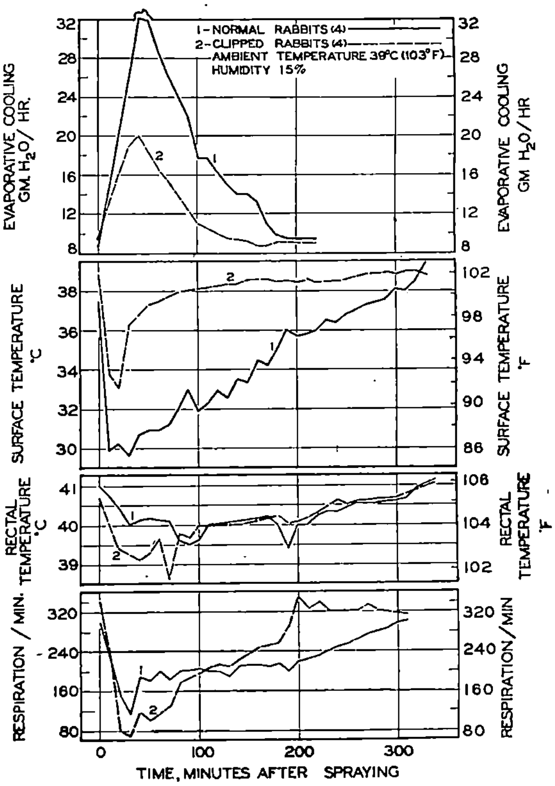

Fig. 1. Influence of spraying on various reactions of normal and clipped rabbits

Respiration-rates were measured by counting the flank movements of the animals in the cages. Each point in Fig. 1 represents an average of three determinations. Surface temperatures were taken by the Hardy dermal radiometer. Evaporative cooling (insensible weight-loss) was measured by weighing the animals on a large, sensitive, 'chainomatic' scale placed in the Climatic Laboratory. Rectal temperatures were taken by clinical thermometer.

Merely clipping the rabbits at 103° F. showed no striking effect on the homœothermic responses of the animals, although it was beneficial. Average values for the clipped rabbits at that temperature were: respiration-rate, 335 per min.; surface temperature, 38·8° C.; rectal temperature, 40·68° C.; and evaporative cooling, 9·26 gm. water/hr.; corresponding values for the normal rabbits were: respiration-rate, 290 per min.; surface temperature, 37·5° C.; rectal temperature, 41·1° C.; and evaporative cooling, 8·66 gm. water/hr. Clipping exposed the warm skin directly to the ambient air, resulting in a slightly greater rate of evaporation, a greater rate of non-evaporative cooling, and a lower rectal temperature. Respiration-rates were higher in the clipped rabbits. All these measurements indicate some benefit from clipping at high temperature.

However, there were striking differences in the responses of clipped and normal rabbits to spraying. Fig. 1 (top) shows the evaporative cooling of New Zealand white clipped and unclipped rabbits after spraying. Rabbits with normal coats showed a great increase in evaporative cooling in contrast to the clipped animals (cf. curves 1 and 2 in Fig. 1), amounting to approximately fourfold 50 min. after spraying for the normal rabbits, and only twofold for the clipped animals. These increased rates of evaporative cooling after spraying persisted for about 125 min. for clipped rabbits and 175 min. for normal rabbits. Thereafter both curves return to their initial level for the environmental temperature of 103° F.

The surface temperature (Fig. 1, second section) was lower for the normal-coated rabbits, for about 275 min. after spraying, due to the greater surface evaporative moisture. There was, presumably, less loss from non-evaporative cooling.

The lower rectal temperature of the clipped rabbits reflects a greater immediate physiological response to spraying than in normal rabbits (Fig. 1, third section) for the first 75 min. after spraying. Thereafter less difference between the rectal temperature of clipped and normal rabbits was noted. A greater immediate benefit of the clipped rabbits to spraying is also shown in the respiration-rate (Fig. 1, bottom section), which, however, increases considerably after about 100 min.

Thus the physiological and physical responses of the clipped and normal rabbits to spraying are quite different. The more sensitive respiration-rate of the normal rabbits 145–300 min. after spraying demonstrates the value of wet fur, the action of which may be compared to that of a moist sponge-rubber blanket[1]. Following spraying, the rectal temperature and respiration-rate declined rapidly, though only temporarily (Fig. 1), particularly in clipped rabbits. The major cooling factor responsible for the decline in this case was undoubtedly the increase in evaporation, since in both clipped and normal rabbits their surface temperatures (radiometer reading) were below that of the environment.

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Validity of Motokawa's Technique for investigating Retinal Function

IN the past decade, Motokawa and co-workers have published in about sixty papers the results of a new technique for investigating retinal function. Gebhard[1] has published a review of this subject. Michaels[2] claims to have confirmed Motokawa's observations. Recently, Riggs *et al.*[3], and ourselves[4], working independently, have failed to confirm the most important of Motokawa's results. We believe that there are serious flaws in Motokawa's and Michaels' technique and that their experimental results may be artefactual.

Motokawa's technique is based on the curve of the change of threshold for electrical stimulation of the human eye after various types of light stimulation. The threshold is said to be minimal 1 sec. after red light, 2 sec. after white and green and 3 sec. after blue.

Both Motokawa and Michaels use very highly trained subjects and rather unusual psychophysical methods. Motokawa starts with a stimulus well above threshold and reduces the intensity in fairly large (10 per cent) steps until the suspected threshold is approached; the step size is then reduced (to about 1 per cent) and, when requested by the subject, a zero stimulus may be given for comparison. Michaels gives stimuli which are alternately above and below the threshold and approaches the threshold by a method of "successive approximations". Motokawa's method will certainly contain a source of error due to the greatly increased probability of finding a threshold when the large steps are changed to small ones. Michaels' results would be affected by the range of high and low intensities selected by the experimenter and by any sequential response habits, such as alternation, of the subject. The use of very highly trained subjects could set up unconscious subject-experimenter interaction, since the long training period seems to continue until the subjects give the 'correct' results. The consistency of threshold determinations by Motokawa's subjects is much better than that found for any other visual threshold. This in itself induces a feeling of uneasiness about the methods used.

Riggs *et al.* used a few trained subjects and attempted to reproduce Motokawa's technique as closely as possible. However, they had a rigidly defined threshold criterion, and they always reduced the intensity of the stimulus by a constant fraction. This meant that they gave, in a single run, rather more stimuli well above threshold than did Motokawa. Kohata *et al.*[5] have now claimed that the relatively intense stimuli used at the beginning of the run produce an after-effect which obscures the fall in the phosphene threshold and increases the variability of the measurement.

In our own experiments, we reduced the intensity of the stimulus by equal steps on a linear scale, and each intensity was presented only once. The sequence was stopped after the subject had failed to see three consecutive stimuli. A variety of threshold criteria was applied to our data (including taking the lowest positive response), but all gave essentially the same result. We used both naïve and experienced subjects and intervals between the light flash and the electrical stimulus of 1, 2, 3, 4 and 9 sec. In almost all our subjects the threshold was lowest in the 1-sec. condition and rose in an approximately exponential manner for the longer intervals no matter what the colour of the light flash, and even if the light were replaced by a bell. A very similar result was obtained also for an auditory difference threshold following a brief flash of light. We interpreted this effect as being due to the initial light or bell acting as a warning to the subject when to expect the stimulus. Following this interpretation we found that the phosphene threshold was completely unaffected by a preceding flash of light, provided a bell rang at a constant interval (1 sec.) before the electrical stimulus. This condition provided our most stringent test of Motokawa's basic observation, since it excluded the warning effect.

We have met the objection of Kohata *et al.* by repeating this experiment, but approaching the threshold from below, to exclude the possible after-effects of strong stimuli[4]. We did not find in either case any effect of the light on the electrical threshold, nor was there any marked change in the variability of the threshold measurements. The results of these experiments are shown in Table 1. It may be that only the lowest of the multiple thresholds which Motokawa claims to have observed will give the Motokawa phenomenon, and that Riggs *et al.* and ourselves may have observed higher and inappropriate thresholds. However, neither we nor Riggs *et al.* have been able to record multiple thresholds even in highly trained subjects.

Table 1

Interval between light and electrical stimulus (sec.)	1	2	3	4	9
Mean threshold when approached from above (log μamp.)	2·0535	2·0425	2·0629	2·0633	2·0728
Mean standard deviation	0·0628	0·0688	0·0641	0·0547	0·0737
Mean threshold when approached from below	2·1223	2·1422	2·1111	2·1255	2·1564
Mean standard deviation	0·0488	0·0299	0·0473	0·0682	0·0407

The number of subjects in the two conditions were 10 and 6 respectively. Each subject gave four estimates of each threshold. Unfortunately they were largely different subjects so that inter-subject variability cannot be ruled out in comparing the two sets of figures.

The most stringent test of the multiple threshold hypothesis is obviously to present a range of intensities near the threshold in random order (method of constant stimuli) and to see if the probability of seeing changes monotonically with the intensity or in a series of steps. Riggs *et al.*[3] and Howarth[6] have done this each using just one experienced subject and find that the probability of seeing changes in a 'normal' manner is 25–75 per cent between intensities of 110–145 μamp. There is no evidence of discontinuities in these curves.

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Passage of Phosphate through the Human Tooth

The first experiments using isotopes on teeth appear to be those of Hevesy *et al.*[1]. They administered phosphorus-32 to two human subjects, and to cats and rats, then found it in both dentine and enamel, attributing this finding to ion exchange. Later work with other isotopes (those of hydrogen, iodine, sodium, calcium, sulphur, carbon and potassium) showed that labelled ions may pass into tooth structure, more readily into dentine than into enamel. However, apart from Hevesy *et al.*, such work seems to have been restricted to animals (see ref. 2 for summary).

The present investigation describes work on the movement of phosphate through human teeth. The teeth have been tested as quickly as possible after removal from the mouth. The pulps of such teeth are known to respire[3]: $Q_{O_2} = 0 \cdot 31$, $RQ = 0 \cdot 93$.

Sound bicuspid teeth from subjects aged between 9 and 12 years were used, and, within 10–15 min. of removal, preparation of the teeth was completed. Crowns and roots were separated at the gum-line, cutting across the central root-canal; crowns were used. The bulk of the pulp was then removed from the pulp chamber leaving it lined by odontoblasts. Four methods of examination (the first three microscopical) were used for confirming the presence of odontoblasts *in situ* in such preparations: (1) de-pulped teeth were examined after staining with methylene blue, when odontoblasts have been seen *in situ*; (2) scrapings from pulp-chamber walls, spread on glass slides and stained with methylene blue, show odontoblasts; (3) de-pulped teeth were sectioned by microtome (after decalcification); examination of stained sections shows a ring of odontoblasts *in situ* lining the pulp-chamber; (4) de-pulped teeth were decalcified and examined by electron micrograph, when odontoblasts are seen *in situ*[4].

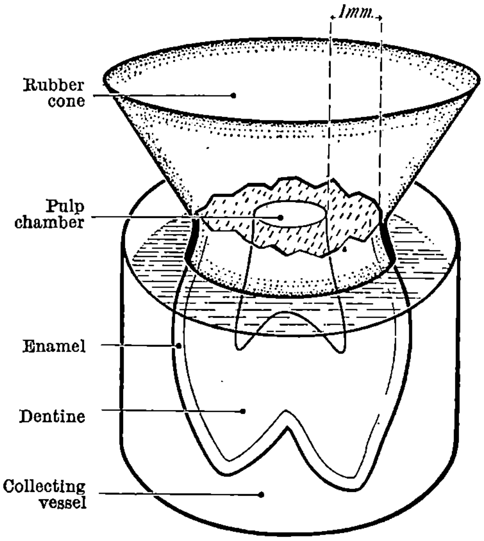

Fig. 1. Test of passage of phosphorus-32 through tooth. The labelled phosphate is added to the pulp chamber by a fine pipette. Later the tooth-crown is removed when the collected fluid is examined for radioactivity

On being de-pulped, a tooth crown intended for test was at once filled with Krebs–Ringer solution saturated with 95 per cent oxygen/5 per cent carbon dioxide at 37°. The tooth crown was then clamped in a rack, and by means of a pinion lowered into a small vessel of 1·6 ml. Krebs–Ringer at 37° so that the crown is submerged to the cut and exposed dentinal aspect, while this remains above the fluid level (Fig. 1). Splash is avoided by fitting a thin rubber cone with a 1-mm. hole in the apex,

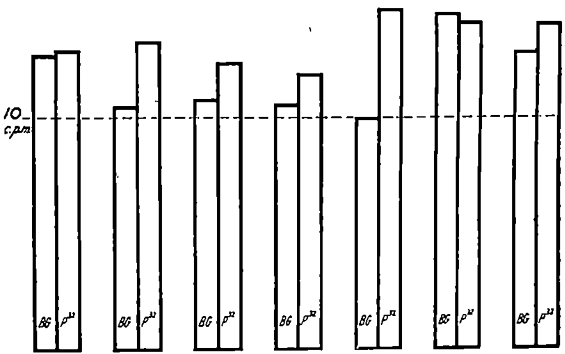

Fig. 2. Collected labelled phosphate and background compared on passage of labelled phosphate through each of seven teeth

Table 1. Results of Seven Tests

Experiment No.	$\overline{X}$ c.p.m. of collected phosphate	Background (c.p.m.)
1	12·9	12·7
2	13·3	10·5
3	12·4	10·8
4	11·9	10·6
5	14·7	10·0
6	14·1	14·5
7	14·2	12·9

around the tooth ; the cone extends about 1·5 cm. upwards. Creep is avoided by tying a thin, strong cotton thread tightly around and close to the base of the rubber cone.

Inorganic phosphate labelled with phosphorus-32 was now added to the Krebs–Ringer in the pulp-chamber. Every 5 min. the tooth-crown was racked up and a fresh vessel of Krebs–Ringer brought underneath, when the tooth-crown was lowered into it. The contents of the pulp-chamber were changed for fresh Krebs–Ringer about every 15 min. A test series usually comprises 20–24 such vessels, each of 1·6 ml. Krebs–Ringer, which collect any labelled phosphate that passes through the tooth. A test takes in all about 2 hr. The collections of fluid were dried and their radioactivity determined. Background counts were made before, during and after tests ; all counting periods were of 5 min. duration.

Passage of phosphorus-32 is seen to occur through human teeth when introduced in inorganic form, and results are shown in Table 1 and Fig. 2. In each case the c.p.m. shown is the mean of all the counts made on the one tooth collection. Actual counts of phosphorus-32 range from 9·4 to 62·6 c.p.m., while backgrounds ranged from 8·8 to 17·2 c.p.m. Combining the tests[5] gave a χ^2 of 51·7 on 14 d.f., which is highly significant, $P < 0{\cdot}001$.

In one test, phosphorus-32 was collected for the usual 5-min. period, c.p.m. being 14·2 ; a 30-min. collection was then made, which gave a mean of 15·4 c.p.m., reasonably close to the mean, and which may indicate a steady rate of passage. In each experiment, activity was determined of each of the vessels (about twenty) containing phosphorus-32 which had passed through the tooth ; the mean of each of these series is shown in Table 1 and Fig. 2.

Thus passage of phosphorus-32 through odontoblasts, dentine and enamel occurred in these tests on human teeth which are believed to be alive. However, such passage is limited in extent, any part played by the odontoblasts being unknown, though the use of suitable fluid media is aimed at keeping the cells viable. There are here two supporting observations to be kept in mind : (1) under suitable conditions tooth-pulp respires for some hours after removal of the tooth from the body ; (2) de-pulping of a tooth leaves odontoblasts *in situ*, each cell held in place by the long cell-process extending through the dentine as far as the enamel.

From the present work, enamel appears more permeable than has hitherto been supposed, though little comparable work has been found in the literature. This permeability may well be related to the inhomogeneity of enamel. Saunders *et al.*[6], and Symons describe two kinds of ameloblasts in developing enamel. During development, one kind of cell (a minority) shows special staining reactions and also a higher ribonuclease activity[7]. While completed enamel is devoid of cells, residual pathways of enzymic activity greater than the bulk of enamel could facilitate passage. Histochemical examination of enamel may yet provide evidence here. Autoradiography of human teeth through which phosphorus-32 has passed presents difficulties not completely overcome so far.

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Blocking Effect of Morphine on the Secretion of Thyroid-stimulating Hormone in Rats

The ability of morphine to inhibit certain pituitary functions has been established. The administration of morphine on the day of pro-œstrus resulted in the suppression of ovulation[1]. It is also possible by pre-treatment with morphine to prevent the secretion of adrenocorticotrophic hormone which follows an injection of adrenaline or other stress[2]. Sawyer *et al.*[3] have observed that morphine in doses sufficient to block the activation of the pituitary depressed the electrical activity of the central nervous system and also of the hypothalamic centres. The present experiment was designed to ascertain whether morphine is capable of blocking the secretion of the thyroid-stimulating hormone of the pituitary also.

Male rats of the Wistar strain, weight 140 gm., were used in this investigation. The right lobe of the thyroid and half the isthmus were removed under ether narcosis and the animals were divided into two groups. The control group received a daily dose of 0·1 ml. saline solution subcutaneously, while the other group received morphine in a daily dose of 2 mgm. per rat. After 14 days the rats were injected intraperitoneally with 25 μc. of iodine-131 and 24 hr. later were exsanguinated from the abdominal aorta. The following parameters were evaluated for the remainder of the thyroid : weight of the thyroid lobe, epithelial cell height, uptake of iodine-131 in the thyroid and percentage of iodine-131 which

Table 1

Group	Control (8 rats)		Treated (17 rats)	
Partial thyroidectomy	Before	After	Before	After
Weight of one lobe of thyroid (mgm./100 gm.)	4·05* ± 0·25	4·76 ± 0·40	4·32 ± 0·17	4·46 ± 0·16
Epithelial cell height (μ)	9·74 ± 0·32	11·27† ± 0·46	9·63 ± 0·26	9·27 ± 0·64
Thyroidal uptake of iodine-131 (per cent/100 mgm.)		61·24 ± 8·04		33·02‡ ± 5·53
Protein bound iodine-131 (per cent)		0·1313 ± 0·0114		0·0665‡ ± 0·0088

* Mean ± standard error. † $P < 0{\cdot}02$. ‡ $P < 0{\cdot}01$.

became bound during 24 hr. to proteins in serum.

The results are summarized in Table 1. No significant change was observed in the weight of the thyroid during the period. The average epithelial cell height in the control group, however, was significantly increased compared with the pre-operation values. In the animals treated with morphine there was no histological activation, as values before and after the operation remained unchanged. The thyroidal uptake of iodine-131 in the treated group was lower than in the controls. The difference is statistically significant ($P<0\cdot01$). The ability of the thyroid to bind iodine-131 to proteins was similarly lowered. The levels of protein-bound iodine-131 in serum were significantly lower than in the controls ($P < 0\cdot01$).

The increased epithelial cell height in the control group suggests that the removal of half the thyroid tissue itself stimulates increased secretion of thyroid stimulating hormone. The administration of morphine prevented the morphological activation and markedly inhibited the thyroidal uptake of iodine-131 as well as the formation of hormonal iodine. Since all these functions of the thyroid are regulated by the thyroid stimulating hormone, it may be supposed that morphine is also able to block the secretion of the latter.

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An Abnormal Type of Lymphocyte

DURING the past four years I have noticed in normally coloured smears of blood, bone marrow and spleen puncture from 9 cases of hepatosplenomegaly with strongly marked granulocytopenia and lymphocytosis, a considerable number of cells closely resembling lymphocytes but showing several special features. I have never observed this type of lymphocytes in lymphatic leukosis, which I have studied for many years from the cytological point of view, nor in any other disorder of the lymphatic system.

These cells prevailed in smears of bone marrow. In smears of spleen puncture there was a great mass of cells consisting almost exclusively of this type of lymphocytes.

Fig. 1 shows these cells in blood, bone marrow and spleen puncture. Their size corresponds to the size of a large lymphocyte. The nucleus, which is generally larger than the nucleus of an ordinary lymphocyte and usually central, is round, oblong or kidney-shaped. Sometimes there are two round or oblong nuclei partly covering each other. The nuclear membrane is sharply outlined. The chromatin is delicate and of a fine network, clearly differing from the compact masses of chromatin in normal lymphocytes. Sometimes, however, there are small chromatin blocks divided from each other by clear zones similar to the nuclear pattern of an ordinary lymphocyte. Sometimes there is a barely perceptible nucleolus corresponding in character and location to the nucleolus of a rather young lymphocyte. The amount of cytoplasm varies, it is bluish in colour, and meshy, usually fringed on the whole periphery. Sometimes, however, the amount is much reduced, as if used up, with only small shredded particles conserved around the nucleus. Occasionally azurophil granules closely resembling those of an ordinary lymphocyte can be seen.

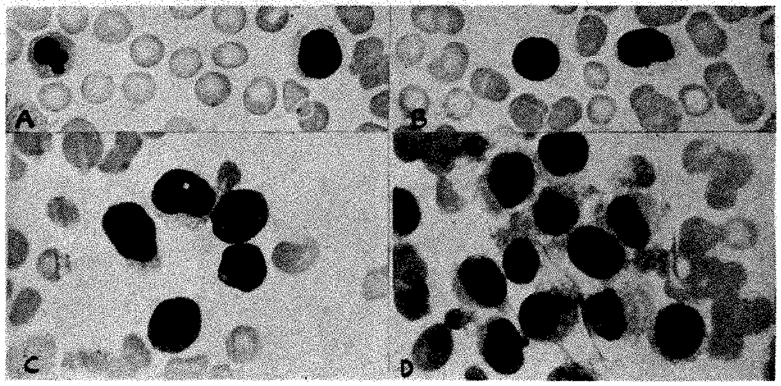

Fig. 1. *A*, Blood: a normoblast and abnormal lymphocyte with fringed cytoplasm *B*, blood: an abnormal lymphocyte with fringed cytoplasm and an ordinary lymphocyte *C*, bone marrow: abnormal lymphocytes with varying amounts of fringed cytoplasm *D*, spleen puncture: abnormal lymphocytes with fringed cytoplasm

At first I was not sure whether these cells, which show a negative peroxidase reaction and stain only faintly red with methyl green and pyronin, belonged to the series of lymphocytes or not. The phase-contrast microscope, however, revealed the same character and arrangement of mitochondria as in a mature lymphocyte.

In the first five cases, the clinical course was acute. All five findings at autopsy disclosed a rare type of tuberculosis known as "sepsis tuberculosa gravissima[1]", "areaktive generalisierte Tuberkulose[2]", or "septicémie tuberculeuse foudroyante maligne[3]". The remaining four patients are still under clinical control. The clinical course is acute in one case, subacute in one case, and chronic in the other two.

As a routine designation in the hæmograms I have called these lymphocytes 'Dozet cells', after the surname of the first patient in whom I noticed them.

So far I do not know whether this lymphocyte is characteristic of "sepsis tuberculosa gravissima". This question remains to be answered by further observation. Yet it is of interest to direct attention to this cellular element not only from the morphological point of view but also as a diagnostic difference with respect to lymphatic leukosis.

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Significance of the Adrenal Glands during the Post-natal Development of Thermoregulation in the Rat

THE range of environmental temperature within which rats maintain a stable body temperature increases with age[1-3]. It is therefore possible that the lack of effect of adrenalectomy on thermoregulation before the sixteenth day after birth[4-6] is the result of the relatively very low environmental temperature used (5° C.) at which thermoregulation fails in very young rats. In order to test this hypothesis rats were adrenalectomized under cold anæsthesia on the fourth day after birth. One, two and three days after operation their power of thermoregulation was tested as follows: rectal temperature was taken with a thermocouple immediately before the experiment after removal of infant rats from the nest. The animals were then placed in a Bargeton–Krumm–Heller[3] respirometer and oxygen consumption was measured at an environmental temperature of 35° C. for 30 min. Then the external temperature was changed to 30° C. at which readings were continued for a further 60 min. Finally, the rectal temperature was again taken.

It was found that rectal temperatures of operated animals always dropped to significantly lower values than those of sham operated controls. Oxygen consumption always rose when the environmental temperature was lowered to 30° C. If cortisone was administered for three days between the fourth and seventh day after birth to adrenalectomized rats via the intramuscular route (0·5 mgm./ml. saline; 1 ml./100 gm. body-weight) the effect of adrenalectomy was nullified. Rectal temperatures no longer decrease to such an extent at 30° C. external temperature and oxygen consumption at 35° C. is increased. If control animals are treated in the same way oxygen consumption is increased significantly and rectal temperatures do not fall at all.

Thus on the third day after adrenalectomy the rectal temperature drops from 33·5 ± 0·481° to 31·9 ± 0·298°, while in similarly treated animals receiving cortisone the final temperature is 33·3 ± 0·466°. In control animals receiving cortisone rectal temperature remains at 34·6 ± 0·274°. Oxygen consumption in normal infant rats after treatment with cortisone is raised from 41 ± 3·33 to 60 ± 1·41 ml./100 gm./10 min. at 35° C. surrounding temperature and to even higher values at 30° C.

The above results show that the adrenal glands participate in the maintenance of body temperature in five-day-old rats. On the other hand, they evidently are not indispensable for the increase in oxygen consumption which occurs when the external temperature is changed from 35° to 30° C. The negative results obtained by previous workers[4-6] are probably due to the low environmental temperature used.

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'Gastric Para-Mucus'

WHEN an aqueous solution of either iodoacetamide or N-ethyl maleimide, in suitable concentration, is applied topically to the mucosa of a canine Heidenhain pouch half an hour before the injection of histamine, the hydrochloric acid secretory activity of the pouch is inhibited completely, though reversibly[1]. This inhibitory action may be presumed to involve a competitive inhibition of one or more enzymes within the parietal cells, though Davenport's assumption[2] that these enzymes contain sulphydryl still awaits confirmation. Instead of the water-like solution of hydrochloric acid ordinarily obtained in response to histamine stimulation, the pouch now pours out a mucinous cell-free liquid of *p*H greater than 7, and sometimes even as high as ·8. Flow of this viscous liquid continues for many hours after drainage of the iodoacetamide or N-ethyl maleimide solution from the pouch, whereas the acid-secretory response to subcutaneously administered histamine usually lasts for no more than 1–1½ hr. Further evidence that this mucinous material bears no relation to the parietal secretion is given by the fact that the same response is obtained when the instillation of iodoacetamide or N-ethyl maleimide into the pouch is not followed by the subcutaneous administration of histamine.

This viscous fluid has the pale yellow or tawny appearance of blood plasma, even when it contains no visible blood, but its acid-neutralizing power, and its concentrations (after hydrolysis) of total solids, reducing substance, hexosamine, and total nitrogen are generally less than those for dog serum. Rather, these divers characteristics, together with its viscosity, suggest that we are dealing here with some kind of a mucinous secretion—different from the true gastric mucus obtained in response to topically applied acetylcholine[3], and certainly bearing no resemblance to the cellular variety of mucus formed in response to treatment of the pouch mucosa with eugenol[4]. It may be a modified form of mucus secretion proper, elaborated by the columnar epithelium of the mucosa, or it may be the hypothetical mucoid secretion of earlier investigators (sometimes identified with the dilution secretion or *Verdünnungssekretion*[5]); but as yet there is no sound evidence to support either such physiological characterization of this material. In view of this lack, and until such time as a definitive statement of its origin is possible, I propose to designate this fluid gastric 'para-mucus', because the Greek prefix (παρα) expresses (according to the Oxford English Dictionary) "faulty, irregular, improper, alteration, simulation, etc.".

About ten years ago, we reported from this laboratory that a 1 per cent aqueous suspension of mustard oil (allyl isothiocyanate) applied topically to the gastric mucosa, is a very poor mucigogue by comparison with irritants like an emulsion of clove oil, distilled water saturated with ethyl ether, etc., as evidenced by a persistently low viscosity, and probable small mucin content shown in metachromatically stained smears. Chemical analyses were not performed at that time. On the contrary, "the high volume, rate, and duration of secretion; the resemblance in colour of early specimens to blood plasma; the almost invariable appearance of fresh blood, increasing in intensity with progress of the experiment—all these, together with the observations on viscosity, opacity, etc., support the view that the 'secretion' is a transudate or exudate"[6].

It seems altogether possible that this material induced by mustard oil is essentially of the same nature as the gastric para-mucus evoked by iodoacetamide and N-ethyl maleimide, the presence of blood in the former being a result only of the great 'irritant' character of the allyl isothiocyanate in 1 per cent concentration. A fluid of similar appearance has been obtained from gastric pouches also following the topical application of 'Phenergan' (4 mgm./ml.) and, occasionally, 'Nupercaine'[7]. Whether these various mucinous fluids are identical with para-mucus obtained after the mucosa has been treated with iodoacetamide and N-ethyl maleimide can be decided only by chemical analysis. The results of electrophoretic, chromatographic and other chemical studies will be reported shortly.

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Distribution of Norepinephrine in the Heart

THE concentrations of norepinephrine found by various investigators in the hearts of different animal species are summarized in the 1956 monograph by von Euler[1]. These values range from 0·3 to 1·0 μgm. per gm. of heart tissue.

Recent reports, however, indicate that the heart norepinephrine-levels may be even higher than those found in the earlier experiments. Measurement of the levels in rabbit heart by a simple and sensitive spectrofluorometric method[2] gave an average value of 2 μgm. per gm., a considerably higher level than those reported earlier, but agreeing with the levels reported recently by Bertler, Carlsson and Rosengren[3]. Raab and Gigee[4] and von Euler[5] have reported levels of about 0·2 μgm. per gm. in dog heart. Levels in dog heart as measured by the spectrofluorometric technique[2], however, showed a concentration of about 2 μgm. per gm.

The high concentration of norepinephrine in heart brings up the question of its function in this organ. It was thought that study of the distribution of the amine in various parts of the heart might shed light on this question, since, to our knowledge, no distribution studies have been carried out on this organ.

Dogs of both sexes were killed by intravenous injection of pentobarbitone or by exsanguination. The hearts were removed immediately, dissected, and the various parts analysed for norepinephrine and epinephrine by the spectrofluorometric method described elsewhere[2].

Little epinephrine was found in any portion of the heart, the levels being less than 10 per cent of the norepinephrine concentration. Norepinephrine-levels are shown in Table 1. The average concentration in the atria was 2·7 μgm. per gm. It is noteworthy that the concentration in the portion of the right atrium which includes the sinoauricular node was not significantly different from that in other atrial samples. The level throughout the ventricular muscle was quite uniform—about 1·5 μgm. per gm. The endocardium may be devoid of norepinephrine since the valves, which are endocardial structures, lack norepinephrine. Furthermore, removal of endocardium and epicardium from ventricular samples did not significantly alter the levels found.

Table 1. DISTRIBUTION OF NOREPINEPHRINE IN NORMAL DOG HEART

Part of heart	No. of hearts	μgm. per gm.		
		Mean value of norepinephrine concentration	Standard error of mean	Range of values
Atria				
Atria, pooled	6	3·1	± 0·3	1·9–3·6
Right auricular appendage	4	2·4	± 0·4	1·9–3·5
Right atrium without appendage	2	2·7	± 1·0	1·7, 3·7
Portion containing sinoauricular node	4	2·3	± 0·5	0·8–3·1
Left auricular appendage	4	2·8	± 0·3	2·2–3·7
Left atrium without appendage	2	2·3	± 0·9	1·4, 3·2
	22 determinations			
(Mean of 22 determinations is 2·7 μgm. per gm.)				
Ventricles				
Apex of heart	11	1·3	± 0·2	0·7–2·9
Right ventricle	4	1·4	± 0·3	0·8–2·1
Right papillary muscles	4	1·5	± 0·3	0·7–2·2
Portion containing atrioventricular node	4	1·4	± 0·1	1·1–1·6
Left ventricle	4	1·3	± 0·1	1·1–1·6
Left ventricle, epicardium and endocardium removed	2	1·8	± 0·6	1·2, 2·4
Left papillary muscles	4	1·6	± 0·4	0·9–2·8
Septum	10	1·6	± 0·2	0·9–3·4
	43 determinations			
(Mean of 43 determinations is 1·5 μgm. per gm.)				
Valves of heart				
Semilunar valves	2	0	0	0
Mitral valve	2	0	0	0
Tricuspid valve	2	0·1	±0·1	0, 0·2
Major blood vessels				
Aortic arch	4	1·3	± 0·2	0·9–1·7
Pulmonary artery	3	1·1	± 0·3	0·8–1·6
Superior vena cava	1	0	—	0

The average norepinephrine concentration in the atria was significantly higher ($P < 0·001$) than in ventricles, the ratio being 1·8 : 1.

The concentrations of norepinephrine in the aortic arch and in the pulmonary artery were almost as high as in ventricular muscle, while the superior vena cava was apparently devoid of norepinephrine.

Since sympathetic denervation has been shown to reduce markedly the norepinephrine content of the heart[1], von Euler and other investigators concluded that the norepinephrine in the heart is associated with adrenergic nerve endings. Since stimulation of sympathetic nerves affects the heart-rate profoundly, it is perhaps not surprising that the atrial concentration of norepinephrine is significantly greater than the ventricular concentration.

Anatomical findings[6–8] and studies on the effect of electrical stimulation of sympathetic cardiac nerves on ventricular contractile force[9,10] suggest, however, that adrenergic nerve endings are distributed throughout the ventricles as well as the atria, a conclusion which is supported by the high concentrations of norepinephrine found throughout the ventricular muscle.

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Polymorphism in the β-Globulins of Sheep

POLYMORPHISM in the β-globulins of cattle, giving five phenotypes[1,2], and in humans giving three phenotypes (Smithies, O., personal communication), has been described. The present communication concerns polymorphism in the β-globulins of the serum of sheep, giving to date eight phenotypes. The phenotypes are indicated diagrammatically in Fig. 1. The conditions for obtaining these serum protein differences by starch gel electrophoresis are similar to those described for cattle sera[1] except that 5–6 hr. is required to achieve adequate resolution of the β-globulins; in this time the trailing edge of the albumin zone migrates 6–7 cm.

It seems probable that the greatest degree of polymorphism in the serum proteins of mammals will be found in the β-globulins, notwithstanding the fact that serum protein polymorphism was first detected by Smithies in the haptoglobins of humans[3]. A rational nomenclature for the β-globulin phenotypes, sufficiently flexible to cover analogous systems in other animals, is therefore necessary. It is suggested that the proteins contributing to each β-globulin polymorphic system be designated by letters in sequence starting at the β-globulin nearest the albumin, that is, the one with greatest mobility; an intensely staining zone could be designated by a capital letter, a less intensely staining zone by a lower case letter, and the absence of the zone by omission of the letter. Such a phenotype nomenclature which makes no implications about the genotypes, is shown for the sheep β-globulin types in Fig. 1.

The distribution of the eight phenotypes in sheep found by examination of 118 abattoir samples (mixed breeds) was: 17 BcdE, 18 BcD, 13 BCd, 5 B, 2 bCdE, 45 bCD, 3 bCd and 15 cD.

The nature of the zones contributing to the one-dimensional starch gel electrophoretic patterns in sheep was determined by two-dimensional agar-starch gel electrophoresis as used for cattle[1] (Fig. 2).

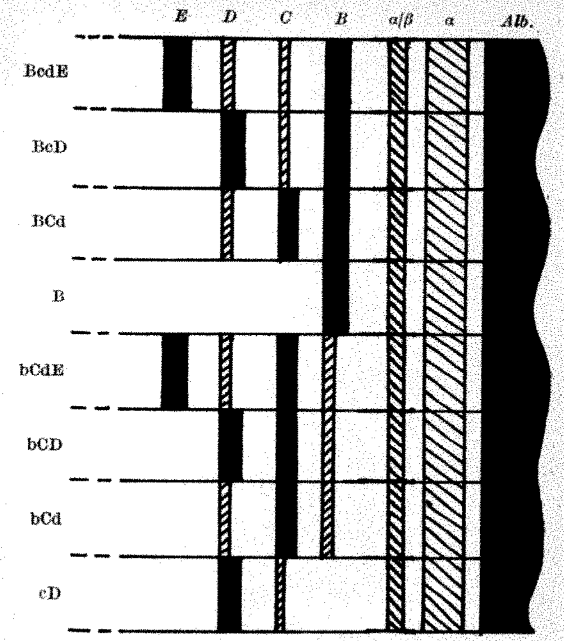

Fig. 1. Diagrammatic representation of β-globulin polymorphism in sheep sera by one-dimensional starch gel electrophoresis. Only a portion of the anodic side of the gel is shown. *B*, *C*, *D* and *E*, β-globulins; *α/β*, zone consisting of β-globulin *A* plus some α-globulin components; *α*, α-globulin components; *alb.*, part of albumin zone. Solid bands, intense staining; cross-hatched, medium or faint staining. For phenotype code, see text

It will be seen that the β-globulins coincide with some of the α-globulin components when the sera are run in starch gel only. Fortunately the α-globulins do not stain sufficiently intensely to obscure the β-globulin pattern, although where β-globulin *B* is absent, α-globulin zones 10 and 11 (Fig. 2) can be seen as background staining. Usually the α-globulin zone 9 (Fig. 2) can be seen as a faint poorly defined zone just behind β-globulin *E*. No 'thread proteins' such as those found in cattle[1] or pigs[4] were observed in sheep.

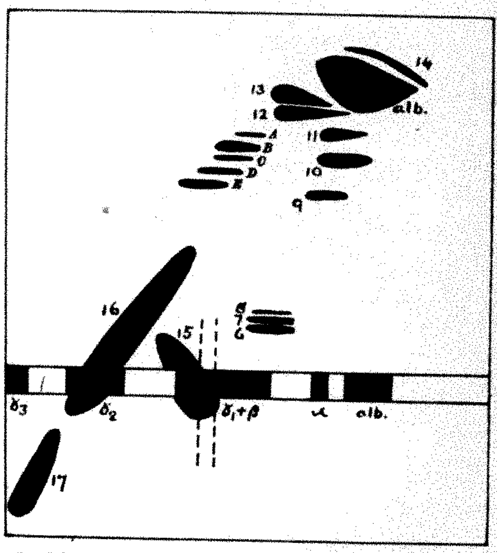

Fig. 2. Diagram prepared after two-dimensional agar/starch gel electrophoresis of type BcdE serum. Broken lines indicate position of original sample insertion in agar. *Alb.*, albumin; *α*, α-globulin (zones 9–13); *β*, β-globulin (zones *A*, *B*, *C*, *D*, *E*); γ_1, γ_2, γ_3, γ-globulins (zones 15, 16 and 17); zones 6, 7, 8, 'slow α-globulins'; zone 14, pre-albumin

So far insufficient mating data have been obtained to postulate genetic control, but it seems probable, by analogy with cattle and human results, that the various phenotypes will prove to be inherited.

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Giant Compound Hair Follicles in the Skin of the Rabbit

THE hair of the rabbit grows from a compound follicle[1] which contains one large outercoat hair, a few smaller outercoat hairs of intermediate morphology and numerous fine undercoat hairs. The true compound nature of the follicle is best seen during the growth-phase, when the follicles extend into the dermis forming distinctive groups at their deepest level (Fig. 1). As the hair shafts reach the surface the compound follicle is subdivided by fibrous septa into smaller groups which surround the large outercoat hair. Each of these smaller groups of undercoat hairs penetrate the skin through a common follicle opening, whereas the outercoat hair has a separate opening.

If the hair is plucked out in the quiescent phase it can easily be separated into tufts that correspond to the pattern of the compound follicle (Fig. 2). This act of plucking out the hair initiates its regrowth cycle, and in the pigmented rabbit evidence of regeneration is first observed on about the seventh day, when the skin begins to darken as a result of the formation of pigment in developing follicles[2]. Between this period and the time the hair penetrates the skin on about the fourteenth day, the skin surface shows small discrete elevations uniformly distributed about 0·5–1·0 cm. apart (Fig. 3). Serial sections through the skin at this time show that these elevations are caused by giant compound follicles (Fig. 1) which contain several outercoat hairs and many more undercoat hairs than the normal follicle. In the chinchilla rabbit the central hair is large, thick and uniformly black in contrast to the banded black-and-white outercoat hair of the normal follicle.

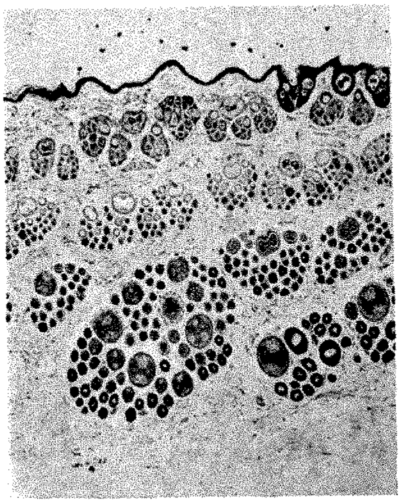

Fig. 1. Section, cut across the slope of the hair, of rabbit skin in the twelfth day of the regrowth cycle showing one giant follicle and several normal compound follicles. The subdivision of the follicle with the single isolated outercoat hair is seen as the hair shafts near the surface. (× *c.* 30)

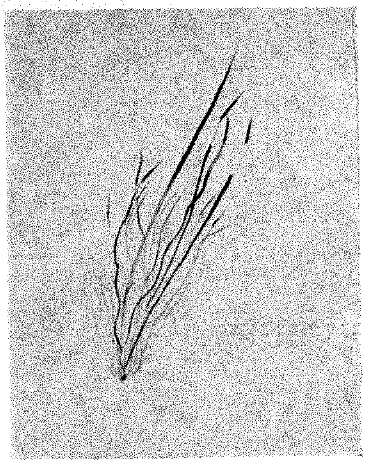

Fig. 2. Drawing of a tuft of rabbit hair showing the large black outercoat hair

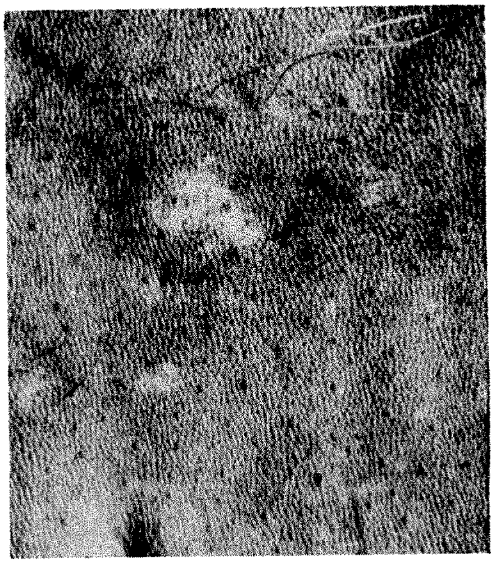

Fig. 3. Photograph of the skin of the rabbit on the twelfth day of the cycle showing nodular elevations caused by the giant follicles. (× 1½)

These giant follicles have always been seen in the chinchilla rabbit when the hair is regenerating, and observations indicate that they are present in many other types of rabbit, including the agouti, albino, rex and angora strains.

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Capacitation of Mammalian Spermatozoa

It has been previously shown that spermatozoa of the rat and rabbit require to undergo some form of physiological preparation within the female reproductive tract before they are capable of fertilizing eggs[1]. This preparatory process, known as capacitation, has hitherto lacked more precise description.

Recently, we have obtained evidence that the acrosome is removed from the spermatozoon head before the entry of the spermatozoon into the egg. Modification and loss of the acrosome have been observed in living spermatozoa of the golden hamster, guinea pig and Libyan jird recovered in the fluid from the Fallopian tubes and in the cumulus oophorus. Further, spermatozoa found embedded in the zona pellucida of guinea pig and golden hamster eggs, lying free within the perivitelline space of golden hamster and jird eggs, and entering the vitellus of golden hamster and Chinese hamster eggs all lacked their acrosomes. In no instance was a spermatozoon that retained its acrosome found within any part of an egg. These and other observations indicate that, in the normal course of events, removal of the acrosome probably occurs at the surface of the zona pellucida.

Clearly the acrosome is not involved in the penetration of the egg, and its function is probably restricted to assisting the passage of the spermatozoon through the cumulus oophorus. Loss of the acrosome exposes a specialized region of the nuclear membrane, the perforatorium, and we believe that this is the organelle that enables the spermatozoon to make its way through the zona pellucida.

We therefore conclude that acrosome removal is a prerequisite of fertilization, and that the induction of those changes that lead to detachment of the acrosome represents capacitation.

A preliminary report of these investigations was presented at the ninth International Congress for Cell Biology, 1957; a detailed account is being submitted for publication elsewhere.

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Effect of Gibberellic Acid on Fruit Set and Berry Enlargement in Seedless Grapes of *Vitis vinifera*

Although an increased set of fruit as a result of gibberellic acid or related compounds has been observed in tomatoes[1], there are insufficient data concerning the effect of this chemical on enlargement of fruit in any plant.

In several experiments performed at Davis, California, in 1957, an increase in fruit set and/or fruit size resulted from treatment with gibberellic acid. The potassium salt of gibberellic acid, supplied by Merck and Co., contained about 80 per cent active ingredient. 'Dreft' was used for a wetting agent. The procedure for determining average weight per berry, percentage of total soluble solids, and percentage of acid has been described previously[2].

Girdling (ringing) has long been used to induce fruit set and enlargement in Black Corinth grapes, although in recent years it has been partially replaced by applications of 4-chlorophenoxyacetic acid[3,4]. In one experiment flowering clusters on mature Black Corinth vines were dipped momentarily on May 31 into solutions containing gibberellic acid at 0, 1, 5, 20, 100 or 500 p.p.m., ten replicates per treatment. When the fruit was collected on July 30 the regulator at 1 p.p.m. had resulted in a fairly good set of large berries, but the clusters were straggly owing to occurrence of small undeveloped berries. The compound in the range 5–500 p.p.m. resulted in an excellent set of enlarged berries (Table 1). Heavier clusters and elongated berries resulted from higher concentrations of the compound. The percentage of total soluble solids was usually comparable even though the treated clusters were heavier. The regulator decreased the percentage of total acid.

Table 1. Effect of Gibberellic Acid on Yield and Composition of Black Corinth and Thompson Seedless Grapes

Treatment, concentration (p.p.m.)	Av. wt./ cluster (gm.)	Av. wt./ berry (gm.)	Total soluble solids (per cent)	Acid (per cent)
Black Corinth				
0 (not girdled)	91·6	0·26	23·4	1·75
1 (not girdled)	206·5	0·47	23·6	1·50
5 (not girdled)	258·0	0·58	23·9	1·29
20 (not girdled)	366·6	0·78	21·3	1·34
100 (not girdled)	391·3	0·99	23·0	1·26
500 (not girdled)	500·7	1·31	22·6	1·30
Thompson Seedless				
0 (not girdled)	0·66	1·59	22·4	0·79
5 (not girdled)	0·95	1·91	23·2	0·73
20 (not girdled)	1·46	2·71	18·9	0·83
50 (not girdled)	2·15	3·15	17·6	0·94
0 (girdled)	1·10	2·26	23·0	0·74

Girdling has been shown to increase size of berry in Thompson Seedless[2]. On June 11, after berry set was completed (berry shatter stage), mature, ungirdled Thompson Seedless vines were heavily sprayed with solutions containing gibberellic acid at 5, 20 and 50 p.p.m., four vines per treatment. One group of vines was ungirdled and unsprayed, and another girdled but unsprayed. Fruit was harvested on August 26. The weight of clusters and berries sprayed with the regulator at 5 p.p.m. was greater than those from unsprayed and ungirdled vines, but smaller than those from unsprayed but girdled vines (Table 1). Very large clusters and berries resulted from treatment with 20 and 50 p.p.m. The percentage of total soluble solids was lowest and percentage of acid highest in fruit sprayed with compound at 50 p.p.m., probably as a result of the greater weight of fruit in this treatment.

Elongation of stems and hastening of flowering, previously reported for other plants[1,5] occurred in grapes. Accelerated coloration in red grapes, and in ripening, occurred in many experiments not reported here.

It has been suggested that levels of naturally occurring auxins are of importance in fruit set and enlargement[6,7]. Perhaps naturally occurring gibberellic acid or related compounds may be concerned in fruit set and enlargement on grapes under discussion herein. Berry size of varieties with seeded berries was not increased appreciably. Perhaps seeds produce sufficient quantities of the compound to result in almost maximum berry enlargement. The occurrence of 'gibberellin-like' substances in many seeds[8] suggests an investigation be made on the regulator in grape seeds.

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Effects of Kinetin on Cell Division in *Paramecium caudatum*

Kinetin (6-furfurylaminopurine) has been reported to stimulate cell division in excised tobacco pith tissues[1], in onion root tips[2] and, most recently, in sarcoma tumour cells[3]. Lettré and Endo[4] found no changes in cell division or tumour growth with kinetin in cultures of normal or malignant human and animal cells. They concluded that these tissues either did not possess a kinetin-like trigger for cell division, or contained optimal levels of such a substance.

This communication presents some of the findings on changes in rates of division induced by kinetin in a free-living organism, *Paramecium caudatum*.

Stock cultures of *P. caudatum* (obtained from the Hebrew University Department of Zoology) were maintained as clones on hay infusion medium at 25° C. in the dark. Families were begun in depression slides containing a single animal in two drops of hay infusion plus four drops of sterilized tap water. Treatment slides contained hay infusion with kinetin (kindly supplied by Prof. F. Skoog), dissolved in sterilized tap water and added to the hay infusion at the time of treatment. All slides—treatments and controls—had equal proportions of infusion and water and were adjusted to pH 6·5–6·8.

The findings reported here were obtained from tests with isolation cultures using the following procedure. A single individual was isolated in a depression slide. After two divisions, the four resulting animals were transferred each to a new slide—one control and three different concentrations of kinetin solution. Thus each experimental observation was matched by its own control, originated from the same individual. The number of divisions per slide was recorded every 24 hr., after which two animals were transferred from each slide to new medium. Readings were made for three days in succession: at the end of these the experiment was discontinued and a new set begun. Mean division-rates of treatments and controls were compared and their differences tested for significance by Student's t test for the mean of differences.

Table 1. Comparisons of Division-Rates of *Paramecium caudatum* in Control Medium and in Various Concentrations of Kinetin

Concentration of kinetin (mgm./l.)	No. of 24-hr. period comparisons	Mean No. of divisions/24 hr.		Proportion $\bar{e}/\bar{c}$	$t\bar{c} - \bar{e}$
		Control $\bar{c}$	Kinetin $\bar{e}$		
0·25	60	1·32	1·48	1·12	−1·57
0·5	18	1·24	1·72	1·39	−2·71*
1·0	24	1·42	2·06	1·45	−3·20†
1·5	18	1·24	2·20	1·77	−3·88†
2·0	24	1·42	1·99	1·40	−2·29*
2·5	18	1·24	1·91	1·53	−2·41*
3·0	24	1·42	1·86	1·31	−2·35*
4·0	21	2·36	2·50	1·06	−0·42
10·0	53	1·60	1·25	0·78	3·34†
17·0	35	2·14	0·94	0·44	6·53†
33·0	30	2·03	0·89	0·44	6·80†

* Significant at 0·05 level. † Significant at 0·01 level.

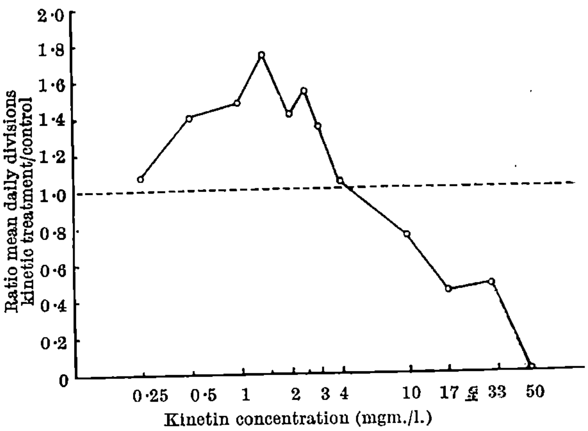

Fig. 1. Variations in division-rate of *P. caudatum* with changing kinetin concentration

In order to test a possible effect of the kinetin on the bacterial populations of the culture media during the 24-hr. periods, hay infusion samples—with and without kinetin—were tested on agar and in bouillon. No gross changes were observed in either size or constitution of the bacterial populations.

Table 1 shows appreciable changes in mean daily division frequencies (for 3-day periods) in cultures containing a variety of concentrations of kinetin. 100 mgm./l. kinetin caused death of all *Paramecia* within ½ hr., while 50 mgm./l. blocked division completely without being lethal. (The animal remained alive during the 3-day period but did not divide.) Between 33 mgm./l. and 0·25 mgm./l. we found a sensitive range of responses from significant elevations to severe inhibition of cell multiplication (Fig. 1). As the dose of kinetin decreased from 33 to 4 mgm./l., the ratio of experimental to control divisions rose from 0·44 to approximately 1. The ratio rose steadily above 1 as the concentration dropped from 4 to 1·5 mgm./l., and fell steadily back to 1 as the concentration dropped from 1·5 to 0·25. It is interesting to note that the concentrations found to be most active in our material, as well as in onion and tumour cells[2,3], have all been of the same order of magnitude.

Tests are under way to determine the time of onset of the effect of kinetin during the life-cycle of the protozoan cell.

We are indebted to Miss Edna Naim, Mr. Y. Ginzburg, Mr. Y. Koffler and Prof. L. Guttman for their assistance and advice during various phases of the investigation.

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Chromosomes and Chromocentres in the Nuclei of *Halidrys siliquosa* (L.) Lyngb.

DIVIDING nuclei in the apical groove of *Halidrys siliquosa* show large numbers of small chromosomes, and at metaphase more than 55 have been counted (Fig. 1*c*, *d*, *e*). Metaphase plates at the first three divisions in developing antheridia have given counts of the order of 30 chromosomes (Fig. 1*b*), and one at the first division of the oogonium of approximately 28 chromosomes. This indicates that the thallus of *H. siliquosa* is diploid with meiosis at the first division of the gametangia, as is usual in the Fucales[1].

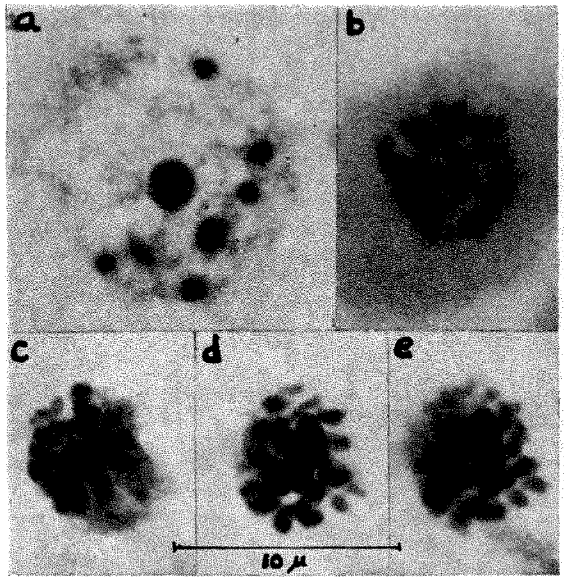

Fig. 1. Photomicrographs of nuclei of *Halidrys siliquosa*, all to the same scale. *a*, Acetocarmine smear of a nucleus of a medullary cell showing the nucleolus and seven chromocentres; *b*, Feulgen-stained metaphase plate at the first division of the antheridial initial: this plate gave a count of 34; *c*, *d*, *e*, three optical planes of a metaphase plate of a dividing meristoderm cell in the apical groove. This plate gave a count of 55 chromosomes plus several more the number of which could not be accurately determined, lying in a higher plane. The illustration was prepared by W. H. Smithson from untouched negatives

The resting nuclei of *H. siliquosa* contain several Feulgen-positive granules about 1μ in diameter (Fig. 1*a*) and slightly larger than the chromosomes, as has been described by le Touzé[2] and Roy[3]. The number of granules varies from cell to cell but is usually between 2 and 9, whether the cell is diploid, as in the somatic cells, or haploid, as in the developing gametangia. Such variability in number and independence of chromosome complement is a characteristic of chromocentres[4]. It seems possible that the eight chromosomes recorded by Moss and Elliot[1] in both somatic and reproductive cells of *H. siliquosa* correspond to these bodies, which are probably chromocentres.

A more detailed account of this work will appear elsewhere[5].

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Cytology of Indian Species of *Artemesia*

CONSIDERABLE cytological work has been done on the genus *Artemesia* in North America[1,2], Japan[3] and Europe (cf. Darlington and Wylie[4]); but so far nothing has been known about the Indian species. The genus, besides being of medicinal importance, is extremely interesting from the cytotaxonomic and cytogeographic points of view. It was therefore thought worth while to work out the available species of the genus. Following the conventional taxonomic treatment we have worked out 11 species out of 27 reported by Hooker[5] from the Indian subcontinent. In the present investigation the various species have been primarily sampled from the north-western Himalayas; but material from the eastern Himalayas and other areas has also been studied. This has been supplemented with the study of herbarium specimens. Most of the species have been worked out for the first time. In addition to the 11 Indian species, the chromosome number in *A. vulgaris* Linn. from Germany has also been investigated. The chromosome numbers are given in Table 1.

Table 1

Species	Chromosome No.	
	n	2*n*
A. scoparia Waldst. and Kit.	8	16
A. absinthium Linn.	9	—
A. glauca Pall.	18	36
A. laciniata Willd.	—	18
A. maritima Linn. (Kashmir)	18	—
A. maritima Linn. (Japan)	27	—
A. parviflora Roxb.	9	18
A. roxburghiana Bess.	9	18
A. roxburghiana Bess.	18	36
A. tournefortiana Reichb.	9	18
A. vestita Wall.	9	18
A. vulgaris Linn. (Germany)	—	16
A. vulgaris Linn. (India)	18	—
A. vulgaris Linn. (India)	27	54
A. species	9	—

One of the interesting aspects of this study is the cytological situation in Indian *A. vulgaris*. In this connexion, it is pertinent to mention that *A. vulgaris* Linn. was originally described from northern Europe[6]. The chromosome number of this species ($2n = 18$) was worked out by Weinedel as early as 1928 (cf. Darlington and Wylie[4]). In view of all the subsequent work it is reasonable to revise the above number to $2n = 16$ [1,7-10]. This is fully borne out by the present investigation since we also found 16 chromosomes in root-tips from seeds collected at Kitzeberg near Kiel (Germany) and sent to us by Prof. H. D. Wulff. This is a significant point, since Indian *A. vulgaris* has been compounded from the basic number 9 and not 8 as expected on the basis of true *A. vulgaris* from Europe. Evidently the former taxon has to be appropriately evaluated taxonomically.

The Indian *A. vulgaris* complex is also interesting phytogeographically. We have found only diploids in the innermost Himalayas, in regions which have undergone a period of glaciation, and often at such places glaciers are still in existence. In the middle Himalayas diploids are at the tops of mountains and perhaps extend farther down. The tetraploid forms occur only at lower altitudes and extend also into the valleys below. In the outer Himalayas the diploids of this complex are either rare or have not been found so far, whereas tetraploid forms are preponderant. The hexaploid forms appear at lower altitudes and have also been found in valleys between the outer Himalayan foothills and the Siwalik Ranges. Furthermore, hexaploid has also moved down to the Nilgiri Hills (south India) in all probability through Mount Abu. From a study of the herbarium specimens we have reason to believe that hexaploid *A. vulgaris* also occurs in Ceylon, and on the eastern side it has also moved down to the Martaban Mountains in Burma. This is an interesting situation and will be further elaborated later.

A. maritima Linn. is a widespread species. It is distributed from the coasts of Europe and extends throughout saline tracts in north Asia[5]. The species has been reported as diploid from Europe[11] and as hexaploid from Japan[3]. We have confirmed the later report from plants at Yarikhah Drug Farm (Tangmarg, Kashmir) which were raised from seeds imported from Japan. We have, however, found the indigenous plants of the species at Gurez (Kashmir) to be tetraploid.

Fuller discussion will be published elsewhere.

We are grateful to Col. R. N. Chopra and Dr. I. Chopra (D.R.L., Jammu) and Prof. P. N. Mehra (Panjab University) for their encouragement and for affording us facilities to carry on this investigation. Furthermore, we are indebted to Prof. H. D. Wulff (Saarbrucken, Germany) for sending seeds of European *A. vulgaris*.

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Chromosome Size in *Lolium temulentum* and *L. perenne*

Morphologically the grasses *Lolium perenne* and *L. temulentum* are markedly dissimilar and easily distinguished from one another. They differ also in habit and in their breeding system; the former is perennial and outbreeding, while the latter is an annual and inbreeding. Despite their divergencies in form and habit, the species can, however, be crossed, and hybrid plants are readily grown from seed produced when *L. perenne* is used as female parent. This was demonstrated by Jenkin[1], who has described the hybrids in detail.

A cytological investigation by Thomas[2] has revealed considerable genetic variation in the size of chromosomes. When the chromosomes were compared in order of size, those of *L. temulentum* were found to be approximately a third longer than those of *L. perenne*. In seeking to explain this variation there are two possibilities to consider. Either there are differences in the amount of genetic material in the chromosomes of the two species or there are genotypic differences between them which affect chromosome size—such as reported between a number of species[3], and even between individuals within a species[4]. Comparisons were therefore made between the parent species and their hybrids to decide which of these possible causes applies in this instance. This was done by comparing the lengths of particular chromosomes in the nuclei of the parent species with their lengths in hybrid nuclei. The measurements were made in sectioned preparations of root tips which had not been subjected to pre-treatment of any kind that would affect the length of chromosomes.

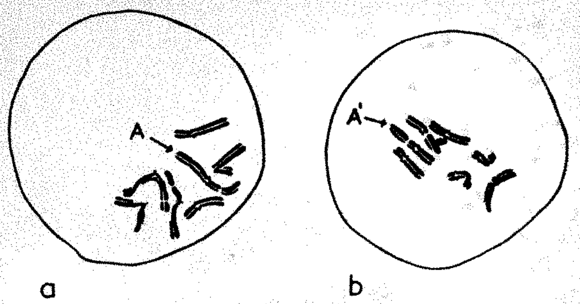

Fig. 1. The first pollen grain mitosis in (*a*) *Lolium temulentum* and (*b*) *L. perenne*. The average chromosome length is about a third greater in *L. temulentum*. (× 1,000)

In *L. temulentum* the chromosomes are too long to permit accurate measurement of complete nuclei. Consequently, one particular chromosome in the complement, *A* (Fig. 1*a*), was measured in suitable cells in the parent plants and in the hybrids. Similar measurements were made of the *L. perenne* chromosome, *A′* (Fig. 1*b*). The chromosomes were identified by the positions of their centromeres and secondary constrictions. Their lengths relative to one another are typical of the average length ratio between the chromosome complements of the two species. Whether they are homologous is not certain, but, from their appearance, probable. Sample measurements from within species were homogeneous, so also were those within hybrids. The results, therefore, were pooled and are represented in Fig. 2.

The average length of each chromosome within cells of the parent species is not significantly different from that in the cells of the hybrid, and the ratio A/A' calculated from measurements in the parent cells (1·3) is much the same as the ratio calculated from hybrid cells (1·4). There is, therefore, no evidence that the size difference is to any extent genotypically determined. The difference, we conclude, is at least mainly due to additional genetic material in the chromosomes of the inbreeding species.

This interpretation is corroborated by our own and Thomas's observations of meiosis in the pollen mother

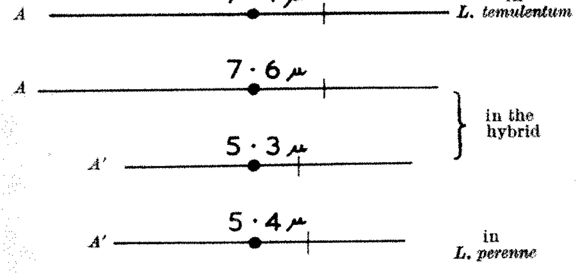

Fig. 2. The average lengths of a chromosome from each species in the nuclei of the parent cells and in those of the hybrid cells. The lengths are based on ten measurements in each case. Lengths of the secondary constrictions are not given

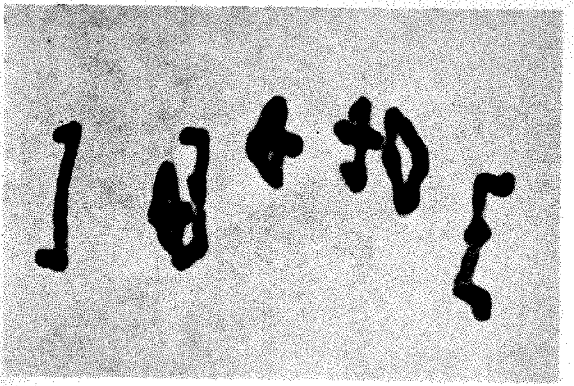

Fig. 3. First meiotic metaphase in a pollen mother cell of the *Lolium* hybrid showing asymmetrical bivalents. (× 1,750)

cells of the hybrids. At pachytene unpaired loops indicating deficiency or excess of genetic material are frequent. At metaphase the persisting inequality of chromosome size is manifested by the distinct asymmetry of up to six of the bivalents (Fig. 3). These asymmetrical bivalents are, with respect to long and short arms, orientated at random. There is no evidence for 'affinity'.

There may well be a causal relation between the variation in the amount of genetic material in the two species and the difference in their breeding systems. We have no evidence to show whether this is so, or how it may operate.

We wish to thank Mr. Beddows, of the Welsh Plant Breeding Station, Aberystwyth, for seeds of *L. temulentum*.

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Fortifying Influences of Coconut Milk and Cow's Urine on 2,4-Dichlorophenoxyacetic Acid in the Control of Button Shedding in the Coconut

DURING several trials carried out by us with different hormones in the control of button shedding in the coconut, there was clear indication that, while sprays of 2,4-dichlorophenoxyacetic acid in 30 p.p.m. strength helped in securing a heavy set of buttons, quite a large number of them turned out to be abnormal or barren and markedly reduced in size when they attained maturity. This was observed to be particularly pronounced when pre-fertilization sprays were given. Although a change from pre-fertilization to post-fertilization sprays brought about a considerable reduction in the occurrence of abnormal and barren nuts and an appreciable improvement in the size of nuts at maturity, it did not help in completely offsetting the defects. It was therefore thought worth while to test the utility of coconut milk and cow's urine in overcoming these defects, since these might, by virtue of their growth-promoting properties, be expected to fortify the action of 2,4-dichlorophenoxyacetic acid, acting synergistically[1] or in some other way.

Preliminary trials were accordingly undertaken by using mixtures of coconut milk or cow's urine (which by themselves were inactive in improving button setting) with equal volumes of 2,4-dichlorophenoxyacetic acid in order to ascertain to what extent these would serve as an improvement. The results of these trials have indicated the interesting beneficial effect in using the mixtures, as these have not only helped to increase the percentage set of nuts and their overall development, but also reduced the incidence of barren nuts compared with the results secured with sprays of 2,4-dichlorophenoxyacetic acid alone, as may be seen from the results presented in Table 1.

Table 1

Characters determined	Control (water spray)	Sprays of 2,4-D alone	Sprays of 2,4-D mixed with coconut milk	Sprays of 2,4-D mixed with cow's urine
Mean percentage set of good nuts	7·62	26·20	44·83	31·23
Mean No. of under developed nuts	0·00	9·66	4·33	4·66
Mean vol. per nut (ml.)	2,158·33	1,516·67	2,373·33	2,360·83
Mean wt. per nut (gm.)	903·33	619·00	745·40	731·00
Mean wt. of copra per nut (gm.)	171·67	135·00	152·50	150·33

2,4-D = 2,4-dichlorophenoxyacetic acid

It is quite clear that there is a significant fortifying influence when 2,4-dichlorophenoxyacetic acid was used with a supplement of coconut milk or cow's urine and that the former proved to be superior in its synergistic effect than the latter.

Further trials are in progress to evaluate the beneficial effects of these and similar other mixtures on a statistical basis. We thank Dr. K. P. V. Menon for his interest in the work and Mr. T. P. Gopalakrishnan for his technical assistance.

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An Infectious Fertility Factor for *Pseudomonas aeruginosa*

ONE unusual feature of the system of sexual recombination occurring in *Escherichia coli* is the infectious nature of the *F* factor. *F* − strains may be readily converted to *F* + by growing the two types together[1,2].

A similar type of sexual recombination to that occurring in *E. coli* occurs in *Pseudomonas aeruginosa*[3,4]. Two of the *Pseudomonas* strains used, 1 and *L*, are interfertile. Furthermore, 1 is self-sterile but *L* is self-fertile with a lower frequency of recombination than the 1 × *L* combination. This situation is comparable to the fertility system occurring in *E. coli K*12. Strain 1 is the equivalent of the *F* − strain, strain *L* the equivalent of the *F* +. Previous attempts to find an infectious fertility factor in *Pseudomonas* have, however, been unsuccessful. In those experiments, strain 1 and strain *L* auxotrophs were grown together under various conditions and the strain 1 auxotroph afterwards re-isolated. However, in no case were the mating characteristics of strain 1 altered in any way.

It has been previously shown that from crosses of multiple auxotrophic strains of 1 and *L*, auxotrophic recombinants may be isolated which show segregation for the ability to cross with either strain 1 or *L*[3]. Most of the recombinants resemble strain 1 in many of their characteristics, for example, pigment formation and susceptibility to phages. Thus it was thought possible that those recombinants of *L*-like mating ability may show a greater ability to transfer a fertility factor, should it exist.

A doubly auxotrophic recombinant $R629$ (IV$_1^-$ T_1^- S^s), *iso*leucine plus valine requiring, tryptophan requiring, streptomycin sensitive and *L* mating type, was obtained from the cross $1(M_1^- T_1^-)$, methionine requiring, tryptophan requiring, × $L(Ad^-$ IV$_1^-)$, adenine requiring, *iso*leucine plus valine requiring. This recombinant was mixed with a strain 1 auxotroph, $1(T_1^- S^r)$, tryptophan requiring and resistant to streptomycin, in 'Difco' nutrient broth plus 0·5 per cent 'Difco' yeast extract in a ratio of 20 : 1 in favour of $R629$ and grown overnight on a shaker at 37° C. The mixture was plated out on 'Difco' nutrient agar plus 250 µgm./ml. streptomycin to re-isolate the strain 1 auxotroph. Twenty-five colonies of this strain were then picked off and tested to see if overnight growth in the presence of the *L* mating type $R629$ had caused any change in the mating type of $1(T_1^- S^r)$, that is, the ability to cross with either strain 1 or strain *L*. It was found that 20 of the 25 colonies picked had permanently acquired the ability to cross to strain 1, thus resembling strain *L* in their mating ability. This change is analogous to the infection of $F-$ strains in *E. coli K*12 to become $F+$. The conclusion is drawn that a factor similar to the *F* factor in *E. coli K*12 controls fertility in the 1 and *L* strains. This factor has been named *FP*. Thus, strain 1 is $FP-$ and strains *L* and $R629$ are both $FP+$.

No reason can be given at present for the failure of strain *L* to infect strain 1 with *FP*. The infectivity of *FP* within strain 1 is irregular. Infection of a $1(FP-)$ strain from a $1(FP+)$ strain under the above conditions occurs only at low frequency and it is possible that the optimum conditions of transfer have not been obtained. The change from $FP-$ to $FP+$ has been achieved in a number of different strain 1 auxotrophs. Different lines derived from strain 1 vary in the facility with which they are converted from $FP-$ to $FP+$, and one of these lines has proved refractory to this change. It is thought possible that the transfer of *FP* may be under the control of certain hereditary factors. These factors may be also responsible for the segregation of *FP* in recombinant progeny previously observed.

In view of recent experiments[5] on the effect of acriflavine on the conversion of $F+$ to $F-$ in *E. coli K*12, the action of this substance on *FP* was investigated. No conversion of $FP+$ to $FP-$ could be accomplished either by growing the $FP+$ strains in 'Difco' nutrient broth plus 200 µgm./ml. acriflavine for up to 48 hr., or by making $FP+$ strains resistant to 1 mgm./ml. acriflavine.

Attempts were also made to select $FP-$ mutants from $FP+$ strains by selection for mutants with higher motility[6]. Repeated trials failed to produce any $FP-$ mutants by this method.

We wish to thank Prof. S. D. Rubbo for his interest in this work.

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Acetylcholine in Milk

ACETYLCHOLINE has recently been reported to be present in low concentrations (0·1–1 µgm./ml.) in the milk of various species[1–4]. On the other hand, the mammary gland does not appear to possess a cholinergic innervation[5,6]. Accordingly, the question of the presence of acetylcholine in milk has been re-examined.

Fresh cows' milk, assayed on the frog rectus abdominis muscle preparation, gave varying responses equivalent to 0·1–0·4 µgm. acetylcholine chloride/ml. The activity differed from that of acetylcholine in the following ways: (1) the dose-response curve was much steeper; (2) heating the milk at *p*H 12 and 100° C. for 10 min. (conditions which destroy acetylcholine) caused little or no reduction of the activity; (3) amounts of milk which should have evoked, on the basis of their acetylcholine equivalence on the rectus, a good response from the anti-histamine-treated guinea pig ileum, failed to do so; (4) samples of milk, ashed and dissolved in a volume of water equal to that of the original sample, showed the same activity as the original milk. This suggested that the rectus activity was due to an inorganic constituent of the milk, probably potassium. It was found possible to duplicate the response to the milk with a potassium chloride solution of the same potassium content.

Since acetylcholine might be present in milk in a bound or pharmacologically unavailable form, or in such low concentration as to escape detection unless concentrated, the milk was treated with trichloracetic acid and the basic constituents of the trichloracetic acid supernatant precipitated as reineckates, procedures which release and concentrate acetylcholine from tissues (see ref. 7 for references). The trichloracetic acid was added to a final concentration of 10 per cent (w/v); the precipitate was removed by centrifugation, extracted with 10 per cent (w/v) aqueous trichloracetic acid and again removed by centrifuging. The combined supernatants (trichloracetic acid extract) were extracted with ether to *p*H 4·5 to remove the trichloracetic acid and the ether removed in a stream of air before testing. Bases were precipitated as reineckates by the addition of excess saturated ammonium reineckate and converted to the chlorides by passing the reineckates in 50 per cent (v/v) aqueous acetone through a column of the anion exchanger 'Deacidite *FF*' (Permutit Co., Ltd., London, −16 +50 mesh) in the chloride form. Control experiments with acetylcholine gave an overall recovery of about 50 per cent for this procedure. Potassium and choline were estimated in the various fractions by flame photometry and by the enneaiodide method[8] respectively.

The activity of the various fractions on the rectus was, in every case, alkali-stable and could be equated with a solution of potassium and choline of equivalent strength. Whereas the activity of the original milk was almost entirely due to potassium, the activity of the base concentrate was mainly due to choline; that of other fractions was due to both substances. On the ileum, about 80 per cent of the activity of the base concentrate was abolished by the anti-histaminic pyrilamine maleate (1 μgm./ml.), and was attributed to histamine; the remaining 20 per cent was more than accounted for by the choline content of the concentrate.

The conclusion drawn from these experiments is that the acetylcholine content of milk is negligible, and that the contractions of the frog rectus and guinea pig ileum preparations produced by milk or milk extracts are due to the potassium, choline and histamine content of milk.

The skilled technical assistance of Miss J. M. Gilson is gratefully acknowledged.

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Use of Tidal Streams by Migrating Elvers (*Anguilla vulgaris* Turt.)

Each spring large numbers of elvers enter the Dutch Wadden Sea through the Marsdiep tidal inlet and migrate to the places where freshwater is discharged, such as at the sluices in the enclosing dam of the Ijssel Lake at Kornwerderzand and Den Oever (Fig. 1).

To study the migration in this tidal area, catches were made in the Texelstroom and the Marsdiep with a 1 m.^{2} ring-trawl during the years 1955, 1956 and 1957, using a small cutter. The catches consisted of horizontal surface hauls of ¾ hr. each, mostly made at night, during the flood as well as during the ebb. During both tides they were carried out alternately in the direction of the North Sea and in the direction of the inland waters, the speed of the boat being approximately constant in relation to the flowing water.

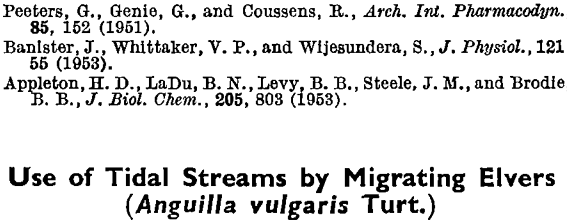

Fig. 1

If the elvers, which rise to the surface at night, do indeed swim actively from the North Sea to the freshwater, we would expect a greater yield of the hauls made towards the North Sea than of those made in the opposite direction. Actually, however, no significant differences in yield between hauls in either direction were found. This seems to exclude the possibility of an active migration of elvers swimming towards the freshwater.

A very significant difference was found, however, between the catches made during the flood tide and the ebb tide, respectively. Three to ten times more elvers were caught during the flood. This means that the greater part of the animals leave the surface during the ebb.

Therefore, during the spring of 1957, catches were also made at a depth of 8 metres, at places where the total depth was 10–20 metres. Also at this depth the yields were much larger during the flood than during the ebb. Hence, we must suppose that during the ebb tide the elvers are to be found near or on the bottom.

It follows from these observations that the elvers most probably use the tidal streams for their migration; they are transported in the direction of the inland waters by the flood, and go to the bottom during the ebb in order not to be carried back to sea.

By fishing in the day-time we obtained evidence that in daylight also this method of migration is used; however, the elvers do not reach the surface then. We have not yet established whether during the ebb the elvers dig themselves into the sand or swim against the current close to the bottom.

The migration principle described above is in accordance with a hypothesis developed theoretically by Van Heusden[1], who also assumed a phase of pelagic transport of the elvers by the flood tide and a phase of active swimming close to the bottom against the ebb tide.

On the other hand, Deelder[2] found no conclusive differences between ebb and flood catches from a ship anchored fairly near the sluices (Wierbalg, Visjagersgaatje) in the years 1947–50. The discrepancy between his and our results, however, can probably be explained as follows.

From our observations in 1957 it was established that the great majority of the elvers passed the Marsdiep during the end of February and the beginning of March. From the observations kindly put at our disposal by the Dienst van de Zuiderzeewerken, we learned that the elvers arrived a full month later at the sluices of Den Oever. Hence, there must be an area between the Marsdiep and Den Oever where the migration suffered a temporary delay; in this area an important accumulation of elvers should take place. Catches made in the Wierbalg during the period in question indeed gave yields which exceeded those in the Marsdiep and the Texelstroom by approximately a hundred times. Moreover, the yields of the ebb and flood catches did not differ significantly. We assume, therefore, that Deelder's results refer to catches made in an area where the migration has temporarily come to a standstill.

The assumption of a temporary stagnation of elver migration in front of the freshwater outlets is also in accordance with the observation of Deelder[3] that at the sluices of Den Oever the elvers at the beginning of the season do not show any preference for freshwater, whereas after some time they are strongly attracted by it.

As regards the use of tidal streams by the elvers migrating from the open sea to the area of stagnation, an important problem arises. How do they discriminate between the flood and the ebb ?

Van Heusden[1] supposed that differences in salinity play an important part. One could imagine, for example, that the elvers remain on or near the bottom so long as the stream (mostly the ebb[4]) carries water of lower salinity, whereas they leave the bottom as soon as the stream (mostly the flood[4]) provides water with a higher salinity. Our observations have not progressed sufficiently to allow a conclusion in this respect ; probably also the water temperature exerts a certain influence.

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Relationship between Aggressiveness and Egg Production in the Domestic Hen

A relationship between position in the peck order and egg production in the hen was first reported by Sanctuary[1] (quoted by Guhl[2]), who found that the birds in the upper half of the peck order laid more eggs than those composing the lower social level. This observation was confirmed by Guhl[2], who obtained a correlation of 0·26 (P, 0·01) between the number of birds pecked in the peck order and the number of eggs laid by 96 White Rock pullets.

The following observations were made on an Australorp flock maintained on the Animal Husbandry Farm of the University of Queensland. The experiment involved the measurement of aggressiveness of pullets in two groups, the first in battery laying cages and the second in an intensive shed on deep litter.

All birds were scored against panels of 10 birds under standard conditions[3] ; 6 such panels were used.

There seemed to be no relationship between aggressiveness score and egg production for birds housed in laying cages and, while there appeared to be some effect of aggressiveness on egg productivity in intensively housed birds, it did not appear to be linear. It seems that the majority of birds with low egg production also have low aggressiveness scores. This can similarly be discerned by inspection of Guhl's[2] scatter diagram.

Since Collias[4] has reported that position in the peck order is one of the factors which makes for success in single encounters of the type used in scoring aggressiveness, and correlations between scores and peck order position in assembled groups of these birds have been demonstrated, it would appear that the low aggressiveness scores are reflecting low peck order position in the intensively housed birds. Low position in the peck order is related to low priority at the feed troughs, nests and roosting places[5], and it would appear that it is the rather harsh environmental conditions to which these birds are subjected that is responsible for their low egg production and thus for the observed correlation.

Blyth[6] considered the shape of the egg production frequency distribution to be fundamentally normal although in fact it is skewed with a long 'tail' towards zero. She considered this to be the result of factors not specifically concerned with egg production. The frequency distribution for egg production of sisters housed under three environments, caged, semi-intensive and intensively on deep litter, shows an increasing degree of negative skew from cage to intensive. This suggests that position in the peck order is certainly one of these factors, though the fact that the 'tail' is still present in the caged birds suggests that it is not the only factor. Recent work[7] involving the feeding of antibiotic and vitamin B_{12} supplements has been effective in raising the egg production of low-producing birds while apparently leaving the high-producing birds unaffected. This suggests that this treatment has been effective in removing even more of the 'tail' from the distribution.

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Sodium Phosphate Crystals on Salt Fish

Several times in the past few years, samples of undried or partly dried salt cod with an accumulation of crystals appearing over the surface have been submitted to this laboratory for examination. These deposits did not resemble either the sodium chloride or the calcium sulphate crystals often found on salt fish. One sample had many water-clear rhombic crystals with edges 2 cm. or more long. Others had a second type of crystals : they were dry, powdery white, and thickly scattered over the surface. Curiously, chemical analysis indicated that both types of crystals contained large proportions of phosphate and sodium, a small amount of chloride, but no sulphate, calcium or magnesium.

When the clear rhombic crystals were exposed to the dry laboratory atmosphere for a day, they changed into a white powder, similar to the second type. This powder contained 20·0 per cent moisture and appeared to be the dihydrate of disodium hydrogen phosphate. On analysis of the sample dried at 105° C., the sodium, phosphate and chloride contents indicated 96·0 per cent disodium hydrogen phosphate with 3·0 per cent sodium chloride.

Thus, the clear rhombic crystals appear to have been the dodecahydrate, the least soluble of the sodium phosphates, which in a dry atmosphere loses water to form the dihydrate (containing 20·2 per cent water) in a white powdery form. This is the form found in samples of the second type.

Since sufficient observations on the solubility of disodium hydrogen phosphate in a solution saturated with sodium chloride were not available, determinations were made at temperatures varying from 0° to 20° C. The results, with some values taken from the literature[1,2], are given in Table 1, and in Figs. 1 and 2.

Table 1

Temperature (° C.)	System $Na_2HPO_4.12H_2O$–NaCl–H_2O Solubilities (gm./100 gm. H_2O)						System $Na_2HPO_4.12H_2O$–H_2O Solubilities (gm./100 gm. H_2O)		
	Na_2HPO_4			NaCl			Na_2HPO_4		
	A	*B*	Average	*A*	*B*	Average	*A*	*B*	Average
0·3	0·579	0·586	0·583	35·41	35·22	35·31	1·76	1·73	1·75
2·5	0·669	0·658	0·664	35·68	35·67	35·68	1·96	1·97	1·97
4·8	0·899	0·900	0·900	35·67	35·60	35·64	2·28	2·28	2·28
10·1	1·77	1·77	1·77	35·40	35·36	35·38	3·60	3·26	3·43
14·5	3·09	3·11	3·10	34·79	34·87	34·83	4·82	4·82	4·82
21·6	7·11	7·08	7·10	33·44	33·41	33·43	8·14	8·15	8·15

Values *A*, equilibrium approached from higher temperatures; values *B*, equilibrium approached from lower temperatures

Fishery salt contains only traces of phosphate. On the other hand, and in agreement with other results[3,4], fresh cod muscle was found to contain 0·2 per cent total phosphorus, of which 0·16–0·17 per cent is inorganic phosphate. Assuming a moisture content of 81 per cent, this would correspond with a concentration of 0·97–1·13 gm. anhydrous disodium phosphate per 100 gm. water. In undried salt fish this figure should remain unchanged: only dry salt is added during salting, and the concentration of phosphate in the water held by the fish should be the same as in the pickle lost, unless some phosphate is held by the tissue. Such a solution, saturated with sodium chloride, would also be saturated with the disodium phosphate dodecahydrate at about 4° C.

After partial drying, the temperature of saturation with respect to the phosphate would be higher. In one sample of slightly dried heavy-salt fish, analysis for moisture and phosphate indicated that this temperature would be about 11° C. Drying therefore favours the formation of the crystals.

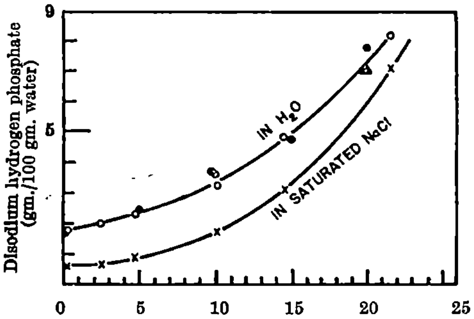

Fig. 1. Solubility of disodium hydrogen phosphate dodecahydrate in water and in saturated sodium chloride solution from 0° to 20° C. ●, In water, data from I.C.T. (ref. 1); ○, in water, experimental; ×, in saturated sodium chloride solution, experimental; △, in saturated sodium chloride solution (ref. 2)

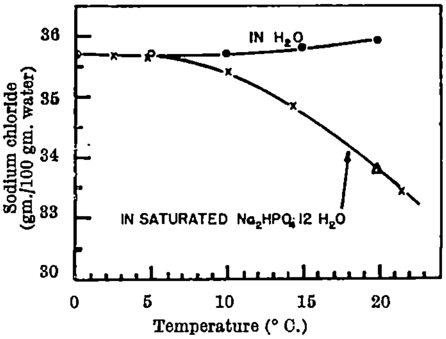

Fig. 2. Solubility of sodium chloride in water and in saturated disodium hydrogen phosphate dodecahydrate solution from 0° to 20° C. ●, In water, data from I.C.T. (ref. 1); ×, in saturated phosphate solution, experimental; △, in saturated phosphate solution (ref. 2)

A slightly alkaline *p*H (about 7·5–8) is also required for the formation of disodium hydrogen phosphate crystals. While the fish itself is almost neutral, most solar fishery salts are alkaline, and any slight spoilage (which often occurs with medium-salt fish) would also tend to increase the *p*H.

Thus the occurrence of these crystals on partially dried salt bulk fish, particularly while in cool storage or during transportation in the winter months, is readily explained. Its higher incidence with medium-cure fish probably depends on the susceptibility to rapid spoilage and the consequent elevation of the *p*H in this type of salt fish.

The effect of the sodium phosphate on the solubility of sodium chloride should also be noted. At 20° C. the solubility of the latter is only 93·9 per cent of the value in the absence of the phosphate. This explains why, in practice, salt fish is not often found in which the water is completely saturated with respect to sodium chloride when the solubility in salt-water systems only is considered, as is usually done.

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Effect of Phenobarbitone on the Requirement of *Lactobacillus leichmannii* for Vitamin B_{12}

When sodium phenobarbitone (2 mgm. per ml.) is added to the medium used in a modified method for the microbiological assay of vitamin B_{12} with *Lactobacillus leichmannii* as test organism, an increase occurs in the amount of growth produced by small amounts of vitamin B_{12}[1]. This communication describes results which suggest that phenobarbitone has a specific vitamin B_{12}-sparing action under the experimental conditions previously described[1]. The strain of *Lactobacillus leichmannii* used was supplied by the National Collection of Industrial Bacteria, and is derived from the American Type Culture Collection strain No. 4797.

Table 1. THE EFFECT OF PHENOBARBITONE ON THE GROWTH OF *Lactobacillus leichmannii* IN THE PRESENCE OF VITAMIN B_{12}

Exp. No.	Incubation time (hr.)	Mgm. sodium phenobarbitone per ml. medium	mμgm. vitamin B_{12} added per 5 ml. medium						
			0·025	0·05	0·1	0·2	0·4	0·5	0·6
			mμgm. vitamin B_{12} required to produce the same amount of growth in the absence of phenobarbitone						
1	24	2·0	0·12	0·24	0·44	0·64	1·1	—	1·6
2	24	2·0	0·06	0·12	0·22	0·42	0·60	—	0·82
3	72	2·0	0·14	0·22	0·38	0·52	0·70	—	0·72
4*	24	2·0	—	0·15	0·20	0·32	0·45	—	0·52
5†	24	2·0	0·09	0·15	0·27	0·47	0·91	—	1·5
6	24	2·0	—	0·17	0·28	0·46	—	0·75	—
		1·0	—	0·14	0·27	0·50	—	0·74	—
		0·5	—	0·075	0·16	0·33	—	0·84	—

* Incubated in anaerobic jars under hydrogen.
† Using phenobarbitone recrystallized three times from water.

By comparing the amount of growth produced by different quantities of vitamin B_{12} in the presence and in the absence of phenobarbitone, the apparent increase in the concentration of vitamin B_{12} due to the presence of phenobarbitone could be assessed. The results, summarized in Table 1, show that phenobarbitone can cause nearly a sixfold increase in the apparent concentration of vitamin B_{12}. The effect is most marked at the lowest level of vitamin B_{12}, and it is as great after incubation for 72 hr. as after 24 hr. (exp. 3). Anaerobic incubation (exp. 4), and the use of recrystallized phenobarbitone (exp. 5) did not affect the results. Lower concentrations of phenobarbitone caused slightly less marked effects (exp. 6).

Higher concentrations of vitamin B_{12}, between 1 and 5 mμgm. in 5 ml. medium, produced almost the same amount of growth whether phenobarbitone was present or not. In several experiments the amount of growth at these levels of vitamin B_{12} was higher in the absence of phenobarbitone than in its presence.

To test the effect of phenobarbitone on growth in the presence of varying amounts of other growth factors, excess vitamin B_{12} (5 mμgm. in 5 ml. medium) was supplied, and either pteroyl glutamic acid or calcium pantothenate was omitted from the basal medium. With increasing amounts of pteroyl glutamic acid there was a slight reduction in growth in the presence of phenobarbitone over the whole range of concentration. With pantothenate there was a suggestion of stimulation of growth by phenobarbitone at the lower levels, but the effect was much less marked than with vitamin B_{12}.

If phenobarbitone was replaced by thymine or uracil at the same molar concentration, there was little change in the growth response to vitamin B_{12}. Some other barbituric acid derivatives have been tested, also at the same molar concentration as phenobarbitone. Barbituric acid itself had a depressant effect, diethyl barbituric acid had some stimulatory effect though less noticeably than phenobarbitone, while nembutal, amytal and butobarbitone appeared to have stimulatory effects similar to that caused by phenobarbitone.

The property of enhancing growth appears to be connected specifically with vitamin B_{12}, and to be confined to certain barbituric acid derivatives with relatively large substituents in the 5-position. No explanation of the phenomenon has been found, but in view of the chemical resemblance between the barbiturates and the iminazole part of the 5,6-dimethyl benziminazole in the molecule of vitamin B_{12}, it seems possible that barbiturate radicals might replace the benziminazole in vitamin B_{12}, forming analogues of vitamin B_{12} with greater growth-stimulating activities for *Lactobacillus leichmannii* than vitamin B_{12} itself. Experiments are in progress to test this possibility.

I wish to thank Prof. D. D. Woods, of the Microbiology Unit, Department of Biochemistry, University Museum, Oxford, for advice in connexion with these experiments. Thanks are also expressed to Prof. L. J. Witts for his interest in the work, and to Mrs. Elisabeth Ross for assistance with the microbiological assays.

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[1] Spray, G. H., *Clin. Sci.*, 14, 661 (1955).

Resistance to Dieldrin in *Lucilia cuprina* Wied., the Australian Sheep Blowfly

WHILE the modified Mules operation[1] greatly assists in reducing the incidence of fly strike of sheep in Australia, chemicals also have an important role in sheep blowfly prevention and control. In agreement with other sheep-raising countries, dieldrin and aldrin have been widely used here for the past three years for the prevention of attack by sheep blowflies.

These insecticides, when used at concentrations of 0·025–0·1 per cent, give periods of protection from 6 to 10 weeks and 12 to 16 weeks against breech and body strike respectively. Aldrin is frequently applied to sheep at twice the concentration of dieldrin.

While dieldrin and aldrin are still affording satisfactory protection against fly strike in sheep throughout New South Wales, there have been recent isolated instances of strikes occurring on sheep within 7–14 days of treatment with either of these insecticides. Field inquiries revealed that the chemicals had been correctly applied, and indicated that insecticidal resistance may have been acquired by *Lucilia cuprina*, which initiates fly strike in sheep in many areas in Australia.

Small numbers of adult flies recently hatched from larvæ, obtained from active strikes on sheep on three properties, currently experiencing difficulty in preventing fly strike with either aldrin or dieldrin.

Comparative toxicity tests have been conducted on flies from the three field strains and from a normal laboratory colony. In this work dieldrin was dissolved in kerosene containing 10 per cent acetone. A volume of 0·25 ml. of insecticidal liquid was applied to the thorax of female flies, seven to ten days old, by means of a microburette[2] while the insects were immobilized with carbon dioxide. The flies were treated with a range of concentrations of 0·01–1·0 per cent dieldrin. The flies were placed, following treatment, in glass containers standing on blotting paper and covered with Petri dish lids. Water and sugar were provided, and mortality records were taken 24 hr. after treatment.

The *LD*50 for the normal laboratory and one field strain of flies is approximately 0·025 μgm. of dieldrin per female fly. Two field strains of flies have an *LD*50 between 1·25 and 2·5 μgm. of dieldrin per female fly. The *LD*50 dosages for the two resistant field strains may be in excess of the maximum figure shown, for the work was undertaken during a heat wave and there was no provision for lowering the temperature in the chamber in which the treated flies were held. Dieldrin has been shown to have a positive temperature coefficient with *Lucilia cuprina* in earlier investigations.

In addition to conducting tests with adult flies, tests were also made with prepupæ of field and normal strains. Prepupæ were immersed for 5 min. in emulsions of dieldrin and placed in sand following drainage. A complete hatch of flies was obtained from prepupæ of the field strains after immersion in 0·5 per cent dieldrin, but no flies emerged from prepupæ from the normal strain following treatment with 0·05 per cent dieldrin. The prepupæ from the field strains are at least ten times more resistant to dieldrin than those from the normal strain.

The demonstration of resistance to dieldrin in the two field strains of *Lucilia cuprina* reported here is interesting, for a very small increase in resistance has been obtained in a laboratory programme aimed at selecting for resistance to this insecticide. Laboratory selections have been made for twelve generations.

The resistance to dieldrin in the field strains could, however, explain the unsatisfactory results being obtained on the two properties concerned. In view of the rapid development of resistance of dipterous insects to dieldrin[3], it is highly possible that dieldrin resistance in *Lucilia cuprina* will appear in other areas. The laboratory investigations have been confined to studies on dieldrin owing to the small numbers of flies available for the tests. The work will be extended to include toxicity studies with other insecticides used for sheep blowfly prevention.

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Dec. 31.

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Tryptophan Content of Wool

Previous results for the tryptophan content of wool have given results varying from 0·5 to 2·3 gm. per 100 gm. of wool[1-7]. In the majority of cases the tryptophan has been determined after alkaline hydrolysis of the wool. Spies and Chambers[8] have shown that the determination of tryptophan in casein, after alkaline hydrolysis, is unreliable unless special precautions, such as the use of an atmosphere of hydrogen, are taken. They found that there is reaction of tryptophan with serine, threonine and cystine during hydrolysis, and, since wool contains larger amounts of these amino-acids than casein, the results are likely to be less reliable than those for casein. They developed a method for the estimation of tryptophan in intact proteins by reaction with *p*-dimethylamino-benzaldehyde in 19 *N* sulphuric acid which avoided these side reactions.

We have used a modification of this method to determine the tryptophan content of wool and have obtained very consistent results. 30 mgm. wool, of known moisture content, is added to a solution of 100 mgm. *p*-dimethylaminobenzaldehyde in 18·1 *N* sulphuric acid and the mixture allowed to stand in the dark at room temperature with occasional shaking, until the wool dissolves. This takes about one week. The blue colour is then developed by the addition of 0·1 ml. 0·01 *M* sodium nitrite solution and estimated with a Spekker photoelectric absorptiometer using Chance *OR*2 filters.

Table 1. Tryptophan Content of Wool

Wool	Fibre diam. (μ)	gm. Tryptophan per 100 gm. dry wool
Durban merino	16·0	1·07
Port Elizabeth merino	19·8	1·01
64's B.A.	21·3	0·97
56's New Zealand	23·9	0·95
56's Monterides	30·2	0·94
44's New Zealand	34·3	0·93

The tryptophan contents of a number of wool samples determined by this method are given in Table 1.

These results show that there is a tendency for the finer quality wools to contain more tryptophan than those of lower quality. This does not appear to be due to destruction by the sulphuric acid of some of the tryptophan in the coarser wools, since we have obtained the same tryptophan content for a sample of wool using sulphuric acid varying in strength from 17·1 *N* to 23·0 *N* and also using hydrochloric acid in place of the sulphuric acid.

The tryptophan content of a number of other keratins has been determined by this method and the results are given in Table 2.

Table 2. Tryptophan Content of Various Keratins

Keratin	gm. Tryptophan per 100 gm. dry keratin	Previous values
Wool (root ends)	0·93–1·07	0·5 (ref. 1), 0·7 (ref. 2), 0·94 (ref. 3), 1·45 (ref. 4), 1·8 (ref. 5), 2·1 (ref. 6), 2·3 (ref. 7)
Mohair	0·74	—
Camel hair	0·84	0·8 (ref. 2)
Cow hair	0·82	1·4 (ref. 2)
Human hair	0·54	0·7 (ref. 2), 1·0 (ref. 9)
Cashmere	0·97	—
Cow horn	0·84	0·7 (ref. 2), 1·43 (ref. 4)
Finger nails	0·66	1·1 (ref. 2)
Pigeon quill	1·08	—

These results show that the tryptophan contents of the keratin samples examined lie between 0·5 and 1·1 per cent. This contrasts with the occurrence of only trace amounts of tryptophan in various collagens[10,11] and suggests that determination of the tryptophan content of tissue proteins may be a convenient method for classifying the proteins as collagens or keratins.

We hope to publish a fuller account of this work in due course.

We wish to thank the directors of Wolsey, Ltd., for permission to publish this communication.

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Polymely in *Xenopus laevis*

IN several genera of the order Anura supernumerary limbs occur naturally[1]. They are usually extra hind limbs[2]. Polymely does not appear to have been reported in the genus *Xenopus*. The female toad (*Xenopus laevis*) described here came with a consignment of toads imported from South Africa in 1956. The toad measured 8·0 cm. from snout to vent and weighed 60 gm. and, except for a supernumerary right arm, was quite normal in appearance. The additional forearm was a mirror image of the normal right arm and was the same size as the two normal limbs. It measured 3·2 cm. from the axilla to the tip of the longest digit. The additional limb was attached immediately anterior to, and in the same plane as, the normal right arm. The point of attachment of the two limbs formed a prominent bony lump (Fig. 1). The extra limb was functionally normal and capable of independent movement. *Xenopus* is aglossate and pushes food into its mouth with both hands. In this specimen the back of the supernumerary hand assisted the normal left hand to carry food to the mouth, and the normal left hand alone was used for pushing food into the mouth. This toad had no difficulty in competing with normal *Xenopus* for food and was well nourished.

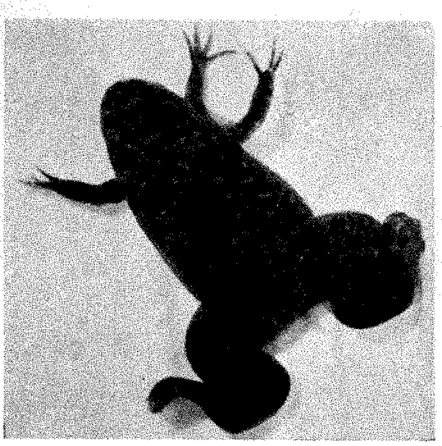

Fig. 1. Female *Xenopus laevis* with a supernumerary right arm

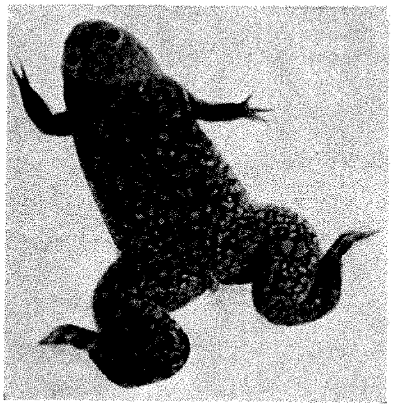

Fig. 2. The toad in the 'two-armed' position; supernumerary arm concealed

The toad had been in the laboratory for more than a year before its abnormality was noticed, and it was only discovered then because the toad was handled. Fig. 2 shows the animal in the 'two-armed' position; the supernumerary limb is concealed by the head. When the toad rested in this position it was indistinguishable from normal animals in the same tank. Accounts of supernumerary limbs in the Anura show that the extra limb is abnormal, being incomplete osteologically and deficient in muscle. This was not the case for the toad described here. The extra limb was functional, and had the same dimensions as the two normal fore limbs. This example of polymelia in the genus *Xenopus* appears to be the first that has been reported, and supernumerary limbs have never been described in the related genera *Pipa*, *Hymenochirus* and *Pseudohymenochirus*. During 1947–57, we have imported 23,250 toads from South Africa, and in the same period 6,480 *Xenopus* have been bred in this Laboratory. No other toad has had a supernumerary limb.

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A New Type of Light Organ in the Deep-Sea Fish *Opisthoproctus*

IN the closely related salmonoid genera *Opisthoproctus* and *Monacoa* the ventral surface is formed as a flat sole reaching from under the head to the terminal or subterminal anus. Trewavas[1] found an organ immediately under the skin of the sole which she regarded as a swim-bladder. The question why these fishes, in contrast to all other known bathypelagic fish, should have a flat ventral surface and presumably swim upside down called for an explanation.

Dissections and serial sections of specimens from the *Dana* Oceanographical Collections revealed the following facts:

1. *Opisthoproctus* has a swim-bladder in the normal position (Fig. 1, *SW*).
2. The organ in the ventral sole (Fig. 1, *REFL*) is not a swim-bladder. Its lumen is completely filled with a very transparent gelatinous tissue and no *retia mirabilia* or gas gland is present.
3. As described by Trewavas, the so-called swim-bladder is posteriorly attached to a swelling of the rectum (Fig. 1, *RE*). The wall of this rectal bulb is strongly pigmented and contains numerous blood vessels. A sagittal section through the bulb shows that its posterior wall is covered inside by a thick luminous epithelium of similar appearance to that found in the light-organs of ceratioids. Like these, this light-organ is an open gland most probably containing luminous bacteria. In front of the

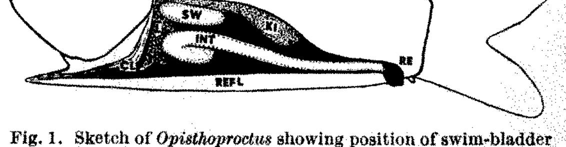

Fig. 1. Sketch of *Opisthoproctus* showing position of swim-bladder (*SW*), rectal light-organ (*RE*) and its reflector organ (*REFL*). Paired fins and gonad removed. (*CL*, cleithrum; *KI*, kidney; *L*, liver)

luminous epithelium is a transparent lens-like structure consisting of two lateral halves filling the rest of the bulb, leaving only a narrow slit for the passage of the fæces.

4. The wall of the rectal bulb, which elsewhere is thick and pigmented, has a very thin and completely transparent window where it is attached to the bladder-like organ of the ventral sole. Dorsally the inner surface of this 'bladder' has a silky brilliance.

Evidently the function of the organ in the sole of *Opisthoproctus* is to serve as a reflector for the rectal light-organ. The light is transmitted through the lens and window of the bulb to the crystal-clear tissue of the reflector organ. From the shining ventral wall of the latter the light is reflected downwards and dispersed over the whole ventral surface of the fish. The flat sole is covered with large thin scales which are transparent at the base but pigmented with increasing density towards the distal edge. A shortening of the sole will thus screen the light.

Probably the main biological significance of this complicated organ is that it enables the fish to be recognized by others of its kind which have sensitive, upwardly directed, tubular eyes. Possibly a very low light intensity is sufficient for this purpose. This would greatly reduce the risk of being detected by predators, and furthermore the downwardly directed light from the flat sole will be difficult to observe by fish with normal horizontally directed eyes.

Somewhat similar types of light-organs with open glands connected more or less directly with the intestine, and emitting light indirectly through transparent parts of the body, have been found in some Percomorphi from shallow water: *Acropomona japonicum, Leiognathus equula, Gazza minuta* and *Apogon marginatus*[2-5].

A more detailed report on the rectal light-organ of *Opisthoproctus* and related genera is under preparation and will appear in the "*Dana* Reports".

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Charlottenlund.
Jan. 6.

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Effect on Earthworm and Diptera Populations of BHC Dust applied to Soil

IT is well known that BHC affects earthworms and soil insects. A review of these problems has been given by Satchell[1].

In May 1956, 12 per cent γ-BHC dust was applied at surface concentrations of 10·08, 20·16, 28·8 and 57·6 gm./100 m.² to ploughed plots and was thoroughly mixed with soil to a depth of 4 in. In 1956 and 1957 the plots were sown with sugar beet and potato. In October 1957 (18 months after treatment with BHC) the earthworms and other fauna were extracted from the experimental plots.

A significant increase in the earthworm population occurred in all the plots treated with BHC (Table 1). This may be partly explained by 'food mobilization' in soil treated with BHC[2].

A statistical examination has shown that there is a curvilinear correlation (parabolic) between BHC concentration and the number of earthworms. The optimal γ-BHC concentration is 31·03 gm./100 m.². This gives the highest number of earthworms.

Table 1. EFFECT OF BHC ON NUMBERS OF EARTHWORMS IN POTATO PLOTS

gm./100 m.² of γ-BHC	No. of earthworms per m.²
Untreated	10·0
10·08	21·6
20·16	25·8
28·8	26·1
57·6	14·6

Table 2. EFFECT OF BHC ON POPULATIONS OF WIREWORM AND DIPTERA IN SUGAR BEET PLOTS

gm./100 m.² of γ-BHC	No. per m.²	
	Wireworm	Diptera
Untreated	1·1	3·6
10·08	0·2	4·3
20·16	0·2	6·0
28·8	—	7·1
57·6	—	6·6

It was observed (Table 2) that on all treated sugar beet plots the number of wireworm was reduced and the population of Diptera (*Pegomyia hyoscyami* and others) was increased. It is suggested that the significant increase in the number of Diptera in all plots treated with BHC was due to a reduction in predators, the numbers of wireworm. Similar results were obtained by Stone[3] with the wireworms *Limonius californicus* and *Hylemyia ciliclura*.

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Dec. 18.

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Thermocline off the Coast of Tropical West Africa

RECENTLY, Salzen[1] has shown that there is a marked difference with depth in the species composition of the demersal fish fauna off Tema in Ghana. He found that there was a distinct change from euryhaline and eurythermal species in the shallow inshore water, to red and brown marine species below 10 fathoms. As the same change in species had been observed by Postel[2] working off French Guinea, Salzen suggested that the results for Tema might be typical of a great deal of the West African shelf in the dry season. The results (unpublished) of an extensive, though not detailed, hydrographic survey of the region, from Dakar to the Cameroons, made during 1952, tend to support such a generalization, and pose the question as to whether the thermocline might be partly responsible for determining the distribution of the inshore fish fauna.

During the course of the hydrographic survey, a number of bathythermograph recordings were made at stations distributed in transects at various intervals along the West African shelf. Salinity samples were also taken using a Nansen Peterssen insulated water-bottle. The results of the survey were in close agreement with the observations of Defant[3] made during the *Meteor* Expedition of 1925–27. It was found that the deeper water on the shelf was separated from the surface waters by a layer within which the density increased so rapidly with depth that it had the character of a discontinuity layer and within this layer there was a distinct salinity maximum. The discontinuity layer or thermocline covered the whole area of the survey and showed a slight slope to seawards.

The water masses above the thermocline showed a small and irregular vertical temperature gradient, but within the thermocline itself, the gradient was very marked—about 9 deg. C. in 13 fathoms off the coast of Sierra Leone, and about 4 deg. C. in 5 fathoms off Ghana. The salinity gradient was most pronounced in the surface waters, especially near the coast. On proceeding away from the coast, the salinity of the surface waters increased rapidly, and at the same time the temperature decreased. Off the coast of Ghana, however, this tendency was reversed, presumably as a result of upwelling near the coast. In this region, colder and more saline water was found close to the surface inshore, and as a result the thermocline had a smaller vertical extension than elsewhere in the area of the survey.

Table 1. AVERAGE DEPTH OF THE THERMOCLINE OFF THE COAST OF THE BRITISH WEST AFRICAN TERRITORIES

Coast	No. of stations	Average depth from surface	
		Bottom of surface water (fathoms)	Bottom of thermocline (fathoms)
Gambia	12	10	24
Sierra Leone	10	12	28
Ghana	14	10	15
Nigeria	16	15	26

The average depth of the thermocline is indicated in Table 1. It will be seen that the bottom of the surface water approximates to that depth (10 fathoms) at which Postel and Salzen observed the change from euryhaline and eurythermal species to predominately marine. This suggests that the thermocline probably plays some part in determining the nature and distribution of the inshore fish fauna of West Africa. Unfortunately, the results of the 1952 hydrographic survey are insufficient to allow any precise relationships to be determined, but in view of the fact that the thermocline is a constant and widespread feature of the waters on the West African shelf, its presence should, perhaps, be considered as a contributory cause of the correspondence between the Tema area and the French Guinea shelf.

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Freetown.
Dec. 31.

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Bixbyite from Nagpur

DURING an examination of polished sections from Prof. A. M. Bateman's collection of Indian manganese made during his trip in 1954 (1232*a*, Joda East Nagpur), I noticed a few grains of a greyish white mineral with a distinct yellow tint and a slightly greater hardness than braunite, with which it is associated. Etch tests with nitric acid, potassium cyanide, stannous chloride and hydrogen peroxide were negative. Microchemical tests indicated the presence of manganese and iron. X-ray photographs of the mineral were taken by the Debye–Scherrer method using iron *K* radiation. The *d* spacings observed from the film, as given in Table 1, agree fairly well with the values obtained by Fleischer and Richmond[1] for bixbyite from the Thomas Range in Utah.

Table 1

d	*I*	*d*	*I*	*d*	*I*	*d*	*I*
4·52	1	2·14	6	1·49	1	1·10	2
3·34	1	1·87	1	1·46	2	1·14	1
3·19	2	1·80	2	1·40	8	1·07	8
2·98	1	1·71	1	1·35	2	1·05	7
2·73	10	1·66	9	1·25	1	1·03	2
2·33	4	1·53	2	1·17	1		

d, Spacings in Angstrom units; *I*, estimated intensities

Fleischer and Richmond give the formula $(Mn/Fe)_2O_3$ for bixbyite. Mason[2] has shown the chemical similarity and structural identity of bixbyite and sitaparite.

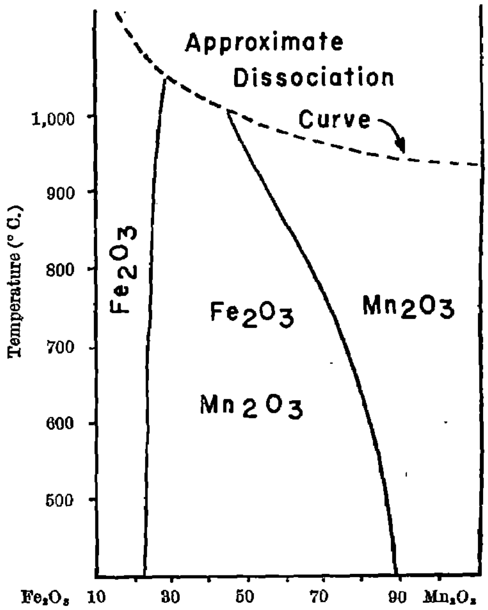

Fig. 1. The system Fe_2O_3—Mn_2O_3 (after Mason, *Amer. Mineral.*, 29; 1944)

Fig. 1 indicates that the solubility of Fe_2O_3 in Mn_2O_3 increases with increasing temperature.

Bixbyite formed at high temperatures contains 45–60 per cent Fe_2O_3. Sitaparite formed during metamorphism of manganese ores contains about 30 per cent Fe_2O_3. Unmixing of these minerals into iron-poor sitaparite and iron-rich bixbyite has significance in geological thermometry.

Bixbyite has been reported from many localities including Patagonia, Sweden, South Africa, Utah and New Mexico. A survey of the literature shows that this is the first report of the mineral from India.

The above observations were made during a study of Indian manganese ores at the Laboratory of Economic Geology, Yale University.

I am grateful to Prof. Alan M. Bateman for his direction and valuable help.

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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, March 24

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Prof. W. G. V. Balchin: "A Water Use Survey".

Monday, March 24—Thursday, March 27

Physical Society (in the Old and New Halls of the Royal Horticultural Society, off Victoria Street, London, S.W.1)—Annual Exhibition of Scientific Instruments and Apparatus.

Tuesday, March 25

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Mr. Gerald Lacey: "Flow in Alluvial Channels with Sandy Mobile Beds".

Institution of Electrical Engineers, Measurement and Control Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Dr. L. Essen: "The Atomic Clock".

Society of Chemical Industry, Plastics and Polymer Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. D. K. Hale: "Ion Exchange Resins".

Royal Photographic Society (at 16 Princes Gate, London, S.W.7), at 7 p.m.—Annual General Meeting.

Tuesday, March 25—Thursday, March 27

Institution of Naval Architects (in the Weir Lecture Hall, 10 Upper Belgrave Street, London, S.W.1), at 10.15 a.m. daily—Spring Meeting.

Society of Chemical Industry (at the University, Aberdeen)—Conference on "Fundamental Aspects of the Dehydration of Foodstuffs".

Wednesday, March 26

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. N. L. Falcon and Dr. P. E. Kent: "The Geological Results of Petroleum Exploration in Britain, 1945 to 1957".

Institute of Fuel (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Dr. V. R. Gray: "The Dewatering of Fine Coal".*

Institution of Electrical Engineers, Supply Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. F. Giordani: "The Objective for Euratom".

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. W. J. Perkins and Dr. M. H. Evans: "Electronics in Medical Research".

Society for Analytical Chemistry, Biological Methods Group, (in the Physiology Laboratory, University College, Gower Street, London, W.C.1), at 6.30 p.m.—Demonstration Meeting.

Royal Institute of Chemistry (joint meeting with the Chelsea College of Science and Technology Chemical Society, at the Chelsea College of Science and Technology, Manresa Road, London, S.W.3), at 7 p.m.—Dr. F. L. Rose, F.R.S.: "Chemotherapy".

Thursday, March 27

Photobiology Group (at Bedford College, Regent's Park, London, N.W.1), at 2 p.m.—Dr. C. A. Parker: "Recent Advances in Spectrofluorimetry and Chemical Actinometry"; Dr. R. S. Spencer: "The Biology of Luminous Bacteria"; Mr. E. S. Trickett: "Problems of Radiation Measurement in Relation to Environmental Control".

Bone and Tooth Society (in the New Lecture Theatre, The Hospital for Sick Children, Great Ormond Street, London, W.C.1), at 5 p.m.—Symposium on "Eosinophilic Granuloma and Related Conditions". Speakers: Dr. Reginald Lightwood, Dr. John Sutcliffe and Dr. Martin Bodian.

Oil and Colour Chemists' Association (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. C. C. Mill: "Some Observations on the Rheology of Carbon Black Suspensions".

Thursday, March 27—Friday, March 28

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2)—Convention on "Radio Aids to Aeronautical and Marine Navigation".

Friday, March 28

Biochemical Society (at the University of Birmingham Medical School), at 11 a.m.—Scientific Papers.

British Psychological Society, Industrial Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. J. N. Bamforth: "Human Relations Training at Roffey Park—an Experiment in Evaluation of Results".

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on papers received during the Session 1957–58. Chairman: Dr. R. Stoneley, F.R.S. Speakers: Dr. A. H. Cook, Mr. H. M. Iyer, Sir Harold Jeffreys, F.R.S., and Mr. A. S. Merriweather.

Medical Research Council (at the National Institute for Medical Research, Mill Hill, London, N.W.7), at 5 p.m.—Prof. N. I. Kalabukhov (Institute for Scientific Research, Ministry of Health, Saratov, U.S.S.R.): "Seasonal Changes in the Organism of Mammals in Relation to the Environment".

Institution of Mechanical Engineers, Internal Combustion Engine Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Ultimate Engine: Stationery, Rail Traction and Marine".

Royal Photographic Society, Kinematograph Group (at 16 Princes Gate, London, S.W.7), at 7 p.m.—Annual General Meeting, followed by a review of recent apparatus, by Mr. A. R. Rigg.

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. Richard Julius Pumphrey, F.R.S.: "Hearing in Man and Animals".

Friday, March 28—Saturday, March 29

Linnean Society of London (in the Lecture Theatre of the British Museum (Natural History), Cromwell Road, London, S.W.7), at 10.45 a.m. Friday and 10.15 a.m. Saturday—Symposium on "The Uses of the Electron Microscope in Biology".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant (Scientific) in the Department of Physiology and Plant Culture, for routine duties connected with plant studies in controlled environments—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford, Herts (March 27).

Scientific Officer (with an honours degree in plant physiology) in the Irrigation Section—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (March 28).

Assistant Physicist, Basic grade (with an honours degree in physics), for duties mainly in the X-Ray Diagnostic Department—The Personnel Officer, St. Thomas's Hospital, London, S.E.1 (March 29).

Hospital Biochemist, Senior grade (with a university degree in science or equivalent qualification), in the routine Biochemical Section of the Department of Clinical Biochemistry—The Administrator, Radcliffe Infirmary, Oxford (March 29).

Demonstrator in Physics—The Registrar, The University, Hull (March 31).

Nuffield Science Teaching Fellow (with a good honours degree in physics and preferably some experience in research or advanced study) in the Physics Department of the Faculty of Science, to pursue research in physics and at the same time participate in teaching at local grammar schools—Prof. Samuel Devons, Physical Laboratories, The University, Manchester 13 (March 31).

Junior (Assistant) Lecturer in Biochemistry, with special reference to physical biochemistry—The Dean, Guy's Hospital Medical School, London, S.E.1 (April 1).

Lecturer (honours graduate) in Physics at Kumasi College of Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (April 4).

Imperial Chemical Industries Research Fellows in Chemistry, Physics, Engineering (including Chemical Engineering), Metallurgy, Pharmacology or related subjects—The Registrar, The University, Sheffield (April 5).

Reader in Soil Science—The Secretary, The University, Aberdeen (April 7).

Lecturer (preferably with experience in reactor physics or nuclear metallurgy) in the Nuclear Engineering Laboratory—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 8).

Senior Tutor (Physicist) (preferably with university teaching experience) in the Department of Physics—The Registrar, University College of Swansea, Singleton Park, Swansea (April 8).

Lecturer in Civil or Mechanical Engineering—The Registrar, University College, Singleton Park, Swansea (April 10).

Research Fellow (with a Ph.D. degree or equivalent experience) in the Chemistry Department, for work on the kinetics of gaseous oxidation—The Professor of Chemistry, The University, Hull (April 10).

Assistant Lecturer in Geography, and an Assistant Lecturer in Philosophy—The Registrar, The University, Leicester (April 12).

Turner and Newell Research Fellow in Engineering, Inorganic Chemistry or Physics or other allied science—The Registrar, The University, Leeds 2 (April 12).

Lecturer (with special qualifications in physical chemistry) in the Department of Chemistry—The Registrar, University College, Singleton Park, Swansea (April 14).

Scientific Officer (with qualifications which include an honours degree in natural sciences), for research on resistance of sugar beet to beet eelworm—The Secretary, The School of Agriculture, The University, Downing Street, Cambridge (April 15).

Senior Lecturer (with a knowledge of tropical pastures and of animal nutrition in humid tropics) in Agriculture (Nutrition) at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 20).

Lecturer (preferably with experience in electronics and instrumentation for automatic control) in Electrical Engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 30).

Lecturer or Assistant Lecturer in Anatomy, and a Lecturer or Assistant Lecturer in Bacteriology at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 30).

Reader in Biochemistry at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

Senior Leverhulme Research Fellow, for research in some aspects of radio-astronomy, using the radio-telescope at the Jodrell Bank Experimental Station—The Registrar, The University, Manchester 13 (April 30).

Lecturer or Assistant Lecturer (with interests in physical and/or inorganic chemistry) in Chemistry at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 3).

Leverhulme Students (graduates in chemistry or engineering) in Chemical Engineering, for advanced training or research in chemical engineering in the Ramsay Memorial Laboratory—The Registrar, University College, Gower Street, London, W.C.1 (May 15).

Lecturer in Physics at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 20).

Applied Mathematician, to provide mathematical services in forestry, fisheries and wild-life management research; a Forest Fire Physicist (preferably with a background in meteorology), to initiate a field research programme on physical and meteorological factors influencing growth and spread of forest fires; and an Oceanographer (physicist, preferably, with a background of hydrodynamics, meteorology or oceanography, and competent in mathematics), to lead scientific parties aboard the research vessel, taking oceanographic and meteorological observations, developing new observational techniques and instruments, analysing data and undertaking model work—Head of Physics Section, Division of Research, Department of Lands and Forests, R.R. No. 2, Maple, Ontario, Canada.

Assistant Professor in the Department of Physics—The University of New Brunswick, Fredericton, New Brunswick, Canada.

Assistant (with Inter.B.Sc. or equivalent qualifications including mathematics) in the Computing Machine Laboratory, for miscellaneous duties in connexion with the preparation of work for an electronic digital computer—Dr. T. Kilburn, The Department of Electrical Engineering, The University, Oxford Road, Manchester 13.

Head (mechanical engineer, with good teaching, industrial and/or research experience) of the Department of Engineering—The Principal, Welsh College of Advanced Technology, Cathay's Park, Cardiff.

Lecturer in Mathematics, to teach pure and applied mathematics to degree standard—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

Lecturer (with a suitable degree and industrial or research experience) in Metallurgy—The Deputy Registrar, The University, Birmingham 15.

Mass Spectroscopist (with a first- or second-class honours degree. and preferably research experience in mass spectroscopy and a knowledge of electronics and vacuum technology), to work on the development of a high-resolution mass spectrometer—Group Recruitment Officer (1045Y/34), Atomic Energy Research Establishment, Harwell, Berks.

Physicist, Experimental Officer or Assistant Experimental Officer grade (with at least G.C.E. in five subjects, with physics and one other scientific or mathematical subject at advanced level or equivalent), to work in a team engaged on specialized nuclear radiation measurements—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1733/34.

Technician (preferably with a knowledge of photography and/or geological techniques) in the Geology Department—The Registrar (GT), Queen Mary College (University of London), Mile End Road, London, E.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Report of the Committee appointed by the Prime Minister to examine the Organisation of certain parts of the United Kingdom Atomic Energy Authority. Pp. 40. (Cmnd. 338.) (London: H.M. Stationery Office, 1957.) 2*s.* net. [3012

Report of the Thirty-Fifth Meeting of the Ross Institute Industrial Advisory Committee—Housing for Estate Labour. Pp. 20. (London: London School of Hygiene and Tropical Medicine incorporating the Ross Institute, University of London, 1957.) [3112

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 1, Vol. 6, No. 1: Hydrographical Survey of the River Usk. By A. Swain and O. F. Newman. Pp. v+34. (London: H.M. Stationery Office, 1957.) 8*s.* 6*d.* net. [3112

London and Home Counties Regional Advisory Council for Higher Technological Education. Bulletin of Special Courses in Higher Technology, including Management Studies and Commerce, 1957–58. Part 2: Spring and Summer Terms, 1958. Pp. 70. (London: London and Home Counties Regional Advisory Council for Higher Technological Education, 1957.) 3*s.* [3112

The Registrar General's Statistical Review of England and Wales for the year 1956. Part 1: Tables, Medical. Pp. x+372. (London: H.M. Stationery Office, 1957.) 15*s.* net. [3112

Aluminium Development Association. Information Bulletin No. 23: Soldering Aluminium. Pp. 35. (London: Aluminium Development Association, 1957.) 2*s.* [3112

Proceedings of the Association of British Chemical Manufacturers Work Study Conference for Senior Work Study Practitioners and Works Managers, Hotel Majestic, Harrogate, 23rd to 25th May, 1957. Pp. v+206. (London: Association of British Chemical Manufacturers, 1957.) 13*s.* 6*d.*, post free. [3112

Other Countries

Rijkslandbouwhogeschool, Gent. Negende Jaarlijks Symposium over Phytopharmacie, 7 Mei 1957. Pp. iv+335–702. (Overdruk uit "Mededelingen van de Landbouwhogeschool en de Opzoekingsstations van de Staat te Gent", 1957, Deel 22, No. 3.) (Gent: Rijkslandbouwhogeschool, 1957.) [3112

Sveriges Geologiska Undersökning. Avhandlingar och Uppsatser. Ser. C, No. 549: The Titaniferous Ore-Bearing Gabbro of Helsingland, Central Sweden. By P. H. Lundegårdh. Pp. 34. (Stockholm: Kungl. Boktryckeriet P.A. Norstedt & Söner, 1957.) 2 kronor. [3112

Indian Council of Medical Research. Technical Report of the Scientific Advisory Board for the year 1956. Pp. xii+290. (New Delhi: Indian Council of Medical Research, 1957.) R.1. [3112

Proceedings of the New Zealand Ecological Society. No. 3: Report of Fourth Annual Meeting, Christchurch, 18th to 20th August, 1955. Pp. 36. 3*s.* No. 4: Report of Fifth Annual Meeting, Wellington, 10th to 12th May, 1956. Pp. 48. 7*s.* 6*d.* (Wellington: New Zealand Ecological Society, 1956 and 1957.) [3112

Research Bulletin of the Panjab University. No. 103, (Zoology): The Millipede Egg. By G. P. Sharma and O. B. Chhotani. Pp. 241–250. Rs. 2–5–0. No. 104, (Zoology): Spermatogenesis of Cicindela, with special reference to Acrosome-Formation, Centrosome and Nuclear Vesicle. By Vishwa Nath, B. L. Gupta and S. Mehta. Pp. 251–259. Rs. 1–80–0. No. 105, (Zoology): Mantodean Oothecae. By G. L. Arora and Indermohan Singh. Pp. 261–267. Rs. 1–0–0. No. 106, (Zoology): On a New Trypanosome from the Blood of an African Gecko, *Hemidactylus Brookii Angulatis* Gray. By Manohar Singh Grewal. Pp. 269–281. Rs. 2–0–0. No. 107, (Mathematics): Partitions into Exactly *k* Distinct Primes. By O. P. Gupta. Pp. 283–290. Rs. 1–30–0. No. 108, (Zoology): Some Critical Observations on the Feeding Activity of the Desert Locust, *Schistocerca Gregaria* (Forskal), under Different Environmental Conditions. By Asket Singh. Pp. 291–298. Rs. 1–0–8. No. 109, (Mathematics): An Analogue of a Problem of Mahler. By R. P. Bambah. Pp. 299–302. Rs. 1–12–0. No. 110, (Chemistry): Synthesis of Fat by *Penicillium aurantiobrunneum* from Different Sucrose Concentrations at Different Periods of Incubation. By Jagjit Singh and Pushpinder Nath. Pp. 303–307. Rs. 1–0–0. No. 111, (Chemistry): Heat of Wetting of Porous Solids in Relation to their Surface Area. By Balwant Rai Puri, Sukarma Mittal and Lekh Raj Sharma. Pp. 309–315. Rs. 1–16–0. No. 112, (Zoology): Mitochondria and Golgi Bodies in the Spermatogenesis of *Periplaneta americana* as Studied under the Phase-Contrast Microscope. By B. L. Gupta and P. Sehgal. Pp. 317–326. Rs. 1–90–0. No. 113, (Zoology): On Two New Species of the Genus *Neodiplostomum* Railliet, 1919, and Discussion on the Validity of *Neodiplostomum* (*Neodiplostomum*) Rufeni, Chatterji, 1942. By N. K. Gupta. Pp. 327–335. Rs. 1–50–0. No. 114, (Chemistry): Diethylenetetra-Ammonium Sulphatocerate as Volumetric Reagent. 4: Direct Determinations with Indicators. By Balwant Singh. Pp. 337–339. Rs. 0–80–0. No. 115, (Chemistry): Volumetric Studies in Oxidation-Reduction Reactions. Oxidation with Chloramine-T. Determination of Metals. By Balwant Singh and S. K. Soni. Pp. 341–344. Rs. 0–90–0. (Hoshiarpur: Panjab University, 1957.) [3112

Library Science and Scientific Method. By Dr. S. R. Ranganathan. (Reprinted from "The Five Laws of Library Science," Edition 2.) Pp. ii+355–424. (Madras: Madras Library Association, 1957.) [3112

British Guiana. Report on the Geological Survey Department for the year 1956. Pp. 32. (Georgetown: Geological Survey, 1957.) 50 cents; 2*s.* 1*d.* [3112

Chicago Natural History Museum. Fieldiana: Anthropology. Vol. 36, No. 8, (November 8, 1957): The Old Copper Culture and the Keweenaw Waterway. By George I. Quimby and Albert C. Spaulding. Pp. 189–201. (Chicago, Ill.: Chicago Natural History Society, 1957.) 40 cents. [3112

University of Helsinki: Institute of Meteorology. Papers, No. 83: On the Observed Zonal and Meridional Circulations at Latitudes 15° N and 30° N in Winter. By P. A. Vuorela. Pp. 105–120. (Reprint from *Geophysica*, Vol. 6, No. 2.) (Helsinki: University of Helsinki, Institute of Meteorology, 1957.) [3112

Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica. Vol. 2, No. 13: Studies on the Nuclear Photoeffect. By M. D. de Souza, Santos, J. Goldemberg, R. R. Pieroni, E. Silva, Ottavia A. Borrello, Suzanna S. Villaca, and J. Leite Lopes. Pp. 20. Vol. 3, No. 21: On the Capture of Negative Muons by Light Nuclei. By J. Meite Lopes. Pp. 20. Vol. 3, No. 22: Scattering of Nucleons Nuclei in the 30-MeV Region. By L. R. B. Elton and L. C. Gomes. Pp. 18+9 figures. Vol. 3, No. 23: Energy Spectrum of Pions and Polarization of Muons and Electrons in the K_{3y} and K_{e3} Decay. By S. W. MacDowell. Pp. 20+5 figures. Vol. 3, No. 24: Note on the Interaction of Elementary Particles. By L. Leite Lopes. Pp. 16. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1957.) [3112

Bulletin of the American Museum of Natural History. Vol. 113, Article 6: Notes and Descriptions of Some Neotropical Muscidae (Diptera). By Fred M. Snyder. (New York: American Museum of Natural History, 1957.) 1 dollar. [3112

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Details of these courses and other information may be obtained from the Registrar, the University, Birmingham, 15.

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Particulars and application forms may be obtained from the Secretary, Physics Department, Chelsea College of Science and Technology, Manresa Road, London, S.W.3.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3

DEPARTMENT OF GEOLOGY

Head of Department: W. E. Smith, M.Sc., F.G.S.

An advanced evening course of six lectures on " Hydrogeology and Water Supply " will be given by Dr. J. Ineson on Friday evenings, 7 to 8.30 p.m., commencing May 2, 1958. The course is intended for geologists working on water supply problems and engineers with a basic knowledge of geology.

Further particulars can be obtained from the Head of the Department of Geology.

OFFICIAL APPOINTMENTS

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications are invited for Imperial Chemical Industries Fellowships tenable at the University College of North Staffordshire. Fellowships may be awarded for the purpose of carrying out original research in chemistry or physics for a period not exceeding three years. Applicants should preferably hold the degree of Ph.D. or have equivalent research experience. Annual stipend will depend upon age, qualifications and experience, but will be within the range £700 to £1,000 together with F.S.S.U. benefits.

Applications (two copies), stating age, details of education, career, and qualifications, publications, and an outline of the proposed research, together with the names of two referees, should be sent not later than March 31, 1958, to the Registrar, University College of North Staffordshire, Keele, Staffs, from whom further inquiries may be made.

CHESTER BEATTY RESEARCH INSTITUTE

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Graduate required for work involving applications of ultra-violet and interference microscopy, etc., in biology. Person with some postgraduate experience in microscopy and/or biology preferred. The post is permanent and superannuable, and salary will be on a scale in accordance with age and qualifications.

Applications, giving names of two referees and marked " EMFR," should be sent to the Secretary, Chester Beatty Research Institute, Fulham Road, London, S.W.3, by April 19, 1958.

AUSTRALIAN NATIONAL UNIVERSITY

RESEARCH SCHOOL OF PHYSICAL SCIENCES

Applications are invited for a Research Fellowship in the Department of Nuclear Physics. This Department, under Professor E. W. Titterton, has three accelerating machines in operation—600 KeV. and 1.25 MeV. Cockcroft-Walton accelerators and a 33 MeV electron synchrotron. The main programmes of work involve light element and photodisintegration studies. The salary will be within the range £A.1,350 to £A.2,000. The appointment will be for three years, with a probable extension to the maximum of five years. For an overseas appointee the appointment could be taken up at any convenient time during the year 1958. Superannuation on the Federated Superannuation System for Universities pattern will be provided and reasonable travel expenses will be paid.

Further particulars and information as to the method of application are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. The closing date for the receipt of applications, in Australia and London, is April 30, 1958.

UNIVERSITY COLLEGE OF SWANSEA

Applications are invited from Physicists with suitable experience, for a Senior Tutorship in the Department of Physics. University teaching experience is desirable. Salary on the Lecturer scale, £900 to £1,650 per annum. Commencing salary will be at a point on the scale determined by qualifications and experience. Membership of F.S.S.U. and children's allowance scheme.

Further particulars may be obtained from the Registrar, University College of Swansea, Singleton Park, Swansea, to whom applications (six copies), must be sent by April 8, 1958.

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Applications are invited for the post of LECTURER in the NUCLEAR ENGINEERING LABORATORY. The laboratory is primarily engaged in postgraduate teaching and research. Preference to candidates experienced in reactor physics or nuclear metallurgy. Salary scale £900 by £50 to £1,350 (efficiency bar): £1,425 by £75 to £1,650 plus London allowance £60 (initial salary according to qualifications and experience) with F.S.S.U. participation and family allowance of £50 for each child.

Details and application form (returnable by April 8) obtainable from the Registrar.

UNIVERSITY OF LEEDS

DEPARTMENT OF PATHOLOGY

Applications are invited from graduates in medicine or science (if the latter, preferably with a Ph.D. in one of the medical sciences) for appointment to the Lyons Fellowship for Multiple Sclerosis and Allied Nervous Diseases of the annual value of £1,250 rising by £100 a year; the appointment will be for one year in the first instance, renewable for two further years.. Under the direction of the Professor of Pathology the Fellow will take part in a combined programme of research on the biology of myelin and the experimental pathology of the demyelinating diseases.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained), not later than April 14, 1958.

UNIVERSITY COLLEGE OF SWANSEA

Applications are invited for a Lectureship in the Department of Chemistry. Candidates must have special qualifications in physical chemistry Salary on the scale £900 by £50 to £1,350 by £75 to £1,650 per annum. Commencing salary will be at a point on the scale according to qualifications and experience. Membership of F.S.S.U and children's allowance scheme.

Further particulars may be obtained from the Registrar, University College, Singleton Park Swansea, to whom applications (six copies) must be sent by Monday, April 14, 1958.

UNIVERSITY OF LIVERPOOL

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Applications are invited for the following vac cies: (a) Physicist or Engineer to co-operate the design and development of a large liq hydrogen bubble chamber and associated pla for use in high energy nuclear physics resear Salary according to qualifications and experienc (b) Draughtsman to work with above. Sal range £700 to £900 per annum.

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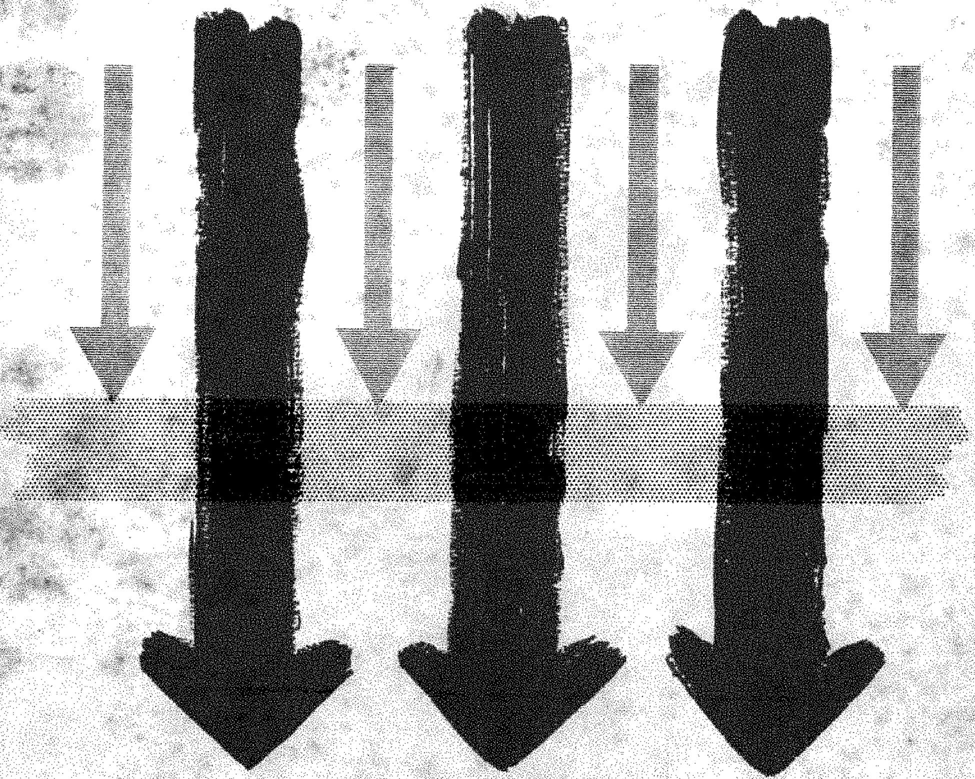

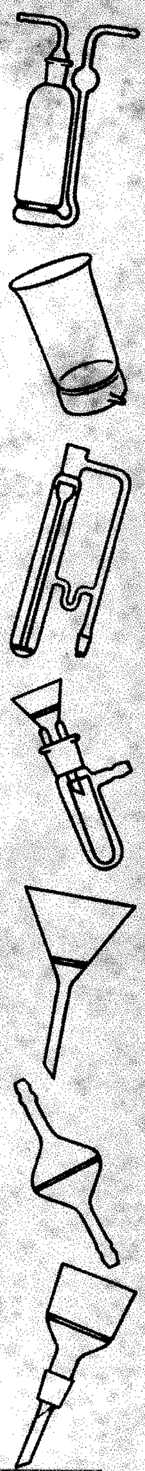

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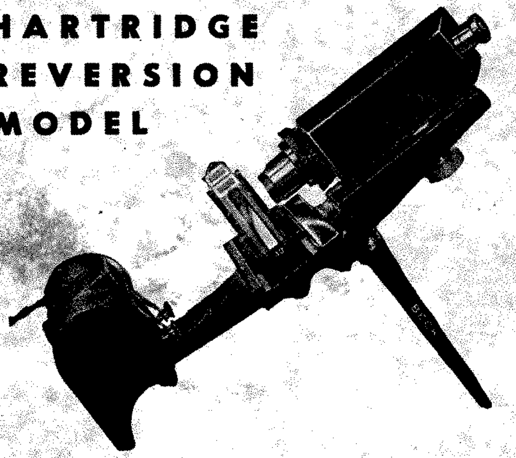

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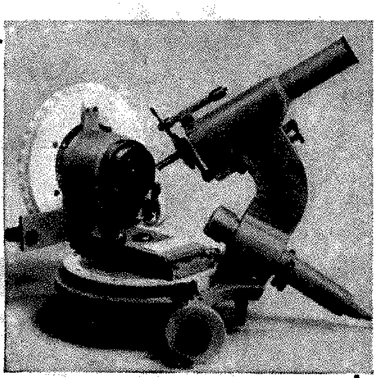

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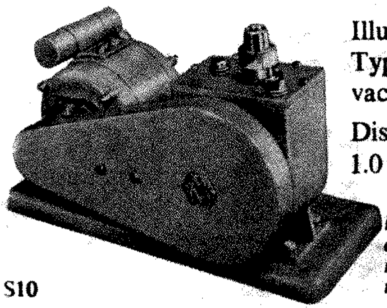
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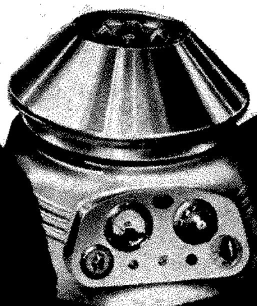

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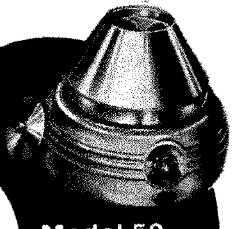

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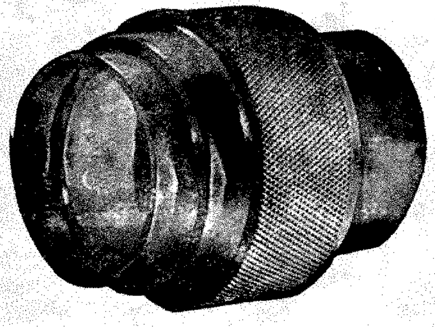

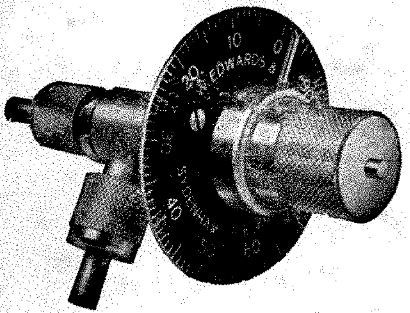

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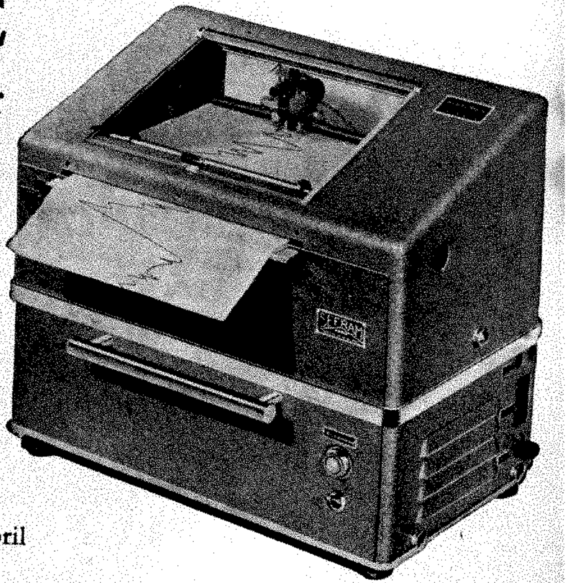

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THE COUNCIL FOR NATURE

THIS year, which sees the celebration of the centenary of the Darwin–Wallace joint statement on natural selection, will also witness, more quietly, several consequences of that statement. Darwin's emphasis upon observation in the field and the importance of searching the rocks for fossils, gave a new stimulus to natural history, and it must be more than mere coincidence that the decade following that statement and, afterwards, the publication of the "Origin of Species"—saw the formation in Britain of an impressive number of naturalists' societies, mechanics' institutes and museums. Clearly, there was then a determination among ordinary people to examine for themselves the facts of Nature.

The pendulum of public interest has swung many times since then, and may currently be said to incline more favourably towards archæology. None the less, many of the societies and field clubs so founded linger on, though in but few is there much evidence of the enthusiasm in which they were so bravely launched. Records testify to the passing away of several proud names and the cessation of journals that were once useful and of wide circulation.

These facts are of importance, for it is clear that there is still need of their former activity. The statement that "all data in natural history are vanishing data" has seldom been so obviously true. The need to collect, collate and to conserve the materials of Nature is urgent. Even such tasks as the observation of the pollution of streams and the deterioration of roadside verges, well within the competence of local societies, are being neglected. Unfortunately, even among continuing bodies, activities seem to be desultory. Useful surveys are begun but fail to be maintained. It is true that there are some few notable exceptions in this depressing picture, and that there are 'unions' of scientific societies, regional affiliations which in some instances, as in the South Eastern Union, have organized programmes and an annual conference.

Naturalists are not alone in facing these problems. After the Second World War, the archæologists took stock of their affairs and, after consultation with local societies, university extra-mural departments and other interested organizations, on a broad and democratic basis, formed the Council for British Archæology, now so ably led by Prof. W. F. Grimes. These and other considerations have suggested to the Society for the Promotion of Nature Reserves that something could be done equally for the propagation and revival of interest in Nature, for the formation of local nature reserves, and the encouragement and co-ordination of appropriate societies.

As a result of these deliberations, a small working party was formed, including representatives of the Society for the Preservation of Nature Reserves, the Council for Field Studies, the Nature Conservancy, several societies and naturalists' trusts, and plans were made for the formation of a Council for Nature. These plans were made public and were freely discussed at a special meeting held in the rooms of the Linnean Society on February 19, and as a result a Council for Nature and a provisional committee were set up under the presidency of Lord Hurcomb and the chairmanship of Sir Landsborough Thomson. The immediate task of the committee is to consult the wishes and investigate the needs of local societies and regional organizations.

This inauguration, which was thought by some to be rather premature, is in fact most opportune. The Carnegie United Kingdom Trust has recently evinced an interest in the amateur in field studies of archæology and natural history, and has discovered the difficulty of finding a representative body with which to discuss aims and methods. As a direct consequence, the British Association has accepted a grant from the Trust to undertake the preparation of a directory of cognate scientific societies. This work is in active progress, its committee endeavouring to steer a course between the eight hundred or so societies that are strictly relevant and the two thousand or more that have a tenuous connexion, usually a sporting interest, with some aspect of botany and zoology. There is no doubt that this directory will provide a valuable basis for consulting all the societies claiming activity in some field of Nature.

But societies, even giving them their full due, are not the only interested parties. There are national bodies, some of which have expressed a desire to co-operate fully with the new Council, that are concerned with much wider aims. The advance of science is frequently a mixed blessing: the claims of technology being made, and sometimes carried, at the expense of natural amenities. Reasonable compromise is often possible and occasionally takes place, but who can really speak for the whole body of naturalists ? With no active voice at the moment, representations made on reasonable grounds are sometimes feeble, often conflicting and frequently ill-argued. The Nature Conservancy, powerful and experienced and friendly to local interests, is none the less a government department, and is hampered in its dealings with other government departments.

The Council for Nature has thus a primary function to fulfil: that of watchdog—but not necessarily that of unflinching opponent—of all schemes alleged to spoil the countryside. It is important to stress that the Council will not exist as a purely restrictive body. The national parks of Britain, with all their problems caused by the access of some members of the public to places of beauty, may welcome its aid. Public education and information may be found, in the long run, more rewarding than compulsion or interference with public freedom. The Council of Nature is, by its origin, favourable to the interests of the amateur, the hiker, the photographer and the bird watcher—the general public of the parks. As yet, in Britain, we lack the service of guides and instructors, so commendably provided by the National Parks Organization of the United States. We would commend the American service to the new Council, and suggest that co-operation and some early exchange of staff would be rewarding.

Education in Nature need not, however, begin either on the hillside or by the seashore. There is need for instruction in schools from members, say, of a special panel of lecturers. Courses for adults could be arranged in evenings in museums and colleges, clubs and societies. More general education by books, pamphlets, guide leaflets (as in the United States), by television and radio could do—and already is doing—much to make an intelligent and constructive approach to the study of Nature and to denigrate careless and destructive actions.

Much of this day-to-day work cannot, of course, be done best by a central body, and much will depend and devolve upon local groups, trusts and societies; but it must be rationalized and co-ordinated. Consideration of surveys that should be undertaken by societies can be made, programmes devised, inaugurated and some continuity of effort guaranteed. This should make for efficiency and economy in general work on natural history.

The foundation of local naturalists' trusts, on the lines of those in Lincolnshire, will obviously be one of the objects deserving the Council's support. Attention must also be paid to the lessening skills in certain aspects of amateur zoological and botanical work that seem to threaten accomplishment. Here instruction, encouragement and, perhaps, even subsidy can be given.

It is obvious that a wide field of liaison with societies, trusts and local interests on one hand, and with the Nature Conservancy on the other, can be effected, and this the Conservancy would no doubt welcome. Legal services too, where necessary, can be organized. Close co-operation with the British Association, the Council for the Preservation of Rural England, the similar council for Wales, the Council for Field Studies, and university departments can be assured from their representatives on the provisional committee. Conservation is still in its youth in Britain. Much needs to be done to make its aims more clear to the general public and to remove that feeling of interference that the name seems to convey in some quarters.

None of this work, least of all a journal devoted to its interests, can be done without adequate finance. The Society for the Promotion of Nature Reserves has generously promised to bear much of the expense of the inaugural years. When the aims of the Council become more legally defined in its constitution and more clearly appreciated, it may be that one of the benevolent financial trusts may see in the new body the organization that naturalists and nature-lovers have long desired. What must be clearly emphasized is that the Council for Nature proposes to act as co-ordinator and agent, as protector, and not suppressor, of local interests. There is room in it for all who love Nature and who respond to Emerson's lines:

> "Hast thou named all the birds without a gun ?
> Loved the wood-rose, and left it on its stalk ?"

The title of that poem might well be the motto of the Council for Nature itself—Forbearance.

PRACTICE FORESHADOWING SCIENCE

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Pioneer Livestock Breeder. By Prof. H. Cecil Pawson. Pp. xv + 200 + 10 plates. (London: Crosby Lockwood and Son, Ltd., 1957.) 25*s.* net.

VERY often old farming books propound theories or describe practices that seem to indicate that their writers had some inkling of the principles of modern science. It is extraordinarily easy to accept this conclusion, because it is very difficult to re-create in one's mind the condition of knowledge at a given date. When a great innovator like Robert Bakewell has written nothing about his theories, and left no record of his practice, this difficulty becomes almost insuperable.

Bakewell left the record of his success in the animals he produced—horses, cattle, sheep and pigs; but he was secretive about his methods. When Prof. H. C. Pawson discovered the letters published here for the first time, there was some hope that more would be revealed about the way in which Bakewell bred such fine animals, that made him so famous, both in his own day and in the esteem of posterity. In this respect the letters are disappointing, but they have provided a good reason for an attempt to write a monograph on this important man, about whom only a few brief periodical appreciations have been written in the past. The character of the man and some of his business methods are more closely delineated in these new letters.

The additional resources provided by the fodder crops, introduced from the Low Countries in the seventeenth century, and developed in English farming in the eighteenth century, had provided a means of feeding better cattle. Before that time there were so-called breeds, but these animals were all subjected to restricted nutrition in the winter, as indeed their owners were. The consequence was that, while almost every county claimed to have a breed of its own, the greatest distinctions that could be drawn were in colour, shape of horn, and perhaps size. Between the haphazard methods of breeding and poorness of feed all sank to a poverty line, and were brought to a low and equal level of comparative uniformity.

With better feed, especially during the winter months, it became possible to maintain the animals in thriving condition throughout the year. If the best of them were selected for breeding, new standards would be set up, and breeds defined. Enclosed pastures made it possible to select breeding material.

Bakewell was not the first man to take advantage of these new developments, but he was one of the most distinguished. Being the tenant of enclosed fields, and having the natural flair that is the most valuable possession of a livestock breeder, he was able to produce an outstanding race of Longhorn cattle, of New Leicester sheep and 'black' horses. The economic conditions of the time, too, encouraged his efforts, as those of others, because there was a rising demand for the meat-producing animal.

Of necessity Bakewell was an empiricist, but he was of an original cast of mind, and Prof. M. McG. Cooper, who contributes to this book a modern evaluation of Bakewell's work, estimates that his ideas were well over a century in advance of his time. So far as can now be learned, the main principles of Bakewell's breeding system was a degree of in-breeding which some have thought excessive, combined with what is now known as the progeny test, something largely neglected in the intervening century and a half. The results were so remarkable that Bakewell earned an international reputation in his own lifetime, and was sought out by visitors from all over the world. He could not, of course, have explained what he did in terms of modern genetical science, but he used the observed results of careful experiments. No doubt intelligent farmers had been in the habit, when they could, of selecting their best animals to breed from in the hope that like begat like, but Bakewell led the way towards modern breeding. His new water meadows added to his supply of 'natural' feeding stuffs. It is unfortunate, as Prof. Pawson says, that his records, if he ever kept any other than in his memory, have vanished, and that little is known of his early life. Nevertheless, this book forms a welcome addition to our knowledge of one of our greatest farming pioneers. The fact that it adds little to an exposition of his methods in a more explicit manner is no fault of the author; the necessary evidence does not, in fact, exist.

G. E. Fussell

PRINCIPLES OF ANALYSIS

Quantitative Inorganic Analysis

By Prof. G. Charlot and Denise Bézier. Translated by Dr. R. C. Murray. Pp. x+691. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1957.) 84*s*.

THE chief aim of this unusual book seems to be to stimulate an interest in fundamental principles rather than to provide detailed descriptions of reliable analytical methods. The authors state that their book is no replacement for specialized works.

In the first half of the book the theoretical aspects of chemical analysis are emphasized, particularly in relation to physico-chemical methods: the thirty-three chapters deal with a variety of subjects, including not only those usually found in works on chemical analysis but also, as examples, with statistical methods, determinations in solvents other than pure water, electrography, coulometry, and the use of radioactivity in analysis. Some practical details are included, though the treatment of some subjects, such as emission spectrophotometry, is very brief and the reader is left to use the many references provided.

Part 2 of the book deals with the determination of sixty-five of the chemical elements and contains much succinct information, though here again the practising analyst will often need to refer to the many original papers and specialized books listed.

The authors have attempted to provide comprehensive, though sometimes very brief and uncritical information and some blemishes are inevitable. As examples, one would hesitate to rely on ferrous ammonium sulphate for the standardization of dichromate, and one wonders why on p. 480 the gravimetric determination of manganese as pyrophosphate is omitted, while the poor method based on weighing as trimanganic tetroxide is mentioned. There is no mention on p. 546 of the gravimetric method for the determination of potassium based on weighing platinum after a chloroplatinate precipitation. One is surprised to read on p. 392 that the determination of bromide in the presence of chloride is difficult; no mention is made of the work of Haslam *et al.* (*Analyst*, 75, 343; 1950).

However, despite its defects, the book should encourage the student of analytical chemistry to strive for a better understanding of his work and to explore the possibilities of new methods.

C. O. Harvey

REASON AND CONTROVERSY

Methods and Criteria of Reasoning

An Inquiry into the Structure of Controversy. By Rupert Crawshay-Williams. (International Library of Psychology, Philosophy, and Scientific Method.) Pp. viii+296. (London: Routledge and Kegan Paul, Ltd., 1957.) 32*s*. net.

AS its somewhat pretentious title indicates, this book deals with the various ways in which disagreements and controversies arise, and in which they can be resolved. Much of the argument expounds and applies ideas that have dominated recent philosophy; unfortunately it is conducted in a repetitious manner, and in a terminology that does not conform to the standards of precision which it, itself, desiderates. Some good points are made on the way, particularly concerning that fashionable shibboleth 'ordinary language'. Mr. R. Crawshay-Williams explicitly confines himself to what he calls 'testable' statements; he is not concerned with those which lack a decision-procedure for their truth or falsity, although he rightly says that these may be illuminating or interesting in some ways. This restriction of topic, quite legitimate in itself, involves a notion of testability which is too *simpliste*. It is baldly asserted, on p. 258, that the only kind of evidence that can be adduced for any belief is 'scientific' evidence; this view, which recalls the logical positivism of the 'twenties, now requires defence, and should not be taken for granted.

If the word 'science' is given such a wide meaning that it becomes vacuous, the principle is trivial; if used in its proper sense, the principle should be stated in a way that faces up to recent criticisms of the verification principle, contemporary developments in ethics, and, indeed, the existence of history as a form of knowledge. Crawshay-Williams's task is to show how, by redefinition and explication, we can render indeterminate, and hence controversial, statements into determinate and testable ones. He discusses examples of scientific controversy ('Are viruses molecules or organisms?', 'Is aphasia a pure or complex disorder?') in an interesting way which illuminates the conceptual tangles at issue, but which does not clarify or reinforce the main thesis. This is that the meaning of all descriptive statements is relative to both the context in which they are made, and to the facts in question. No description can be complete, or true, in itself, that is, out of relation to our cognitive interests; these determine the relevant area of fact, which in turn determines the truth or falsity of the description. Empirical discourse is described as a function of three variables: the subject matter (S), the description (D), and the context of the description (C). A complete analysis of an empirical statement is of the form 'S is D in C'; the correctness of a description depends not only upon facts but also upon the context in which it occurs. If Smith arrives 0·5 sec. before Jones, we correctly say that they arrived 'at the same time' in the context of a party, but it would be wrong to say that they had dead-heated in the context of a race.

This is important and true, but Crawshay-Williams's account of it is not satisfactory. Misgivings can be indicated only briefly. (1) It is assumed that empirical assertions are descriptions; this is not so, because existential statements, which are certainly empirical, are not descriptions, and only in rare cases are they dependent on context ('Is there a ghost in Hamlet?'). Ordinary existential statements like 'There is a fox in the covert' seem to be complete, and true or false, without reference to context. (2) The words 'sentence' and 'statement' are used as if they were synonymous, or nearly so; there is a mistake here, and it leads Crawshay-Williams into muddles. He distinguishes between sentence-token and sentence-type (p. 213), statement and statement-type (p. 72–3), and sentences and propositions (p. 85). The relations between all these are not explained, and hence there is an obscurity at the heart of the argument. (3) The words 'context' and 'criterion' are distressingly vague. The former is used to mean both 'universe of discourse' and 'purpose', while it is not clear whether 'criterion' is used to refer to the truth or to the meaning of a statement. It is regrettable that a book in this well-known series should contain elementary mistakes of grammar; three sentences conclude with the phrase "being paid attention to". C. K. Grant

A NEW APPROACH TO ELECTRICITY

Currents, Fields, and Particles

By Prof. Francis Bitter. Pp. xiv+600. (Cambridge, Mass.: Technology Press of the Massachusetts Institute of Technology; New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 68*s*.

This excellent book represents the second-year work of a two-year course developed by Prof. Bitter at the Massachusetts Institute of Technology, and "based on atomic physics". Sorted out into a more traditional sequence, the contents are similar to those of many books on electricity and optics available for this level, and the standard is at least as high. The arrangement and presentation are strikingly original, for the author has woven modern ideas into the whole of the book, so that the reader assimilates them as he goes through it instead of colliding with them towards the end. The general attitude of the author is like that of R. W. Pohl, to whom indeed he pays tribute, and the work carries the same persistent challenge to think in terms of fundamental physics as Pohl's books did nearly thirty years ago.

The first four chapters centre on the electric field and the electrical structure of matter, ionic and electronic conduction, and the detailed behaviour of dielectrics. It is interesting here to see how fully Rutherford's experiments on α-particle scattering, and, later, various uses of the RC circuit are discussed; these embody most important points of principle. On the other hand, the oscilloscope, the Van de Graaff machine, the linear accelerator, and other rather technical applications are indicated or outlined only. The main object, the study of the interaction between electric field and charged particle, is pursued firmly without digression.

The magnetic field is introduced (after a brief discussion of the unreliability of the magnetic dipole as a test object, and the rather too recent discovery of the utility of the proton for this purpose) in terms of the force experienced by a moving charge. The experimental justification for this is that the cyclotron, the velocity-selector, and measurements of e/m are known to work. Here the more elderly reader, who has after a struggle abandoned magnetostatics and accepted Ampère's experiments as a starting-point, is made to think very hard. Prof. Bitter is quite clear about the two main difficulties to be resolved. First, that the force between two current-carrying conductors is a very different matter from the force between two charged particles in motion; and also that we have no direct experimental knowledge about the field due to a single moving electron. He writes down the expression for the field due to a moving charge, and states that this is *consistent* with all experiments done using current-carrying conductors. This seems quite a revolutionary approach; but after all, only one sound experimental link between charged particle and magnetic field is really needed, and the rest is a deductive chain. It is unlikely that teaching laboratories will ever replace their current-balances by cyclotrons, and of course the author's treatment does not imply this kind of thing. The point is that the basic concept is taken to be the interaction between magnetic field and charged particle, rather than the force between pole and pole or between circuit and circuit. The determination of the ampere is explained clearly; and this chapter can be particularly commended for its presentation of what is at all levels one of the most difficult matters to teach.

From the next three chapters, on electromagnetic induction, electrical oscillations and electromagnetic waves, a few instances only need be given of their quality. The detailed treatment of the energy relations in an inductor, the very full account of the Hall effect, and the opportunity taken in the section on resonance to explain electron resonance and nuclear magnetic resonance in materials, are examples.

It would seem logical, and a great economy of effort, to treat light after the general properties of electromagnetic radiation have been mastered. Chapters 9 and 10, which deal with geometrical and physical optics, respectively, at first seem rather too elementary, for the electromagnetic theory is not, in fact, employed. But these chapters fit into the pattern of those that follow, when spectroscopic evidence for the location of energy-levels, the diffraction of particles, the black-body spectrum, and other topics requiring a background of optical knowledge appear. The beautiful frontispiece, of spectra taken using a grating crossed with an échelle, is, incidentally, not explained until the appendix.

The final chapters, starting with a review of the experimental basis of atomic physics, cover wave mechanics, atomic structure and nuclear physics.

The problems at the ends of the chapters themselves make interesting reading, ranging from calculations on the Massachusetts Institute of Technology cyclotron magnet and the interpretation of tables of experimental results to some very searching tests of a student's capacity to handle complicated data.

The book can be recommended with enthusiasm as an outstandingly clear explanation of fundamental principles in present-day terms. G. R. Noakes

THE SOLAR CORONA WITHOUT AN ECLIPSE

Die Sonnenkorona

Von Prof. M. Waldmeier. Band 2: Struktur und Variationen der Monochromatischen Korona. (Lehrbücher und Monographien aus dem Gebiete der Exakten Wissenschaften. Astronomisch-Geophysikalische Reihe, Band 5.) Pp. 353. (Basel und Stuttgart: Birkhäuser Verlag, 1957.) 68.50 francs; 68.50 D.M.

SINCE the early 1930's a number of astronomers have followed Lyot in making regular daylight observations of the solar corona from suitable mountain-top observatories. Prominent among these has been Prof. M. Waldmeier, director of the Federal Observatory at Zurich, and to-day an acknowledged expert in this field. For nearly twenty years he has carried out an extensive programme of such measurements, working at his Observatory's mountain station above Arosa, and this is the second of a series of three books describing the results. The first two books are confined to little more than a description of the apparatus, the methods, and measures; the third will discuss the physics of the corona, presumably in a much more general way.

Since there is often misunderstanding among those without special knowledge of this subject, it may be well to emphasize that normal coronagraph observations, including Prof. Waldmeier's, do not go more than about 5 minutes of arc from the edge of the Sun's disk. Even with the most advanced electronic devices there is at present no possibility of measuring optically in broad daylight to more than a radius, say, 10–15 minutes of arc, from the solar limb. For everything beyond a few minutes of arc, out to the zodiacal light region, 25 deg. or so away, we must rely still on total solar eclipses and on radio astronomy.

This volume, then, relates to the inner corona only, but within this restricted region the amount of information provided is very considerable. Perhaps the most important feature of Prof. Waldmeier's work is that he has observed systematically, with as standardized a procedure as possible, over more than a whole sunspot period. This second volume concentrates on the brightness distribution within the corona in the light of a few bright spectrum lines, especially the green line, 5303A. of [Fe XIV], and the red line, 6374A. of [Fe X]. These lines are not only the most convenient to measure; their considerable difference in ionization-level means that the relative behaviour of the two gives us valuable information on temperature and electron-density variations.

Prof. Waldmeier provides us lavishly with tables and diagrams, so that we may follow easily the large changes in brightness and shape of the corona through the sunspot cycle, and may see also the close local relationship with sunspots and faculæ. A great deal of the work rests on simple intensity measurements at a given height in the corona, but in addition there are estimates of the greatest height to which the corona could be detected against the sky and a number of measures of isophotes in 5303A. light, made using the 5350A. line from a thallium lamp for comparison. A series of sketches of coronal condensations are also given. These are somewhat rarer phenomena, usually with a life-time not exceeding one hour, and are associated with large, active, sunspot groups, and with typical spot prominences.

Apart from the condensations, however, most of the coronal structure revealed in this work seems to be rather stable, with relatively small changes during intervals of a fortnight. It thus becomes possible, from what we see projected on the sky around the Sun, to construct a first approximation to the three-dimensional corona and to compare what we get with the activity on the photosphere beneath, although the spots, faculæ, etc., by which this activity is assessed are observed near the centre of the disk, separated by a week from the related measurements of the corona. The book gives many charts with comparisons of this kind.

This is very much an individual work. The measurements appear to have been made entirely by the author, single-handed. Literature references are to the author's papers exclusively, and little attempt has been made here to relate the observations to investigations by any other astronomer. Presumably a more general discussion and synthesis will come in the third volume. Meanwhile we have in this and the first volume an impressive collection of measurements, of great importance for anyone who wishes to become better acquainted with the still poorly understood outer atmosphere of the Sun.

R. O. Redman

LOW-TEMPERATURE PHYSICS

Handbuch der Physik

Herausgegeben von S. Flügge. Band 14: Kältephysik I. Pp. vi+349. 72 D.M. Band 15: Kältephysik II. Pp. vii+477. 112 D.M. (Berlin: Springer-Verlag, 1956.)

TO find, in an encyclopædia of physics running to fifty volumes, that two should be devoted specifically to low-temperature physics raises the question whether nowadays it is a sufficiently distinct branch to justify separate treatment. Perhaps before the War an affirmative answer could have been given; only a few laboratories were equipped to handle liquid helium, and they confined their attention almost exclusively to phenomena occurring at the lowest attainable temperatures. This attitude still persists in some laboratories, particularly the larger cryogenic laboratories in Europe, but it is beginning to seem a little out of date now that liquid helium is so readily available and its specialized techniques so easily assimilated. A more realistic taxonomy of physics is one which accepts solid-state physics as a major subdivision, comprising a wide variety of topics such as metals, semi-conductors, dielectrics and magnetic materials, and perhaps incorporating the liquid state into honorary membership. In this classification cryogenics is relegated to a comparatively humble office as one out of many useful techniques, and this is surely as it should be. Electrical conduction at low temperatures is not, one hopes, to be sharply distinguished from electrical conduction at room temperature and upwards; and as our knowledge increases we may expect to see superconductivity (usually quoted as a typical low-temperature phenomenon) fit into place as but one aspect of the behaviour of metals. Similarly, although the interest of liquid helium essentially is derived from the fact that it remains liquid down to the lowest temperatures, its ultimate importance to physics does not so much lie in this as in the light it throws on the liquid state in general, and the fact that it provides both stimulus and critical tests for fundamental theories of the condensed state of matter.

Thus the editorial policy which has singled out low-temperature physics for special treatment has encouraged the authors to take a narrow view of their topics, and unfortunately several of them appear to have accepted this limitation of their scope with something like enthusiasm. Indeed, so much labour has obviously gone into these exhaustive compilations of facts that it may seem ungrateful to complain that the total effect is one of deplorable dullness. Yet there is indeed only one article, that by J. Bardeen on the theory of superconductivity, which can really be said to be exciting; and this is distinguished from the rest chiefly because the author is not content to act as an impassive recorder of what is known, but is eager to explore those regions where the meaning of the observations is obscure. It might perhaps be contended that speculation is out of place in this sort of ponderous compendium; but surely the reader may be permitted to expect a mite of imagination in return for the very stiff price he must pay. All too often we have in these articles the mere body without a breath of the quickening spirit, and £8 a volume is too much to ask for a sarcophagus of physics.

A. B. PIPPARD

NORTH AMERICAN SNAKES

Handbook of Snakes of the United States and Canada

By Prof. Albert Hazen Wright and Anna Allen Wright. Vol. 1: Pp. xviii+564. Vol. 2: Pp. ix+565–1106. (Handbooks of American Natural History.) (Ithaca, N.Y.: Comstock Publishing Associates (Division of Cornell University Press), 1957.) 14.75 dollars the two volumes.

HERPETOLOGISTS must form a very small percentage of the population, for the aversion and horror inspired by snakes in the ignorant is very widespread. "Because of his fear, his agricultural practices, his livestock, and his vehicles, man is the worst enemy of snakes. From senseless fear man kills beautiful small ringnecks and useful large rodent eaters with a wantonness hardly believable." But it will be a long time before he stops blindly following the biblical injunction to crush under the heel the allegorical satanic serpent. This exhaustive work gives an account of all the species of snakes found in the United States and Canada, and forms a valuable handbook for herpetologists everywhere but particularly for those of the North American continent. Gathering material for this book has occupied the authors for many years, during which they have examined, handled and photographed living examples of nearly all the species and subspecies, so that their descriptions are fully authoritative.

An introductory chapter of thirty-one pages explains the plan of the work, and discusses the various topics considered under each species. The authors point out that until recently the emphasis of herpetologists has been almost solely taxonomic, and that other aspects of the subject have been studied more or less incidentally, "for example, most of our life-history studies are of captive specimens in our zoos". The primary purpose of this book is to present the living animal, but "herpetology needs field studies of life-histories, food, movements, habits, general ecology, associations, and colour phases". The introduction includes maps showing the ranges of important plants, structural geology, forests and trees, the physical divisions of the continent, and the vegetation regions. These are most useful when used in conjunction with the numerous maps showing the range of individual species of snakes; "the types of rock masses together with the temperature and rainfall control the varied vegetative areas of the country and these in turn control the food and shelter on which the animal is dependent. We can to some extent associate certain species with distinctive soil and vegetative areas". Several pages deal with courtship and reproduction, and include an account of the varied and often bizarre surface anatomy of the hemipenis. Finally, the authors "urge young naturalists to keep journals", advice that cannot be too strongly emphasized. They note that both voluminous writers and "reticent superb field men, such as W. DeWitt Miller, have religiously recorded their observations", and rightly say that these notes prove "very useful, however good your memory may be". They might have added that even the best memory is unreliable for details, and that notes taken immediately are essential to any serious study.

The description of each species and subspecies is divided into sections: vernacular names, range, size, distinctive characters, colour, habitat, period of activity, breeding, food, field notes, and authorities. Each section is divided under various subheadings as information may be available. The nomenclature followed is mainly that of the second edition of Perkins' "Key to the Snakes of the United States" and of the sixth edition of Schmidt's "Check List of North American Reptiles". The illustrations are a special feature of the book—distribution maps, line drawings of anatomical details and scale patterns, and above all the photographs. The last show dorsal and ventral views of the whole animal, and larger views of the head and sections of the body, often in dorsal and ventral, as well as lateral, view, nearly always taken from the living snake.

The pagination of the work runs continuously through the two volumes, the second of which concludes with a glossary and a copious index. There is a select bibliography of general works on North American herpetology and of check lists. Although the work appears to be complete in two volumes the introduction to the select bibliography states that the complete bibliography will appear in Volume 3; this is the only reference to a future third volume.

DAMAGE TO SOLIDS BY LIQUID IMPACT AT SUPERSONIC SPEEDS

By Dr. F. P. BOWDEN, C.B.E., F.R.S., and J. H. BRUNTON
Physics and Chemistry of Solids Laboratory, Physics Department, Cambridge

A DROP of liquid striking against a solid surface at high velocity may produce considerable deformation and damage. Such damage can occur on the surfaces of aircraft during high-speed flight in rain; in this form it is referred to as 'rain erosion'[1]. Since 1945, when the problem of rain erosion first became apparent, its seriousness has increased enormously with increasing speeds of aircraft and missiles. Investigations into the mechanism of rain erosion have been carried out in the United States by Engel[2], and in Great Britain by Jenkins[3].

We are making a study in this Laboratory of some of the basic aspects of liquid/solid impact at very high speeds. For this purpose a simple apparatus has been developed for projecting a small cylinder of liquid against a stationary solid surface. The cylinder is normally about 1 mm. in diameter and 2 cm. in length, the mass of liquid involved being approximately equivalent to that of a large raindrop. Impact velocities of up to 3,500 ft./sec. have been obtained. Under such conditions even the hardest surfaces will become deformed.

Briefly, the apparatus consists of a small stainless steel injector into which about 0·01 c.c. of liquid can be sealed by a neoprene disk. At the instant of firing, a slug from a high-power air rifle rams the disk into the injector. The highly compressed liquid escapes through a nozzle at the far end of the injector as a short high-velocity jet or cylinder. Information on the structure, velocity and behaviour on impact of the liquid has been obtained by the Cranz–Schardin system of high-speed photography using a six-lens camera designed by Dr. J. S. Courtney-Pratt. In this manner it was possible to obtain six pictures of various stages in an event over a period of 25 μsec.

Fig. 1 is a picture of a water jet of 1 mm. diameter produced by the apparatus and moving in air. The nose velocity in this case is initially about 3,100 ft./sec. The structure of this jet can be regarded as typical of those produced by the apparatus. Air friction is responsible for the mushroom of spray at the nose of the jet; this type of break-up is quite small in the early stages of travel, but increases rapidly with distance. Because of this, target specimens are normally placed at a distance of ¼ in. from the nozzle. The cylindrical core of the jet maintains an approximately uniform cross-section along its length. High-speed photoelastic pictures indicate that only the core is responsible for inducing stress in the target material; the associated spray plays little part in the deformation process on impact. As a simplification then, the impact is considered to occur between a liquid cylinder and a plane specimen surface struck perpendicularly.

Deformation of Metals

An example of the type of deformation which can occur in a hard metal surface subjected to the impact of a water cylinder is given in Fig. 2*a*, together with the surface profile of the region in Fig. 2*b*. The metal in this case was a high-strength stainless steel. The main effect of the impact is to produce a shallow saucer-shaped depression in the surface, with the two additional features of a central pit, and a highly deformed annular region just inside the rim of the depression. The area of deformation corresponds closely to the area over which the spreading cylinder exerts a pressure; this is, of course, considerably greater than its initial cross-section. The pressure is assumed to be a maximum under the centre of the collapsing cylinder, and to fall smoothly to zero at points where the liquid flow first becomes entirely parallel to the surface. These positions can be determined from photographs taken during the impact. Such a pressure distribution on the surface would give rise to a depression similar to that in Fig. 2*b*. For comparison, the depression formed in aluminium under the same conditions is shown in Fig. 2*c*; the area of the surface affected is the same, but the depression is more than ten times as deep. The central pit in Fig. 2*a* and *b* is probably due to the effect of the very high pressure in this region on an already existing flaw or pit in the surface. Such a pit acts as a stress raiser favouring further localized deformation. In a soft metal this effect may be masked by the large overall flow.

The annular region of heavy deformation at the edge of the impact zone in metals has the appearance of having been sheared open by water flowing at very high speeds over it. The deformation marks consist of alternate ridges and depressions running parallel to the rim; in soft metals, flow channels are apparent in the depressions, indicating the manner in which metal has been sheared out to form the ridges. Such

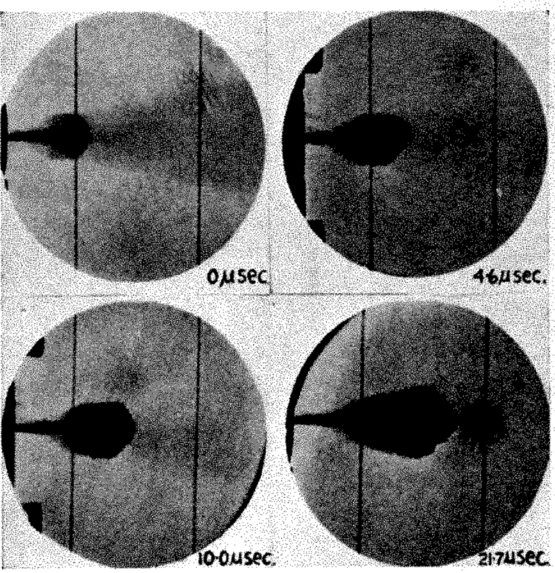

Fig. 1. A series of four frames selected from a group of six showing a water jet moving in air at an initial velocity of 3,100 ft./sec. The jet is travelling from left to right across two vertical marker wires 1 in. apart. The timing of each frame with respect to the first is shown in microseconds

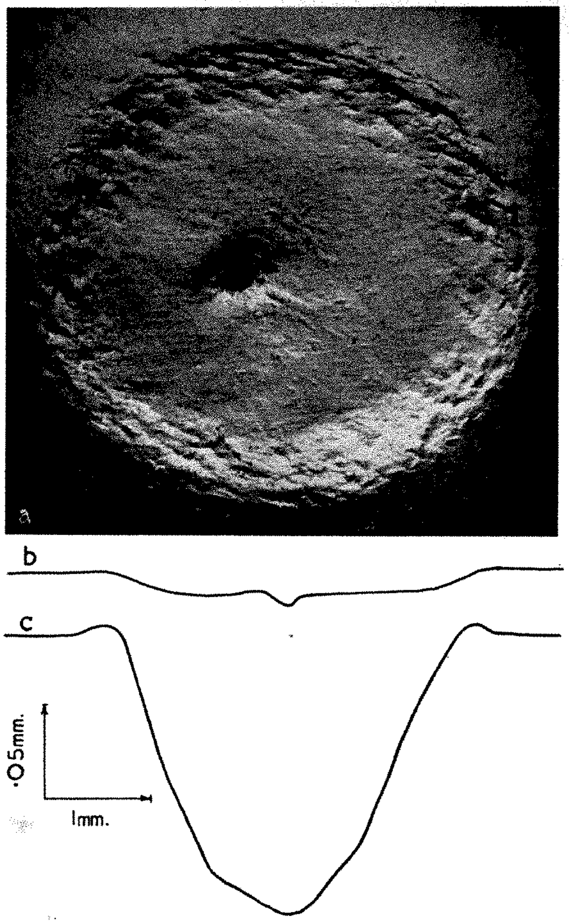

Fig. 2. (*a*) Deformation produced in a stainless steel surface by the impact of a single water jet at 2,500 ft./sec. The surface contour of the deformed region is given in (*b*), and for comparison the deformation of aluminium in (*c*)

a shear deformation of the surface would be most likely to occur at the boundary of the impact zone, where the velocity of the surface flow is greatest. If a shear mechanism is responsible for the rim deformation, then this deformation would be expected to depend upon the viscosity of the liquid. Using aluminium targets and water/glycerol mixtures as the deforming liquid, the intensity of the deformation near the rim was found to increase with the viscosity.

Deformation of Non-Metals

The failure pattern due to liquid impact in rigid plastics, glasses and ceramics is quite different from that observed in metals. 'Perspex' was found to be a convenient material in this group to work with; besides being transparent, it has the additional advantage that the state of stress in it during impact can be studied simultaneously by a photoelastic method.

Fig. 3 illustrates the surface damage in 'Perspex' due to the impact of a water cylinder at 3,000 ft./sec. The main feature of the damage is a ring crack. The area of the surface inside the ring is undamaged, and for a considerable distance outside the ring the surface is pitted with short straight circumferential cracks. The star crack which can be seen in the centre of the photograph is below the surface.

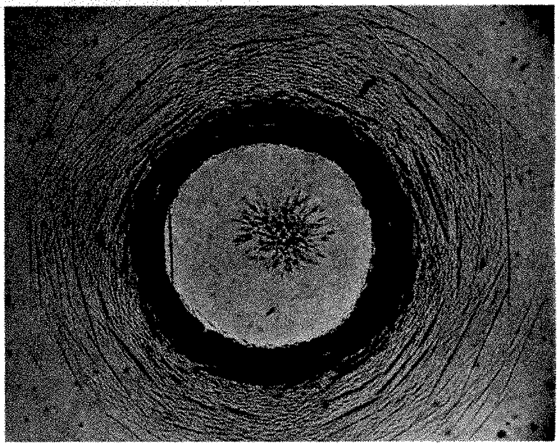

Fig. 3. Surface deformation in 'Perspex' due to the impact of a water jet at 3,000 ft./sec. The ring-crack has a mean diameter of 3·5 mm. The central star crack is beneath the surface

Fig. 4 is a cross-section through an impact zone in 'Perspex'. The central subsurface cracking consists of fracture planes lying approximately normal to the surface. The ring crack as seen in section meets the surface at an angle. Ring cracks produced at impact velocities of less than 2,000 ft./sec. often do not cut through to the surface. When this occurs, an annular depression remains in the surface above the crack; probably the presence of the crack facilitates permanent deformation of the area above it.

The effect of repeated impact on 'Perspex' is shown in Fig. 5. The surface profiles were obtained using a 'Talysurf' machine. The general behaviour is one of widening of the ring crack together with a spreading of subsurface cracks. After four or five impacts, the various fracture surfaces join up, and a large piece of 'Perspex' is dislodged from the surface.

As in the case of metals, failure in 'Perspex' can be thought of as arising primarily from the distribution of pressure under the jet, together with the deformation associated with rapid flow along the surface. Brittle failure may be expected to occur preferentially on planes across which the tensile stress is a maximum. The Hertz theory[4] of contact stresses can be used to predict the regions of high tensile stress in the 'Perspex' for the given distribution of pressure on the surface. Bearing in mind the limitations of the theory when applied to impact problems, it is possible to deduce that the maximum tensile stress occurs at the surface across the circular

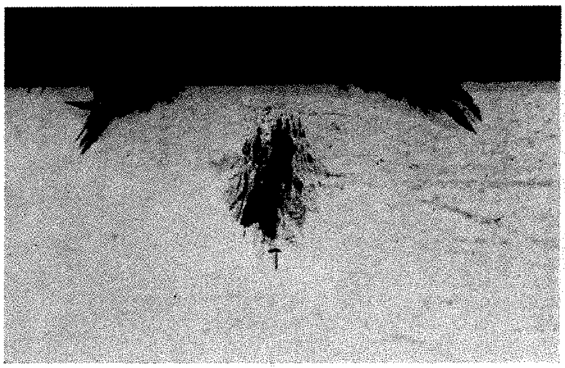

Fig. 4. A cross-section taken through an impact zone similar to that shown in Fig. 3. The shape of the ring-crack and the central zone of subsurface cracking can be clearly seen

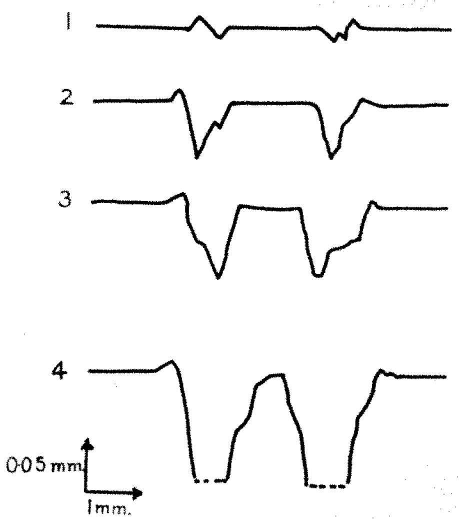

Fig. 5. The effect of 1, 2, 3 and 4 impacts of a water jet at 2,000 ft./sec. on the surface contours of 'Perspex'. The damage is seen to be concentrated in the ring-crack; the central region remains comparatively intact until massive breakdown occurs

boundary defining the limits of the area under pressure. Outside the boundary the tensile stress decreases slowly with distance; inside the boundary it falls abruptly to zero and becomes a compressive stress. Such a stress distribution accounts effectively for the pattern of surface cracking. The theory also predicts that the ring crack should form part of a conical rather than cylindrical surface.

Similarly, the tensile stress across the central axis normal to the surface attains a maximum value a little way below the surface; such a stress would explain the vertical planes of subsurface fracture in Fig. 4. The rapid surface flow accentuates these types of failure by opening up the fracture planes in the direction of flow, and in this way material is chipped from the surface.

Scabbing of the Back Surface

If the specimen is thin, a large scab may be detached from the back surface when the front surface is struck by the liquid. Fig. 6 shows this effect in a $\frac{1}{4}$-in. thick 'Perspex' plate. In this case, the top surface which has been struck has the normal ring crack, and the lower surface has developed a scab.

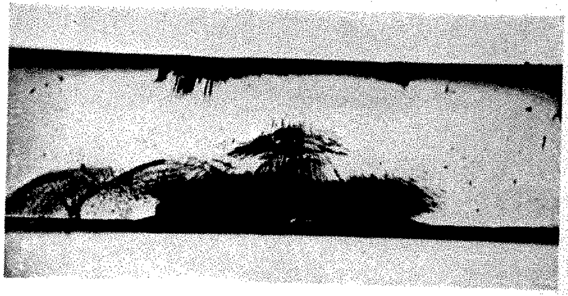

Fig. 6. Scabbing of the lower surface of a $\frac{1}{4}$-in. thick 'Perspex' plate. The velocity of the jet striking the upper surface was 3,000 ft./sec. The central zone of cracking in the body of the plate indicates a tendency to form a secondary scab, and illustrates the manner in which the reflected tension wave pulls the material apart

The compression wave set up on impact is reflected from the back surface as a wave of tension, and the associated tensile stress effectively pulls a piece out of this surface. The new surface so formed reflects the remainder of the compression wave, and the process of scab formation tends to be repeated. An attempt to form a secondary scab is shown by the cluster of cracks in the centre of the plate.

The fact that the impact of a water cylinder with a velocity of 3,000 ft./sec. can deform materials as hard, for example, as tungsten carbide is not surprising if it is realized that the pressure developed on the surface by the liquid is well above the yield strength of most common metals. The associated stress may be further magnified by the presence of surface pits. In addition, there are the shear stresses associated with the high-speed flow of the collapsed cylinder over the surface. Flow velocities parallel to the surface were observed to be two to three times as great as the impact velocity. Any surface irregularity in the path of this flow would certainly be deformed.

Since the present-day tendency is towards air travel at very high speeds, it is clear that an understanding of the mechanism of deformation processes at these speeds is desirable.

We are grateful to Dr. D. Tabor for helpful discussions during this work.

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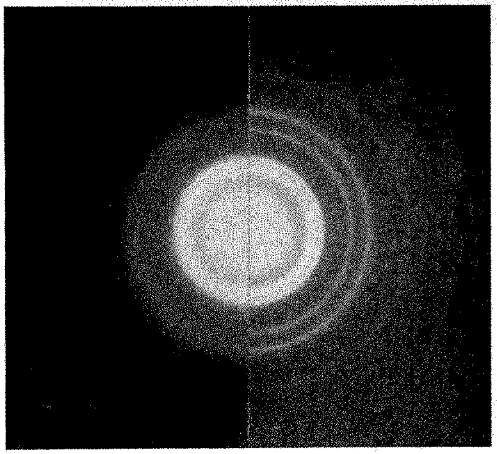
SIMULTANEOUS EVAPORATION OF PLATINUM AND CARBON FOR POSSIBLE USE IN HIGH-RESOLUTION SHADOW-CASTING FOR THE ELECTRON MICROSCOPE

By D. E. BRADLEY
Associated Electrical Industries, Ltd., Aldermaston

CONVENTIONAL methods for shadowing electron microscope specimens[1] have one grave disadvantage: the resolution obtained is seriously limited by the aggregation of the shadowing material into discrete crystallites. In the case of the much-used gold/palladium alloy, these particles may measure as much as 40–50 A. in diameter. Materials such as platinum and uranium, which are used where a higher resolution is required, form particles of about half this diameter. The resolution and quality of the resulting electron micrographs are limited accordingly. A few non-crystalline materials can be deposited by vacuum evaporation; among them are carbon[2] and silicon monoxide[3]. These materials produce sharp shadows, but their electron-scattering power is low, so that films of the order of 50 A. in thickness are



a *b*

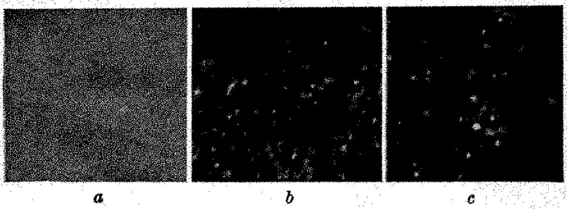
Fig. 1. Electron diffraction patterns of a platinum/carbon film: *a*, under normal operating conditions; *b*, recrystallized with very heavy electron bombardment (accelerating voltage 70 kV.)

required to obtain reasonable contrast. This thickness causes a loss in resolution due to 'pile-up' on the specimen[4], resulting in the distortion of its shape.

Clearly, a shadowing material of high atomic number, which does not form aggregates, is required. Aggregation must not occur either during deposition or under the influence of the electron beam. It has now been found that the simultaneous evaporation of a heavy metal and carbon produces a film with the required properties. Several metals have been tried, and the most suitable found so far is platinum.

The technique described here for achieving the simultaneous evaporation avoids the difficulties which would be encountered if two separate sources were employed. It is based on the method used for the evaporation of carbon alone[1]. Instead of pure carbon electrodes, however, rods containing a high percentage of platinum (about 85 per cent w/w) are used. These rods are prepared in the laboratory by an experimental process which involves bonding together the two constituents in powder form. The rods are pointed by means of emery paper and mounted in metal holders. A weak spring is fitted to hold the points together *in vacuo*. On passing a heavy current, resistance heating at the points causes carbon and platinum to evaporate together. The resulting film, even when thin, is strong enough to form a self-supporting replica. It can, of course, be deposited on previously prepared specimens in the normal way.

As deposited, the films are substantially non-crystalline. This can be seen from the halos of the electron diffraction pattern shown in Fig. 1*a*. When a dark-field image, selected from the brightest halo by means of the objective aperture, is examined, no discrete crystallites can be detected (Fig. 2*a*). It has been found that this dark-field test is extremely sensitive. The film is completely stable under illuminating conditions used for very high resolution work (instrumental magnifications of 40,000–60,000) in the experimental Metropolitan Vickers *E.M.*6, as developed in the Associated Electrical Industries Research Laboratory[5]. Granulation of the platinum only occurs under electron bombardment many times more intense than is required for normal operation. Fig. 1*b* shows a diffraction pattern obtained from a film which has been deliberately recrystallized in this way. The sharp rings of platinum indicate fairly large crystallites, and these are shown clearly under dark-field conditions, selecting the two bright inner rings (Fig. 2*b*). Evaporated platinum metal is shown under similar dark-field conditions for comparison (Fig. 2*c*). The electron diffraction pattern is similar to that shown in Fig. 1*b*.



a *b* *c*

Fig. 2. Dark-field electron micrographs (× 100,000) of: *a*, platinum/carbon film; *b*, platinum/carbon film recrystallized as in Fig. 1*b*; (*c*) evaporated platinum metal on a carbon film

The platinum/carbon ratio of the deposit has not been measured; but comparison of the composite film with carbon films of equivalent thickness in the electron microscope indicates that the platinum content is high.

The preliminary examination of platinum/carbon shadowed surfaces in the electron microscope suggests that the method is extremely promising for high-resolution shadow-casting. Typical results are shown in Figs. 3 and 4. An important point, the production

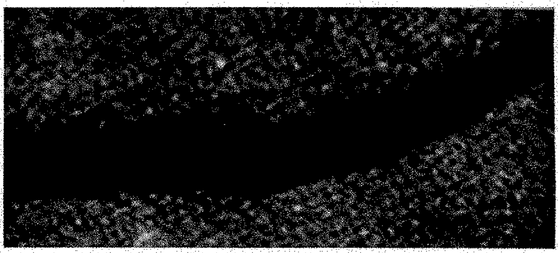


Fig. 3. Platinum/carbon replica (deposited at 45°) of an edge of a methyl orange crystal. (× 250,000)

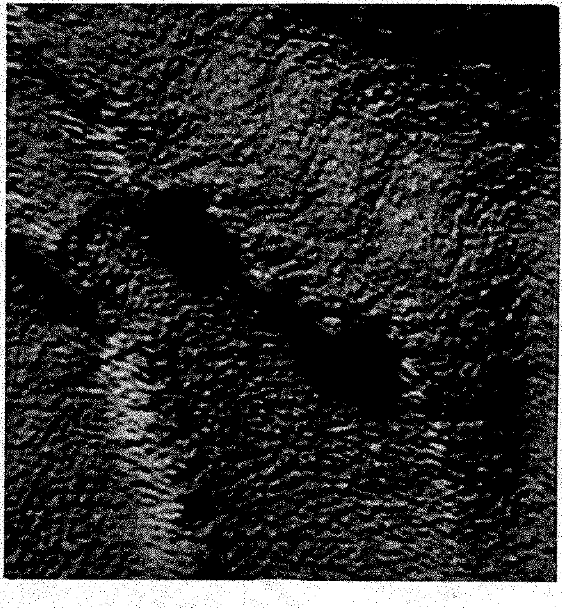


Fig. 4. Platinum/carbon replica (deposited at 45°) of a cleavage surface of a sugar crystal. (× 250,000)

of extremely sharp shadows, is illustrated in Fig. 3, which shows a platinum/carbon replica of an edge of a crystal of methyl orange. It is interesting to note that this shadow was obtained using a target distance of only 2·5 cm. (the distance for evaporated metal is 8–15 cm.), indicating a point source. It will be appreciated that there is a direct relationship between sharpness of shadows and resolution.

The potentialities of the method can be estimated from Fig. 4, which shows a platinum/carbon replica of the surface of a sugar crystal. It can be stated conclusively that the background structure is not due to the granulation of the shadowing material. The reasons are: (1) that the structure varies considerably over the surface; (2) that diffraction and dark-field tests, applied as a control to each specimen, indicate the total absence of any granularity. A close examination of the original plates shows that this structure consists of minute protrusions some 20 A. in width. This work will be published in greater detail elsewhere.

I wish to thank Dr. J. S. Halliday for his valuable advice, and also Dr. T. E. Allibone, director of the Research Laboratory, Associated Electrical Industries, Ltd., for permission to publish this article.

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PROCESSING OF FOODS WITH IONIZING RADIATIONS

MUCH attention has been aroused in recent years by the possibility of using ionizing radiations in preserving foods. Serious investigations started about ten years ago, although the idea itself is considerably older. While it has been found quite feasible to sterilize foods with radiation, some undesirable changes usually accompany the process. Such changes depend markedly on the way in which the food has been treated, and research has been particularly directed towards finding the precise conditions which give the best products. The possibilities and limitations of the method were discussed at a symposium held at Cambridge during September 26–27. About twenty foreign visitors were among the hundred and twenty who attended, and the two principal British laboratories working in this field—the Low Temperature Research Station, Cambridge, and the Technological Irradiation Group, Atomic Energy Research Establishment, Harwell—were represented.

The main attraction in using ionizing radiations to preserve foods is that the amount of radiation energy required to eliminate all food spoilage micro-organisms raises the temperature of the irradiated food by only a few degrees; the preservation of food in the raw state is therefore possible. A major deterrent, however, is that the associated chemical changes, though small in total quantity, may have adverse effects on the quality of the food, and become evident as changes in the odour, flavour or texture. It is necessary, therefore, to find methods to minimize or mask these quality changes. Smaller amounts of radiation which are insufficient to cause noticeable changes can be used. Such treatments eliminate only a fraction of the micro-organisms present—the so-called pasteurization treatments—and additional treatment, such as heat or refrigeration, is necessary to prevent spoilage of the food due to the growth of the surviving micro-organisms. Some of the results obtained using these techniques were described at the symposium. In addition to these generally applicable methods, there are also uses where small amounts of radiation can be applied to achieve a more limited particular purpose, for example, to eliminate insects in grain or packaged foods, or to inactivate food-poisoning *Salmonella* organisms in frozen whole egg; these applications, too, were discussed.

Much of the work on the irradiation of foods has been carried out in the United States, and British work is best considered against the background of American investigations. The Quartermaster Corps of the U.S. Army has sponsored the majority of this work and, not unnaturally, much emphasis has been placed upon military uses. The possibilities for civilian applications have, however, been kept clearly in mind. The present state of the work was outlined in two American papers, one by A. W. Harvey, and the other by D. K. Tressler, B. H. Morgan, M. Simon and V. K. Peterson. The dose of radiation necessary to achieve 'commercial' sterility in foods is considered to be in the range 3,000,000–6,000,000 rads. A large number of foods have been examined after doses of this magnitude, and twenty-one have been considered promising. Objectionable flavours are usually found to decrease on cooking, and generally the flavour of the irradiated foods tends to improve after storage for several weeks or months at room temperature. To support the vast amount of laboratory tests being conducted on irradiated foods, extensive animal feeding tests are in progress. These, so far, have not shown any harmful effects due to irradiation. Limited human feeding tests have also been made, again without showing adverse effects; and troop feeding tests on a larger scale are planned. To provide adequate food processing and radiation facilities for supplying the necessary food, the U.S. Army intends to construct a food-processing plant equipped with gamma-ray and cathode-ray sources, each of which can treat about 1,000 tons of food per month. Much basic research is being carried out by contract with civilian laboratories. In many cases, where the contractor is interested in civilian applications, the emphasis of this work is on the use of low-dose treatments. The smaller quality changes produced in this way will probably be more acceptable to the domestic consumer, who sees the food at all stages in its preparation for the table.

In Britain also, more attention has been given to pasteurization procedures, since most of the research has been aimed at civilian exploitation. R. S. Hannan described some of the results of a detailed examination of the response of chicken meat towards irradiation under a variety of conditions. With doses of 2,000,000 rads or more, flavour changes were considered objectionable by most members of a taste panel;

with lower doses the degree of flavour change depended markedly on the conditions before and during irradiation, for example, its oxygen content, and whether it was frozen. Odour changes in raw minced chicken meat could be detected with doses as low as 50,000 rads, but if such samples were afterwards cooked by steaming most people could only detect adverse flavour changes if the meat had been given doses of 250,000 rads. Whole chicken carcasses responded rather better: after doses of 500,000 rads or more, flavour changes were only just detectable in the roasted birds. Margaret J. Thornley said that bacterial counts on the minced chicken irradiated with 250,000 rads showed that it could be stored at 5° C. several times longer than unirradiated control samples; lower doses produced only a slight increase in storage life. Whole chicken carcasses, packed in 'Polythene' bags and given 500,000 rads, could be stored at 3° C. for two to three times as long as control samples. The bacterial flora of irradiated chicken differed considerably from that normally observed. M. Ingram emphasized that selective elimination of some micro-organisms by irradiation could result in the eventual spoilage of the chicken taking an unusual course. Adequate refrigeration seems essential to prevent the growth of possibly harmful bacteria which might survive irradiation.

A number of techniques have been suggested for minimizing the radiation damage to foodstuffs. Thus, for example, a low dose of irradiation combined with some heat treatment may be useful to sterilize foods. Freezing of samples before irradiation usually makes flavour changes less apparent, and the presence or absence of oxygen during and after irradiation is important. The use of such devices is being actively investigated. A very promising approach is to combine radiation with antibiotic treatment. This technique was used by J. Liston and J. M. Shewan in some experiments on the irradiation of fish. Cod and lemon sole suffered little adverse flavour change after doses of 500,000 rads, and the storage properties under refrigeration were improved. A much greater improvement in storage properties was achieved, however, when this dose of radiation was given after the fish had been dipped in a solution of chlortetracycline.

The use of radiation to eliminate a specific harmful micro-organism was discussed in a paper by R. S. Hannan, J. Brooks and Betty C. Hobbs on the irradiation of frozen whole egg. This commodity, large quantities of which are imported into Britain, often contains *Salmonella* bacteria which cause food-poisoning. 500,000 rads, given to the egg in the frozen state, eliminates the *Salmonella*. The principal adverse change was a slight odour in the thawed raw egg, which was not usually detected in baked products made from the egg.

Another promising application is the use of radiation to eliminate insect infestation. This is easily achieved by preventing reproduction of the insects with doses up to about 20,000 rads. Two methods of control exist: sterilization of all the insects or swamping of the female population by releasing a large excess of radiation-sterilized males. P. B. Cornwell described some experiments on the elimination of grain weevils and flour mill moths, using doses in the range 10,000–20,000 rads. Direct killing of these insects requires doses about ten times larger than this. If the economics of the process are favourable, there would appear to be little objection to the disinfestation of grain by this method. H. G. Harvey and R. S. Hannan had examined the effects of low doses of radiation upon packaged foods (for example, cereals, dried fruits, etc.) to eliminate insects, and found that in nearly all the foods examined, doses of 40,000 rads produced no detectable adverse changes.

The use of radiation in the food industry naturally presupposes that adequate sources of radiation will be available. Not all types of ionizing radiations are suitable. Any which might induce radioactivity in the food would be unacceptable—this excludes neutrons and radiations of energy higher than about 15 MeV. Others are excluded because of low penetrating power or high cost. The most generally useful are gamma-rays, of high penetration, and cathode rays, with rather limited powers of penetration. S. Jefferson, speaking on radioactive sources, said that large quantities of fission products will eventually be available for gamma-ray sources. For a number of years, however, cobalt-60, and smaller quantities of cæsium-137, are likely to remain the principal sources. At present the supplies of these are limited. M. C. Crowley-Milling, dealing with electrical machines as sources of radiation, said that cathode-rays of suitable energy are readily obtainable from linear accelerators now manufactured in Great Britain. Against the limited penetration of cathode-rays are the advantages of easy focusing, their availability as and when required, and the high dose-rates obtainable. The cost of treatment can be calculated, and Mr. Crowley-Milling gave the following estimates: to treat foods with 1,000,000 rads costs 0·4*d.* per lb.; to treat potatoes with 10,000 rads costs 1*s.* 6*d.* per ton; and to treat grain with 50,000 rads costs 5*s.* per ton. These figures make due allowance for running costs, depreciation, percentage of energy utilization, etc., but do not include any handling costs. The costs of treatment with gamma-rays are more difficult to calculate, but, for some time at least, are likely to be higher than those quoted above. Costs of this magnitude do not appear to be prohibitively high.

Other topics discussed at the symposium included the prevention of sprouting of potatoes (papers from W. G. Burton and D. B. Powell); and, among the less-promising applications, the sterilization of milk (T. Horne), the prevention of mould growth in wrapped baked products (F. J. H. Ottaway), and the elimination of micro-organisms in damp grain (T. A. Oxley).

The intensive investigations of the behaviour of food on irradiation have shown many gaps in the knowledge of how non-irradiated food behaves. This has led to the initiation of much fundamental research, both in academic studies and applied technology. As enzymes are not completely inactivated by the amounts of radiation necessary for sterilization, it is important to know what action surviving enzymes might have on stored foods. The paper by R. Zender, C. Lataste-Dorolle, R. A. Collet, P. Rowinski and R. F. Mouton, of the Battelle Memorial Institute, Geneva, was therefore interesting, dealing as it did with autolytic changes occurring during storage of sterile muscle samples. It may be that some of the changes observed with irradiated meats may be due to autolytic processes rather than to radiation effects. Similarly, much research in radiation chemistry and biology has been stimulated. At the symposium, three papers were presented on radiation chemical aspects (by A. J. Swallow, B. Coleby and N. Uri), and a further paper dealt with some chemical effects in irradiated meat (G. M. Wilson). These contributions indicated that the theories of radiation chemistry are still far from adequate to explain the changes in such complex systems as foods. As R. S. Hannan pointed out, in nearly all cases, the easiest approach to a particular problem is an experimental one. In the microbiological field there is obviously need for more information on how micro-organisms behave on irradiation, and particularly on the behaviour of those organisms which survive irradiation. If, ultimately, the idea of processing food with radiation is not exploited, the results of such researches as that of the Quartermaster Corps of the U.S. Army on the properties of packaging materials will be of great value to the food industry.

It will still be necessary to show that irradiated foods are acceptable from the medical point of view, even if the process is considered useful to the food industry and the consumer. To yield information on this topic, animal feeding studies are being conducted at the Wantage Radiation Laboratory, and T. Horne gave details of these, and the plans for future work. The very careful and large-scale experiments being conducted by the Office of the Surgeon General of the U.S. Army should also be extremely valuable. To date, the tests have failed to show any harmful effects through eating irradiated foods. Some destruction of vitamins by irradiation has been noted but, in general, losses are no greater than with most other methods of food processing.

The symposium confirmed the impression that has been growing for some time, that radiation processing is unlikely to displace conventional methods of preservation. It does seem, however, that it will be a useful additional method, and there are clearly some applications of considerable potential use where it has special advantages. But, even with these, there still remains much more research to be done before the process can be exploited commercially.

A fuller account of this symposium is available on application to the Superintendent, Low Temperature Research Station, Downing Street, Cambridge (L.T.R.S. Memorandum 312).

This article has been prepared as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

B. Colеby

OBITUARIES

Prof. R. M. Davies

Rhisiart Morgan Davies, professor of physics in the University College of Wales, Aberystwyth, died suddenly on February 18, a fortnight after his fifty-fifth birthday.

His death terminates one of the most interesting careers in the British university world. He was a native of the quarrying village of Corris, Merionethshire, and received his early education at the village school and at the grammar school at Dolgelley, where his scientific potentialities were recognized by Dr. John Griffith, one of the most remarkable of Welsh headmasters. In 1921 he entered the College at Aberystwyth, where he was destined to spend virtually the whole of his university career. He graduated with first-class honours in 1924, and was appointed assistant lecturer in 1925.

His research career may be said to have commenced at the Admiralty Signal School at Portsmouth, where he spent the summer of 1925 and where he was introduced to quartz crystals and piezoelectricity. On his appointment to the staff at Aberystwyth he entered upon a research programme on the elastic properties of Rochelle salt crystals, as determined both statically and dynamically. The circuitry of this problem led him to digress, at the instigation of a chemical colleague, into a determination of the absolute dielectric constant of pure benzene at low radio-frequencies; he also developed two types of moisture meter for use with granular materials, one of which was marketed commercially.

These various research projects were pursued with characteristic vigour and determination, and gained him in succession the M.Sc. and D.Sc. degrees of his University. An opportunity to devote his whole time and energy to research, and in particular to his early field of interest, elasticity, came in 1939 with the award of a Leverhulme Research Fellowship, with which he proceeded to Cambridge to work with Sir Geoffrey Taylor.

Sir Geoffrey soon recognized in him not only one of the few academic physicists interested in the mechanical properties of materials, but also one who was, in addition, gifted with a penetrating mind, experimental skill of a high order, and an infinite capacity for hard work. The association of the two men, started in 1939, persisted through the years; it produced, during the war period, a wealth of results, embodied in official reports, which were of the greatest value in the war effort, both in attack and in defence, and it was later to inspire much of the work of the research school which Davies established at Aberystwyth, whither he returned in 1945 and where he was appointed professor in 1946.

The research work at Aberystwyth was concerned with transient stresses and the propagation of stress waves in solids, and with detonation pressures and shock waves in gases. Much of this work arose from Davies's investigation, carried out in Cambridge and published in the *Transactions of the Royal Society* in 1948, of the Hopkinson pressure bar, originally devised in 1914 and largely neglected. The resurrection of the pressure bar as a modern instrument of research into transient high-pressure phenomena was typical of Davies's flair for rediscovering near-forgotten techniques; he had read deeply in the classical researches of the past, and nothing gave him more pleasure than to revive, from some forgotten paper by Kelvin or Rayleigh or Reynolds, some argument relevant to a modern problem.

The nature of this extensive research programme, of a type rare in British universities, inevitably brought to Aberystwyth many visitors from many lands, and to Davies himself many invitations to address conferences and symposia, and to join technical committees of various Ministries. In this way he very greatly enlarged his field of activity and became widely known as one of the leading authorities in his particular subject.

In 1956 he was invited to accept a visiting professorship at the California Institute of Technology at Pasadena. During seven months in the United States, he visited many American universities and research institutes and delivered numerous discourses; in quite characteristic fashion, he scorned American public transport, and drove his own car, acquired in New York on his arrival and disposed of there on his departure, across the American continent, over a total distance of 16,000 miles. Shortly after his return, Davies was again invited to visit the United States, to address the annual meeting of the American Institute of Mining and Metallurgical Engineers, held in New York in February this year; he had agreed to do so, and to visit other centres to renew contacts made during the previous year, but he died during the week of the meeting.

Research, though energetically and enthusiastically pursued, by no means represented the sum total of his activity. He was a teacher of unusual quality, and his lectures were invariably prepared with meticulous care and presented with superb lucidity. He was, in addition, a gifted administrator; his department was most efficiently organized, and he was, for a period, vice-principal of his College. He had also numerous other interests quite unconnected with his academic work. He was an accomplished musician with a particular interest in church music, and was organist and choirmaster in his own church at Aberystwyth and at the church which he attended at Cambridge; he had in his early years been an active cross-country runner and retained throughout a lively interest in all kinds of sport, his last hobby being yachting; and in his rare moments of relaxation, he was an avid reader of detective fiction.

In all the many facets of his life, he had an essential good-nature and personal charm which brought him a host of friends, varying immensely among themselves, but united by their regard for his warm humanity and patent sincerity. The key to his character undoubtedly lay in the fact that his roots remained firmly fixed in his native Welsh soil, and he carried into the wide world the virtues implanted in him by the devout, unhurried and unpretentious atmosphere of his upbringing. I. C. JONES

THE sad news of Prof. R. M. Davies's sudden death came as a shock to his many friends in the United States. He had been invited to lecture at the American Institute of Mining and Metallurgical Engineers Symposium on High-Speed Stressing of Solids in New York City on February 17. It was with great disappointment that we heard that, due to illness, it was necessary for him to cancel that visit.

He had been in the United States twice, once during the Second World War and again for the academic year 1956–57, when he was a visiting professor and lectured at the California Institute of Technology and at Rensselaer Polytechnic Institute. During this last visit, in addition, in his travel from coast to coast, he gave lectures at various universities and technical institutes.

Prof. Davies was a superb teacher, and all those who had the fortune to attend his lectures will never forget the excellence and brilliance of his presentation. As a result of his research, especially in the field of stress waves in solids, he leaves important and permanent contributions.

Those who knew R. M. Davies during the Second World War, when he was working under Sir Geoffrey Taylor at Cambridge for the Ministry of Supply, will always remember the very happy combination of 'G. I.' and 'R. M.'. His loss is particularly felt by the many who enjoyed his friendship and appreciated his warm personality, his deep Welsh sense of humour and the interest, helpfulness and understanding he always showed toward other people. These friends will realize that with the passing of R. M. Davies a very dear part of their lives has forever ended.

ENRICO VOLTERRA

Prof. T. Shimizu

TAYEI SHIMIZU, who died suddenly on January 30, was well known as the founder of the chief Japanese school of studies on steroids and especially bile acids. He was a pupil of the late Heinrich Wieland from 1920 until 1923, and again from 1929 until 1931, and from him returned to Japan with an enthusiasm in this field which proved lifelong.

Shimizu was born in Tokyo in 1889 and graduated from Kyoto University Medical School in 1915. He began his studies on bile acids there, under the late Prof. T. Araki. After his return from Germany in 1923, Shimizu was appointed professor of biochemistry at Okayama Medical School: he became president of this School in 1949 and, in 1952, president of Okayama University. He was elected a member of the Japan Academy in 1950, and in 1951 a member of the German Academy of Sciences.

Much of Shimizu's scientific contribution consisted in the persistence and skill with which he and his pupils followed up the observation of Hammarsten (1898), who found the steroid alcohol, scymnol, in the bile of sharks. This ought, perhaps, to have stimulated a much wider search for unusual bile salts, but it was not until Shimizu began his work that such a search was seriously undertaken. It was then pursued with remarkable zeal: for example, 4,000 toads were used to collect 5 litres of bile; from this were obtained interesting alcohols, finally carefully described by T. Kazuno (*Hoppe-Seylers Z.*, 266, 11; 1940) and the bile acids trihydroxysterocholenic and trihydroxy-*iso*sterocholenic, $C_{22}H_{46}O_5$, characterized by Shimizu and T. Oda (*Hoppe-Seylers Z.*, 227, 74; 1934), and by Shimizu and T. Kazuno (*Hoppe-Seylers Z.*, 239, 67; 1936). In later work, Y. Okasaki (*J. Biochem. Tokyo*, 36, 65, 77; 1944) collected 1·5 litres of bile from 100,200 specimens of a newt, *Diemyctylus phyrrhogaster*. An account of the work of Shimizu's school up to 1935 was included by him in a comprehensive book ("Über die Chemie und Physiologie der Gallensäuren", Muramato, Okayama, 1935), which he dedicated to Prof. Araki on his seventieth birthday. K. Ohta (*Hoppe-Seylers Z.*, 259, 53; 1939) reviewed the work at Okayama on fish bile, and later writers have summarized the Japanese contributions up to 1955 (for example, *Physiol. Rev.*, 35, 178; 1955).

The discoveries of Shimizu and his pupils have widened greatly the scope of chemical and physiological study of bile salts, and have stimulated a new awareness of the interest of biochemical species comparisons in this as in other fields.

In June 1957 Shimizu paid his last visit to Wieland, and also visited England for the first time for nearly forty years. He then, in spite of an indifferent command of English, read a paper on some of the work now being done by one of his former pupils, S. Hayakawa. He spent some time in the United States before returning to Japan.

Tayei Shimizu was a man of broad vision, good humour and modesty of character. His memory is held in affection by his friends and former pupils everywhere. G. A. D. HASLEWOOD

NEW FELLOWS OF THE ROYAL SOCIETY

At a meeting of the Royal Society on March 20, the following were elected to fellowships:

MICHAEL ABERCROMBIE, reader in embryology in the University of London at University College, distinguished for his researches in embryology, tissue culture, and wound healing.

DR. E. P. ABRAHAM, senior research officer at the Sir William Dunn School of Pathology, University of Oxford, distinguished for his work on the isolation and chemistry of antibacterial substances.

DR. J. R. BAKER, reader in cytology in the University of Oxford, distinguished for his researches on the chemistry of the cell.

PROF. J. A. BIRCH, professor of organic chemistry in the Victoria University of Manchester, distinguished for his studies on the structure and biogenesis of natural products.

PROF. SATYENDRANATH BOSE, vice-chancellor of the Visva-Bharati University, Santiniketan, India, distinguished as the discoverer of Bose-Einstein statistics.

DR. P. W. BRIAN, head of the Department of Microbiology, Akers Research Laboratories, Imperial Chemical Industries, Ltd., distinguished for his researches on microbiology and plant pathology.

EDITH BÜLBRING, demonstrator in pharmacology in the University of Oxford, distinguished for her work on smooth muscle and on the action of adrenaline.

DR. R. K. CALLOW, research chemist at the National Institute for Medical Research, London, distinguished for his work on steroid chemistry.

DR. F. DIXEY, director of Overseas Geological Surveys, London, distinguished for African geological researches, particularly in tectonics, geomorphology and ground-water hydrology.

PROF. P. P. EWALD, head of the Department of physics in the Polytechnic Institute of Brooklyn, distinguished for his outstanding contributions to the science of X-ray optics.

PROF. F. J. FENNER, professor of microbiology in the Australian National University, Canberra, distinguished for his work on microbiology, particularly the pathogenesis and epidemiology of mousepox and myxomatosis.

DR. W. H. GLANVILLE, director of the Road Research Laboratory, Department of Scientific and Industrial Research, Harmondsworth, distinguished for his researches on reinforced concrete and on road construction.

PROF. A. E. GREEN, professor of applied mathematics in the University of Durham (King's College, Newcastle upon Tyne), distinguished for important contributions to the mathematical theory of elasticity and hydrodynamics.

PROF. A. HADDOW, professor of experimental pathology in the University of London and director of the Chester Beatty Research Institute (Institute of Cancer Research, Royal Cancer Hospital), distinguished for his investigations into the chemotherapy of malignant disease.

DR. G. HIGMAN, reader in mathematics in the University of Oxford, distinguished for his contributions to the theory of groups.

PROF. A. ST. G. J. MCC. HUGGETT, professor of physiology in the University of London at St. Mary's Hospital Medical School, distinguished for his investigations on the physiology of reproduction and on the transfer of materials from mother to fœtus.

PROF. H. C. LONGUET-HIGGINS, John Humphrey Plummer professor of theoretical chemistry in the University of Cambridge, distinguished for his application of mathematics to problems in physical chemistry.

PROF. B. LYTHGOE, professor of organic chemistry in the University of Leeds, distinguished for his contributions to the chemistry of natural products.

PROF. S. K. MITRA, professor of physics and director of the Institute of Radio-Physics and Electronics, University of Calcutta, distinguished for his researches in many branches of upper atmosphere physics.

DR. C. H. MORTIMER, secretary of the Scottish Marine Biological Association and director of the Marine Laboratory, Millport, distinguished for his research upon lakes and lake-deposits, and the chemical and physical conditions which control life in them.

PROF. R. S. NYHOLM, professor of chemistry in the University of London at University College, distinguished for his contributions to inorganic chemistry, especially for his studies of complex compounds of the transition elements.

PROF. G. D. ROCHESTER, professor of physics in the University of Durham (Durham Colleges), distinguished for his researches on the cosmic radiation, and particularly for his contributions to knowledge of the unstable elementary particles.

PROF. O. A. SAUNDERS, dean of the City and Guilds College and head of the Department of Mechanical Engineering in the Imperial College of Science and Technology, University of London, distinguished for his contributions to the study of heat transfer and to the development of the internal combustion engine.

PROF. J. E. SMITH, professor of zoology in the University of London at Queen Mary College, distinguished for his researches on the principles of nervous organization as exemplified by lower animals.

DR. W. B. TURRILL, formerly keeper of the herbarium and library at the Royal Botanic Gardens, Kew, distinguished for his experimental and descriptive work on flowering plants of Britain and the Near East.

NEWS and VIEWS

Animal Physiology at Cambridge :

Dr. Ivan de Burgh Daly, F.R.S.

IVAN DE BURGH DALY, who is retiring from directorship of the Agricultural Research Council Institute of Animal Physiology, Babraham, studied medicine in Cambridge and at St. Bartholomew's Hospital and qualified as a physician in 1918 after serving in the R.N.A.S. He worked as a Beit Memorial Research Fellow at University College, London. He was professor of physiology in Birmingham (1927–32) and Edinburgh (1933–47), before going to Babraham as the first director of the Agricultural Research Council's Institute of Animal Physiology in 1948. In Starling's department he became interested in the physiology of the circulation and his skill as an engineer enabled him to construct elaborate apparatus for perfusing blood through isolated organs from dogs and recording the effects of drugs and of nervous stimulation on the distribution of blood and the resistance to flow. He is especially interested in the complex circulation in the lungs and is the leading authority on this subject.

During the past ten years he has been mainly responsible for the formation of the Institute at Babraham, with a distinguished staff of more than thirty scientists and ideal facilities for work on the physiology of larger animals than those normally studied in the physiological departments of medical schools. Under his leadership the Institute has grown rapidly and continues to grow. Scientists with wide experience in physiology, biochemistry and pathology have joined forces and are doing fundamental work on sheep, cows and pigs. His wisdom in resisting demands for the quick solution of problems of immediate practical importance is becoming more apparent as time goes by.

Prof. J. H. Gaddum, F.R.S.

JOHN HENRY GADDUM, who is to succeed Dr. I. de B. Daly as director of the Institute of Animal Physiology, qualified in medicine at Cambridge and University College Hospital. In 1925 he went to the Wellcome Physiological Research Laboratories at Beckenham, where he worked with the late Dr. J. W. Trevan, and left in 1927 to join Sir Henry Dale at the Medical Research Council Laboratories. At Hampstead he worked on the liberation of acetylcholine-like substances and established in collaboration with W. Feldberg that the nerve impulse in the superior cervical ganglion is transmitted by acetylcholine. He also developed methods for the bioassay of thyroid hormone and became interested in the interpretation of quantal bioassays ; this was a matter of some difficulty as the log dose–percentage mortality curve was sigmoid in shape. He introduced the idea of plotting the normal equivalent deviation against the logarithm of the dose used, thus obtaining a straight line. To avoid the use of a negative quantity it was later suggested that the normal equivalent deviation + 5 should be called the 'probit' and this probit figure should be plotted against the log dose. Gaddum's pioneer work in this subject was published in a Medical Research Council report in 1933. After occupying chairs at Cairo and University College, London, in 1942 he was appointed to the chair of materia medica in the University of Edinburgh in succession to the late Prof. A. J. Clark, where he has added great distinction to the Department during the past sixteen years.

Gaddum has been interested in a wide field of pharmacological experiment, particularly in respect of the pharmacologically active substances obtained from tissue extracts. He has done a great deal to elucidate the substances liberated when autonomic nerves are stimulated. This work started with acetylcholine and noradrenaline, and he has continued it with 5-hydroxytryptamine and substance *P*. He has been interested in the antagonism of 5-hydroxytryptamine by lysergic acid diethylamide, and recently he has edited a monograph on polypeptides which stimulate plain muscle. He has been responsible for the statistical analysis of many bioassay procedures, and has written the appendix to "The British Pharmacopœia" on the mathematical basis of bioassay ; he has also written a very popular text-book of pharmacology, now in its fourth edition. He has been a member of the Committee of the Medical Research Council from 1948–51 and a Fellow of the Royal Society since 1945. His appointment as director of the Agricultural Research Council's laboratories at Cambridge will give a great stimulus to the study of pharmacology in connexion with agricultural problems.

Materia Medica at Edinburgh : Dr. W. L. M. Perry

THE appointment is announced of Dr. W. L. M. Perry to the chair of materia medica in the University of Edinburgh in succession to Prof. J. H. Gaddum, who is leaving Edinburgh to become director of the Agricultural Research Council Institute of Animal Physiology at Babraham. Dr. Perry, who graduated in medicine at St. Andrews in 1943, joined the scientific staff of the Medical Research Council at the National Institute for Medical Research in 1947, having completed a tour of duty in the Colonial Medical Service in West Africa. In his first research, Dr. Perry collaborated with Dr. F. Hawking in work which revealed the indirect mode of chemotherapeutic action of proguanil. Thereafter, he turned to subjects on the borderline between physiology and pharmacology, publishing a number of papers on transmission in the autonomic nervous system, and at the same time developing an interest in the principles and technique of biological assay, to which subject he made notable contributions. In 1951, Dr. Perry was appointed director of the Division of Biological Standards at the National Institute for Medical Research ; in this position he has carried with apparent ease a burden of work and responsibility which, especially during the past two years, has been unexpectedly heavy because of the involvement of the Division in the safety testing of poliomyelitis vaccine. Dr. Perry thus goes to Edinburgh having behind him an unusual breadth of scientific and administrative experience ; with the return to laboratory research that his new post will permit, it can be confidently anticipated that he will not only uphold but also add to the distinguished traditions of the chair of materia medica in Edinburgh.

Viking Fund Medals for 1957

THE 1957 Viking Fund Medals and prizes of 1,000 dollars each for outstanding contributions to anthropology have been awarded to Drs. Raymond A. Dart, James B. Griffin and Margaret Mead. Dr. Dart was elected by the American Association of Physical Anthropologists as medallist in physical anthropology. He is dean of the Faculty of Medicine at the University of the Witwatersrand. Since 1925, Dr. Dart has discovered many specimens of a sub-human creature, *Australopithecus prometheus*. He postulated that this proto-man belonged to the hominid rather than the ape family, and that Africa, not Asia, was the birthplace of man. In 1955, Dr. Dart discovered *Australopithecus* buried with crudely-worked tools of a Pebble Culture. Dart's theory was thereby accredited and his find recognized as the most primitive creature known to date that can be called human. Dr. Griffin, director of the Museum of Anthropology and professor of anthropology at the University of Michigan, was cited by the Society for American Archæology for his great influence in promoting the aims of scientific archæology, and for his unsurpassed knowledge of the form, range and distribution of artefact styles in North America. Dr. Mead was selected as the 1957 medallist in general anthropology by the American Anthropological Association. She is associate curator of ethnology at the American Museum of Natural History, and has done more than any other single individual to introduce anthropology to the American public. A prolific writer, among Dr. Mead's most popular books are "Coming of Age in Samoa", "Growing Up in New Guinea", "Male and Female" and "New Lives for Old".

The Viking Fund Medals and awards originated upon the suggestion of Dr. Axel L. Wenner-Gren, the Swedish industrialist who endowed the Foundation now bearing his name. Since 1946, the Wenner-Gren Foundation has provided the medals and prizes of 1,000 dollars, which are awarded to the general anthropologist, archæologist and physical anthropologist who has made a significant contribution to his field.

Train Control on Railways in Britain

In replying to a debate on automatic train control on March 7, on an adjournment motion moved by Mr. P. C. Goodhart, Mr. G. R. H. Nugent, Parliamentary Secretary to the Ministry of Transport and Civil Aviation, said that in the past 46 years, 698 formal inquiries had been made in Britain into rail accidents in which 1,599 people were killed. Of these accidents, automatic train control could probably have avoided 11 per cent and 31 per cent of the fatalities. Track circuiting is a further safety device which serves primarily to record that a train is in a particular sector of the track, and with colour light signals, which are easier to see, especially at night and in fog, and can be linked with automatic train control and track circuits and the control board in the signal box, could make a big contribution to traffic safety but without eliminating the human element. Automatic train control was started on the initiative of the Great Western Railway in 1905, but the equipment of the main lines of Britain was not completed until 1930, and the non-contact magnetic Hudd system evolved in the 1930's and tried on the London, Midland and Scottish Railway was not finally approved by the Minister of Transport until 1947. In 1948, the British Transport Commission decided to make a wide extension of automatic train control, colour light signals and track circuits: the Great Western system was regarded as unsuitable for electric lines and its heavy mechanized parts were unsuitable for permanent and universal adoption. The Commission is also convinced that a non-contact magnetic system superior to the Hudd system could be found; but although full-scale trials have been carried out since 1950 on the east coast line, as was expected, many difficulties were encountered. The routes carrying the greatest train frequency and speed would receive the earliest attention, and installation is in no way retarded by capital restrictions.

Millenary Celebrations of Al-Mas'udi

The millenary of Al-Mas'udi, the tenth century Arab geographer, traveller and encyclopædist, was recently celebrated at the Muslim University, Aligarh, under the joint auspices of the Institute of Islamic Studies, Aligarh, and the Indian Society for the History of Science. About thirty papers were received from all parts of the world, including Britain, Egypt, France, Holland, India, Iran, Lebanon and the United States

Mr. A. A. A. Fyzee, vice-chancellor of the University of Jammu and Kashmir, devoted his presidential address to the need for studies of the humanities in the university, particularly in view of the technological changes in progress in India. He stressed that the aim was not to produce theologians, which has been the dominant tendency in the past, "but to produce men of understanding and intelligence, of balanced judgment and critical appreciation of the past". Prof. M. S. Thacker emphasized the collaboration that had existed between the Arab countries and India in the search for knowledge. After giving a general survey of Al-Mas'udi's contribution in the field of science, he suggested the great need for a scientific study of the available material, particularly from the point of technology and its relation with the intellectual attainments of the age. Prof. N. Ziadeh discussed the geographical, climatological and certain social details of Sham (Syria) given by Al-Mas'udi, and Dr. M. Shafi dealt with his geographical contributions, particularly in the field of human geography, which Al-Mas'udi did much to establish on scientific lines. In a general survey of science at the time of Al-Mas'udi, Mr. A. Rahman emphasized its characteristic features, namely, its association with the concept of God as the driving force of the universe, and its relation to the Greek philosophical outlook. It is proposed that the contributions shall be published in the form of a commemorative volume.

Society for Visiting Scientists

The report of the secretaries on behalf of the Council of the Society for Visiting Scientists to the tenth general meeting on December 19 records continued restriction, for financial reasons, of the Society's activities, although the Overseas Science Students' Association continues to flourish. The Society has now nearly 2,900 members, from sixty-five countries, but only one reception could be held during the year, for participants in the symposium of the Royal Astronomical Society and the Royal Meteorological Society on "Planetary Atmospheres and Convection in Rotating Fluids". The Society's information service is constantly growing, helped by generous gifts of periodicals and reference books, but only limited success attended an attempt to increase the income from industry. Five most successful discussion meetings were held during the year, dealing respectively with "The Effects of Low Temperatures on Mammals and their Tissues"; "The Widening Field of Application of Electronic Computers"; "Taste and Smell"; "Water Quality Problems in the United Kingdom"; and "Science and Furniture". The lively discussion which characterized all the Society's meetings is further indication of the value of its work and of the desirability that adequate financial support should enable it to make its full contribution in assisting scientific co-operation and understanding.

The Parapsychological Association

The formation of the Parapsychological Association, an international professional group of research workers in the field of extrasensory perception and psychokinesis, has been announced. The objects of the Association are to advance parapsychology as a science, to disseminate knowledge of the field, and to integrate the findings with those of other branches of science. Full membership is restricted to those with doctorate degree training or equivalent. The founding officers are: *President,* R. A. McConnell (Biophysics Department, University of Pittsburgh); *Vice-President,* G. R. Schmeidler (Psychology Department, City College of New York); *Secretary,* R. White (Parapsychology Laboratory, Duke University); *Treasurer,* R. J. Cadoret (Duke University); *Members of Council,* M. Anderson (Duke University), K. Osis (Parapsychology Foundation of New York) and W. G. Roll (University of Oxford).

Conference on High Energy Nuclear Physics

More than 200 scientists from twenty-six nations have been invited to participate in the 1958 Annual International Conference on High Energy Physics, organized by the European Organization for Nuclear Research (CERN), in Geneva during June 30–July 5. Participation at the 1958 Conference is by invitation only. Among the 226 scientists invited so far, more than a hundred have already accepted, among them: Prof. W. Heisenberg, of Germany; Prof. Leprince-Ringuet, of France; Prof. E. Amaldi, of Italy; Prof. Hideki Yukawa, of Japan; Prof. P. Scherrer and Prof. W. Pauli, of Switzerland; Sir John Cockcroft and Prof. P. M. S. Blackett, of the United Kingdom; and from the United States, Dr. C. N. Yang, Dr. T. D. Lee, Dr. J. R. Oppenheimer and Prof. L. W. Alvarez. During ten plenary sessions in the auditorium of the Physics Institute of the University of Geneva, papers will be presented on nucleon structure; the nucleon and its interactions with pions, photons, nucleons and anti-nucleons; fundamental theoretical ideas; strange particle production and interaction; invariance principles and selection rules, and weak interactions. The conference proceedings, including original papers presented, will be published by CERN.

Second Geneva Conference on Peaceful Uses of Atomic Energy

The second International Conference on the Peaceful Uses of Atomic Energy is to be held in Geneva during September 1–13, under the auspices of the United Nations (*Nature,* 180, 217; 1957). The president of the Conference is to be Prof. F. Perrin, of the Commissariat à l'Energie Atomique de France, and the secretary-general, Dr. S. Eklund, of Sweden. Two atomic energy exhibitions will be held in Geneva during the Conference. The first will be a scientific exhibition under the auspices of the United Nations, at the Palais des Nations. A United Kingdom exhibit, 5,000 sq. ft. in extent, is being arranged by the U.K. Atomic Energy Authority, to include a model of the thermonuclear research apparatus, ZETA. The other exhibition, which will be commercial, is the International Exhibition on the Peaceful Uses of Atomic Energy, at the Palais des Expositions. The British section is being organized by the Nuclear Energy Trade Associations' Conference, which represents all major British firms concerned with atomic energy. People interested in attending the Conference as observers should apply for passes not later than April 19. Representatives from industrial firms who are working in the atomic energy field should apply to Mr. M. H. L. Whitehouse, Nuclear Energy Trade Associations' Conference, 32 Victoria Street, London, S.W.1, and all others to Mr. J. C. Walker, United Kingdom Atomic Energy Authority, 11 Charles II Street, London, S.W.1. The United Kingdom representatives on the United Nations scientific secretariat for the Conference will be Mr. F. Hudswell and Mr. W. B. Woollen (Atomic Energy Research Establishment, Harwell) and Mr. T. E. F. Carr (Medical Research Council).

Isotope Courses at Harwell

A course on radioisotopes, designed to give senior executives in industry an appreciation of the possible applications of those materials, will be held at the Harwell Isotope School during September 23–26. Two similar courses have been arranged for April 15–18 and July 8–11 for members of the Institute of Directors only. The course consists of lectures on the elementary principles of work with radioactive isotopes with the emphasis on their application as tools in industry and research. The lectures will be given in as non-technical a manner as possible by scientists experienced in the field; they will be supplemented by visits to a reactor and to the laboratories of the Isotope Division at Harwell and at the Wantage Radiation Laboratory near Harwell. The lectures and demonstrations will be given in the Cockcroft Hall at Harwell. Further information can be obtained from the Registrar, Isotope School, Atomic Energy Research Establishment, Harwell.

City and Guilds of London Institute: Fellowships

The Council of the City and Guilds of London Institute have conferred the Fellowship of the Institute (F.C.G.I.) upon the following past students of the City and Guilds College or Finsbury Technical College in recognition of their distinguished contributions to industry or the professions in which they are engaged: D. H. Alexander, principal, College of Technology, Belfast; W. A. Coates, retired, former director of Metropolitan-Vickers Electrical Co., Ltd.; G. H. Hopewell, managing director, Foster Wheeler, Ltd.; F. C. Wright, managing director, Standard Telephones and Cables, Ltd.

The Night Sky in April

Full moon occurs on April 4d. 03h. 45m. U.T., and new moon on April 10d. 03h. 23m. The following conjunctions with the Moon take place: April 5d. 04h., Jupiter 2° N.; April 9d. 02h., Saturn 3° S.; April 13d. 13h., Mars 7° S.; April 15d. 00h., Venus 4° S. There will be an annular eclipse of the Sun on April 19, invisible at Greenwich. Mercury is favourably placed for observation during the first week of the month, setting at 20h. 20m. on April 1; its stellar magnitude on that date is + 0·5. Later in the month, Mercury is too close to the Sun for observation. Venus is a morning star, visible low in the south-east before sunrise. It rises at 4h. 10m., 3h. 50m. and 3h. 25m. on April 1, 15 and 30, respectively; its stellar magnitude is about − 4·0. During the month its distance from the Earth increases from 58 to 80 million miles and the visible portion of the apparent disk from 0·450 to 0·600. Mars rises at 4h. 00m., 3h. 30m. and 2h. 50m. at the beginning, middle and end of the month, respectively. It is visible low in the south-east before sunrise, but conditions are not very favourable; its stellar magnitude is + 1·0. Jupiter rises at 20h. 05m., 19h. 00m. and 17h. 45m. on April 1, 15 and 30, respectively, and sets at 4h. 20m. on April 30; it is visible throughout the night. Opposition is on April 17; the planet is near Spica. The stellar magnitude of Jupiter is − 2·0, its distance from the Earth on April 15 being 410 million miles. Saturn rises at 1h. 05m., 0h. 10m. and 23h. 10m. at the beginning, middle and end of the month, respectively; it is east of θ Ophiuchi. Its stellar magnitude is + 0·6 and it is at a distance of 890 million miles from the Earth on April 15. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: April 6d. 04h. 20·5m., α Lib. (*D*); April 25d. 20h. 34·9m., 68 Gem. (*D*). *D* refers to disappearance. The Lyrid meteors are active during April 20–22. Conditions are very favourable; the radiant is near right ascension 18h. 04m., declination + 33°.

Announcements

THE Council of the Royal Microscopical Society has made the following elections to honorary fellowship of the Society: Dr. Edwin H. Land, president of the Polaroid Corporation, Cambridge, Massachusetts, in recognition of his contributions to microscopy; Dr. Maria Rooseboom, curator, National Museum for the History of Science, Leyden, in recognition of her valuable work in connexion with the history of microscopy.

THE Council of the Iron and Steel Institute has announced the following awards for 1958: Bessemer Gold Medal for 1958, to Mr. W. F. Cartwright (Steel Company of Wales, Ltd.); Sir Robert Hadfield Medal for 1958, to Mr. W. C. F. Hessenberg (British Iron and Steel Research Association); Ablett Prizes for 1957, £50 each to Mr. C. E. H. Morris and Mr. R. N. Dale (Steel Company of Wales, Ltd.), for their paper, "Planning the Conversion of a High-lift Slabbing Mill to a Universal Mill" (*J. Iron and Steel Inst.*, April 1957).

DR. B. R. NIJHAWAN, director of the National Metallurgical Laboratory, Jamshedpur, has been given the award of 'Padma Shri' by the President of the Republic of India, in recognition of his exceptionally distinguished services in the field of science in India.

MR. J. D. HANDYSIDE has been appointed controller of research, National Institute of Industrial Psychology, with effect from April 1.

THE Institution of British Agricultural Engineers is able to offer, through the generosity of Shell Mex and B.P., Ltd., a number of bursaries for award to candidates eligible for entry to the final-year course of study leading to the examination in July 1959 for the National Diploma in Agricultural Engineering. These bursaries are normally available in units of £50, but their disbursement may be varied at the discretion of the Examination Board. The conditions governing the award may be obtained from the Secretary of the Institution of British Agricultural Engineers, 6 Buckingham Gate, London, S.W.1. The closing date for receiving completed applications is May 1, 1958.

THE Physical Society is holding a conference on "Nuclear Physics" at the Cavendish Laboratory, Cambridge, on April 10–11. Further information can be obtained from the Secretary, The Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

THE 1958 National Symposium of the U.S. Institute of Radio Engineers Professional Group on "Microwave Theory and Techniques" will be held at Stanford University, Stanford, California, during May 5–7. Further information can be obtained from Glenn H. Keitel, Publicity Chairman, 1958 PGMTT National Symposium, 601 California Avenue, Palo Alto, California.

THE 1958 International Conference on Semiconductors, sponsored by the International Union of Pure and Applied Physics, will be held at the University of Rochester, New York, during August 18–22. Further information can be obtained from M. H. Hebb, P.O. Box 1088, Schenectady, New York. Abstracts must be received by May 1.

A ONE-DAY conference on statistical sampling in industry, organized by the Birmingham Group of the Industrial Applications Section of the Royal Statistical Society, will be held at the Birmingham College of Technology on May 7. Further information can be obtained from D. Goldberg, Lamp and Lighting Co., Ltd., Melton Road, Leicester.

AN informal discussion on "The Structure and Physical Chemistry of Nucleic Acids and Nucleoproteins" will be held in the Department of Chemistry, University of Birmingham, on September 17–18, under the auspices of the Colloid and Biophysics Committee of the Faraday Society. Papers on the following topics will be read: nucleic acids (especially ribonucleic acid), synthetic polynucleotides, nucleoproteins. Members of the Faraday Society and others who wish to take part should notify Dr. A. R. Peacocke, Department of Microbiology, University of Birmingham, Edgbaston, Birmingham 15, to whom titles of papers should be sent before June 1.

THE essay subjects for this year's *Endeavour* Prizes of the British Association for the Advancement of Science will be as follows: education for an age of science; rockets and satellites and their scientific significance; photography and cinematography in science; chemicals from petroleum; Darwinism to-day; the measurement of time. The essays must be sent in by June 1 and should not exceed four thousand words. Competitors must be less than twenty-five years old, and the prizes will be 50, 25 and 15 guineas, with two special awards of 5 guineas to those less than eighteen. Further information can be obtained from the Assistant Secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1.

ERRATA. Referring to the article entitled "Non-Conservation of Parity" in *Nature* of February 15, Prof. A. Salam writes: "p. 448 (1*d*), column 2, line 5, for 'right' read 'left'; (*e*) for subscript '*L*' read '*R*'. I am grateful to Dr. J. R. Holt for pointing out these errors".

RECENT ADVANCES IN NUCLEAR PHYSICS

A NEW series of meetings has been inaugurated at the Royal Society at which normally three Fellows will be invited to present statements on topics of current interest. Unlike the usual meetings for the reading of papers and the discussion meetings which are held periodically, the proceedings at these new meetings will not be published and the speakers will be free to treat the subject in a broader and perhaps more speculative manner than would be the case if their words were to be printed in the Society's *Proceedings* and *Transactions*.

The subject of the first meeting, held on February 20, was "Recent Advances in Nuclear Physics". Each of the three speakers, Profs. D. H. Wilkinson, W. E. Burcham and R. E. Peierls, spoke for half an hour. They chose to discuss aspects of what is probably the most significant advance made in the past twelve years, namely, the discovery that the motions of nucleons inside a nucleus are not strongly correlated but are largely independent of each other. In nuclear structure studies discussed by Prof. Wilkinson, this phenomenon has led to the establishment of the 'nuclear shell-model', in which, as a first approximation, nucleons in a nucleus move in an overall common potential V. The counterpart of the shell-model in nuclear reaction studies is the 'optical model' described by Prof. Burcham.

Prof. Wilkinson spoke specifically on "The Structure of Light Nuclei", using the shell-model to interpret the considerable body of data that has accumulated on nuclear-level schemes, transition probabilities, and magnetic moments. In applying the model, one introduces two types of forces acting on the nucleons over and above the common potential V. The first type of force is that acting between pairs of nucleons. By direct analogy with Coulomb forces acting between pairs of electrons in an atom, these forces tend to couple the orbits of the nucleons together to produce L–S coupling. The second type is that which couples the spin of each nucleon to its orbit (like the Thomas force in the atom) and tends to produce j–j coupling. In the presence of both types of forces, the coupling situation in a nucleus is described as intermediate and is characterized by the ratio of the effective strength of the inter-nucleon forces to the spin-orbit forces. This ratio is the most significant parameter available when attempting to fit observations.

Prof. Wilkinson showed an extensive series of slides representing the work of many people and containing comparisons of experimental data on various light nuclei with the predictions of the shell-model. The agreement is impressive, especially in such cases as carbon-13 and nitrogen-13, where the observed values of five different kinds of data are fitted with the same value of the parameter. A satisfactory feature of the fits is that the 'best values' of the effective strengths of the two types of forces vary smoothly with mass numbers and are in reasonable agreement with theoretical predictions.

Prof. Burcham discussed "The Optical Model and Nuclear Reactions". The optical model attempts to incorporate features of both the 'compound nucleus' model of nuclear reactions, and the shell-model of nuclear structure. Corresponding to the latter model, the effects of a nucleus on the motion of a bombarding nucleon can be represented by a real potential V, which merely deflects it. Compound nucleus formation, which occurs as a result of a collision in which the incident nucleon loses energy to a target nucleon, may be included by adding to V an imaginary iW. In the manner well known in optics, such a term represents absorption. Small values of W correspond to small absorption, that is, there is little probability of formation of compound nuclei; large values correspond to large absorption and large probability of formation of compound nuclei; moderate values correspond to intermediate situations in which the number of nucleons passing through the nucleus compares with the number that are absorbed into the compound nucleus. For any given values of V and W, one may calculate the absorption, shape-elastic and total cross-sections, and if a spin-orbit potential is included, the polarization of elastically scattered nucleons. Comparison with observation then enables the potentials to be determined.

At low energies (less than 5 MeV.) total cross-sections for neutrons exhibit variations with energy. Peaks occur at energies corresponding to single-particle resonances in the real potential V, and the fact that such peaks are observed at all means that W must be rather small (about 2 MeV., which is much less than the value of V, ~ 40 MeV.).

Observations at higher energies up to 1,000 MeV. suggest that W increases with energy up to 100 MeV., then flattens off and increases again at energies greater than 400 MeV., where absorption due to meson production is important. In contrast, V appears to decrease steadily until it becomes zero near 350 MeV. (This may be shown directly by use of the optical theorem stating that the total cross-section is equal, apart from known constant factors, to the imaginary part of the forward-scattering amplitude. The observed values of the total and forward scattering cross-sections at 350 MeV. show that the real part, which is proportional to V, must be very small.)

The optical model has proved to be very useful for the analysis of nuclear cross-sections, just as the shell-model is useful for interpreting data on nuclear structure. For many years, it was argued that the type of nucleon motion envisaged by the shell-model is in such contrast to the strong short-range nuclear forces that the model could not possibly be valid. Acceptance of the model has come only with its convincing success in applications. Now that the applicability of the shell and optical models in practice is so well confirmed, much attention has been given to the theoretical problem of understanding why the models work. Prof. Peierls devoted his talk, "The Theoretical Basis of the Shell-Model and Optical Model", to this matter.

It appears that the basic reason why nuclear forces are not nearly as effective in nuclear matter as one might guess is the action of the Pauli Principle. A system of Fermi particles with no interactions in its lowest state has one particle in each of the single-particle momentum states up to the Fermi level. When interactions are introduced, even though they may be strong and of short range, they will not seriously modify the state, since all collisions with small momentum transfers are forbidden. Unfortunately, such an approach, using interactions containing sufficient exchange forces to produce saturation, gives too little binding-energy. The source of this discrepancy appears to be the fact that nuclear saturation arises only partly from exchange forces, another cause being the infinitely repulsive core in the nuclear interaction. The presence of this core means that shell-model wave-functions cannot possibly be correct when any two nucleons are separated by just the range of the core. Nevertheless, since the range of the core is considerably smaller than the mean inter-nucleon spacing, they are expected to be correct otherwise. Mathematical techniques have been developed for taking account of the effects of the cores in the wave-functions, and it is believed that one has, in principle, a reliable scheme for computing nuclear properties, especially binding-energies, using realistic nuclear forces. The main trouble, in practice, is the great labour involved in calculation. This reduces to reasonable magnitude only when considering large hypothetical systems in which surface effects are negligible. An important by-product of such calculations is the estimation of the nuclear potential, V, as a function of the momentum of a nucleon. This emerges in an iteration procedure in which one assumes values for V, then calculates new values and continues until convergence is obtained. It can be identified with the real part of the potential of the optical model, and so the calculations predict this quantity as well as the nuclear binding energies.

The meeting ended after the speakers answered a few questions from the audience. A. M. Lane

BIOCHEMISTRY OF GLUTATHIONE

The Biochemical Society arranged a symposium on glutathione, organized by Dr. E. M. Crook and held on February 15 at the Senate House, University of London. As indicated by Prof. R. H. S. Thompson's opening remarks, the subject is attractive in bringing together a wide range of disciplines: purely chemical and analytical studies, plant and animal biochemistry, and pharmacology, toxicology and general biology.

The metabolism of glutathione in plants is notable, as described by Dr. L. W. Mapson (Low Temperature Research Station, Cambridge), for the well-defined systems which catalyse both oxidation and reduction at its sulphide group. Glutathione reductase has been found in most organisms in which it has been sought. More characteristic of plants than animals is dehydroascorbic acid reductase, which catalyses the interaction of reduced glutathione with the oxidized form of ascorbic acid. The reduced ascorbic acid formed can be oxidized by established routes, and about a quarter or a half the oxygen uptake of preparations of germinating pea cotyledons may proceed by this route, providing an example of the respiratory function envisaged for glutathione by Hopkins and others. However, attempts to demonstrate the generation of high-energy bonds during these changes have so far been unsuccessful.

Glutathione in Animal Tissues

In animal tissues there appears relatively little scope for this route of oxidation; but oxidation by purely chemical routes, for example, by exchange with other disulphides, can readily occur. This and other aspects of the chemistry of glutathione were surveyed by Dr. F. A. Isherwood (Low Temperature Research Station, Cambridge); thus transacylation also occurs spontaneously between the thiol group of glutathione and S-acyl compounds. Oxidation and mercaptide formation at the glutathione thiol group form the basis of two analytical methods for glutathione described in detail by Dr. C. G. Thomson (Institute of Psychiatry, London), who compared results with these methods with those obtained using glyoxalase. A considerable measure of agreement was found when these techniques were applied to blood and to cerebral tissues. Each tissue, however, presents its own problems in fixation, extraction, and the presence of substances likely to interfere in assay, as was evident also from discussion.

Reviewing glutathione in animal tissues generally, Dr. P. C. Jocelyn (University of Edinburgh) described recent studies of its synthesis. Synthesis proceeds through γ-glutamylcysteine and is catalysed by two distinct synthetases in tissues including erythrocytes and liver. In the liver, the synthesis appears to be affected by growth hormone and adrenaline; the extent to which vitamin B_{12} is involved in the maintenance was also appraised. Although glutathione has been suggested as a substrate in the further synthesis of proteins, experiments on incorporation of amino-acids into ovalbumin, and other lines of evidence, have failed to support the idea.

In neural tissues, Prof. H. McIlwain (Institute of Psychiatry, University of London) described the determination of glutathione in the brain fixed rapidly *in situ*, and its maintenance during *in vitro* experiments. Assimilation, synthesis, and breakdown of glutathione in cerebral tissues proceed at relatively slow rates, as also does its acylation. Deacylation is more rapid, especially of an acetylglycyl glutathione. Enzyme catalysis of the oxidation of glutathione has not been found, but the tissue possesses a very active glutathione reductase which forms the main route of oxidation of reduced triphosphopyridine nucleotide. This system operates at nearly maximal rate at the low concentrations of oxidized glutathione and of reduced triphosphopyridine nucleotide which are native to the tissue. Indeed, its operation would appear to be the main factor in securing the great preponderance of the reduced form of glutathione normally found *in vivo*, and to be necessary if glutathione is to perform the role so often ascribed to it, of maintaining thiol enzymes and coenzymes in their active, reduced, forms. Participation of glutathione in cerebral carbohydrate metabolism is well established, and change in level of blood glutathione has been reported to be associated with mental disease. Administration of large quantities of glutathione to man with the intention of altering mental status has displayed the relatively small central effects produced in this way, in distinction to the marked effects of other thiols on the nervous system. Blood constituents are, however, altered by the administration of such quantities.

Analogues of glutathione have been found to occur naturally in the lens of the eye. Their isolation was described by Dr. S. G. Waley (Nuffield Laboratory of Ophthalmology, Oxford); they differ from glutathione at its cysteinyl residue, ophthalmic acid being γ-glutamyl-α-amino-*n*-butyrylglycine, and norophthalmic acid the alanyl derivative. They appear to be produced in the lens by the system which synthesizes glutathione, for competition can occur when substrates for more than one product are provided. Glutathione synthesis is affected also by the X-irradiation which induces cataract; after exposure, the glutathione concentration in the lens falls, but causal relationship between this change and the cataract is still under investigation. A further intriguing product isolated from the lens is S-sulphoglutathione, which can be formed from sulphite and oxidized glutathione.

Radiation Damage; Glyoxalase

In reviewing relationships between thiols and radiation damage generally, Dr. D. B. Hope (M.R.C. Radiobiological Research Unit, Harwell) described the inactivation of thiol enzymes brought about *in vitro* by irradiation. This has not been observed *in vivo*, so the enzymes involved are in some way protected, and attempts have been made to enhance the normal protection by administered substances. Glutathione to a small extent protects mice from the lethal effects of X-irradiation, but cysteamine, dithiocarbamates, and other compounds are more effective; they have in common the property of lowering the body temperature of animals.

Interesting points regarding glyoxalase came from several contributors. This is the system converting methylglyoxal to lactic acid, in which coenzyme status for glutathione was first established, and which once appeared to constitute the main route of glycolysis in many organisms. Its displacement from this role was exemplified in cerebral tissues: lactic acid formation from methylglyoxal, though rapid, is inadequate to account for the high rates at which lactic acid was afterwards found to be produced from glucose. That the glyoxalase system comprises two enzymes, adumbrated by F. G. Hopkins in his posthumous paper with E. J. Morgan, is generally agreed. Perhaps surprisingly, the immediate substrate for glyoxalase I is still debated, Dr. Waley's evidence favouring the hemimercaptal between glutathione and methylglyoxal. In this system in the lens, ophthalmic acid acts as a competitive inhibitor. Glyoxalase I yields S-lactoylglutathione, the substrate of glyoxalase II. However, a preparation from cerebral tissues is reported to hydrolyse at least one other substrate more rapidly than glyoxalase intermediate: this is S-acetylglycylglutathione. Hydrolytic enzymes have also been found in mouse liver which are specific to S-acyl derivatives of glutathione.

Concluding remarks by Dr. C. P. Stewart (University of Edinburgh) emphasized these and other aspects of the biochemistry of glutathione in which further investigation is still required. He indicated how studies of radiation damage, and the *S*-sulphoglutathione from the lens, offer hints on compounds intermediate in the conversion of —SH to —S.S— glutathione, a process likely to involve two stages.

NATIONAL OCEANOGRAPHIC COUNCIL

ANNUAL REPORT 1956–57

THE report of the National Oceanographic Council for 1956–57 (pp. v+34. Cambridge: At the University Press, 1957. 5*s*. net) describes the work carried out by the National Institute of Oceanography during the year ending March 31, 1957. The activities cover the two main fields of marine physics and marine biology, and follow the broad objectives set in previous years.

In marine physics, the technique of determining deep currents by tracking a neutrally buoyant float, drifting freely at a predetermined depth, has been exploited further. The most significant piece of work was the discovery of a southerly-flowing deep current, at depths greater than 2,500 m., beneath the Gulf Stream. This was achieved in the course of a joint expedition by R.R.S. *Discovery II*, and the U.S. research vessel *Atlantis* to an area about 150 miles off the coast of South Carolina. Other measurements of deep currents were made during the year in the Faeroe-Shetland Channel, off the Sogne Fjord, and in a region north of Madeira.

Waves and swell have been one of the Institute's main interests since its inception, and during the past year or two increasing attention has been given to their effects on the rolling, pitching and heaving of ships. The work on this subject has attracted much interest among scientists and engineers concerned with ship motion, in Great Britain and in the United States. A series of theoretical papers has also been published, treating the statistical properties of waves as those of a random, moving surface. Other studies of waves include their relation to microseisms and the relation of both to the movements of storms generating them. Turning to waves on a longer time-scale, basic research with a bearing on storm surges has been continued, both by mathematical models and by electrical analogue techniques.

The productivity of oceanic waters is one of the Institute's major objectives in marine biology, and advances have been made in instrumental and operational techniques for this purpose. An example of this is provided by work on the quantitative sampling of zooplankton from water layers at various depths. Research at sea on organic productivity included three weeks observations in one position, 600 miles west of Portugal, during the autumn of 1956. Repeated measurements were made from *Discovery II* of the light energy, rate of photosynthesis and the standing crop of phytoplankton and zooplankton.

Another broad field of investigation concerns the oceanic distribution of marine organisms. Comprehensive studies have been made of the distribution of various species of the plankton fauna in the Southern Ocean and in the Benguela Current. An interesting feature is the tendency for populations of different species of zooplankton to be segregated in concentric circumpolar zones. A technique for obtaining underwater photographs of squid has been developed and used successfully at depths of 300–1,000 m.

Work has been continued on the distribution and life cycles of whales, a knowledge of which is required in formulating international regulations. An investigation is being made of two alternative methods of age determination in baleen whales: by the laminations in the ear plugs and from the accumulated corpora albicantia in the ovaries. A comprehensive paper has been published on the biology of sperm whales, and a study of ambergris is in progress. Work is also being done on the geographical distribution of the various species of whale and their movements between one ocean area and another.

R.R.S. *Discovery II* was kept in full commission throughout the year, although for three months she was on hire to the Admiralty and so not employed on the Institute's research programme. For six weeks in July–August 1956 the ship was lent to the Department of Geodesy and Geophysics of the University of Cambridge, for a cruise to the Mid-Atlantic Ridge, which included seismic studies and measurements of heat flow through the sea bed.

The Institute has continued to be directed by Dr. G. E. R. Deacon with Dr. N. A. Mackintosh as deputy director. Its total staff is about eighty (excluding the officers and crew of *Discovery II*), of whom thirty-six are in the scientific and experimental officer grades. In addition, seven visiting scientists from overseas were working in the Institute during the year. The expenditure on the year's work amounted to £193,000, of which £78,000 was for running *Discovery II*. The main source of income was £110,000 in grants from the United Kingdom Government. Commonwealth Governments contributed £9,000. The Treasury has decided to increase its grants to £175,000 per annum for the next five years and this should go a long way towards ensuring the further development of the Institute's research programme.

K. F. BOWDEN

OPENCAST MINING

THE Opencast Coal Bill, which had an unopposed second reading in the House of Commons on January 22, is a complicated Bill which replaces the powers at present exercised under Defence Regulations by a system of planning control, acquisition and compensation incorporating some of the main points made in the Franks report. It provides that no opencast operations can take place without the permission of the Minister, who will, in his consent, insert conditions ensuring that damage is reduced to the minimum, and, when agricultural land is affected, that the land be restored to a reasonably fit state for agriculture.

It is intended to proceed wherever possible by agreement, and the compulsory rights order when used will give the Coal Board the right for a maximum of ten years to use the land for opencast mining. In moving the second reading, the Paymaster-General, Mr. R. Maudling, said there would be a continuing need for opencast coal for a considerable period: about 160 million tons of coal had been produced by this method from 109,000 acres, 13·5 million tons of this in 1957, and the need was generally but reluctantly accepted by the House; though Mr. Maudling, and Mr. A. Robens for the Opposition, alike recognized the damage done to amenity and agriculture and our duty to hand on the land in a better and not a worse condition.

While Mr. G. Nabarro condemned opencast mining generally but supported the Bill, Mr. M. Philips Price and Mr. R. Speir pressed more specifically for safeguards and greater attention to amenity both in mining and in restoring the land. In replying on the debate, the Parliamentary Secretary to the Ministry of Power, Sir Ian Horobin, urged that, given the need for opencast mining, while the provisions of the Bill were not perfect, they were probably the best we could make. The vital question of amenity had not been overlooked and would be permanently in the minds of the Ministers who had to administer the Act. Improvements could possibly be made during the Committee stage and compensation would no longer be arbitrary.

ANIMAL HEALTH IN GREAT BRITAIN

ANYONE interested in the health of domesticated animals and in their transit to and from Great Britain should read the "Report on the Animal Health Services in Great Britain 1956" (H.M.S.O., London, 6*s*. net), which includes a report on proceedings under the Diseases of Animals Act, 1950. The outstanding features of the report are, on the debit side, the high incidence, during 1956, of foot and mouth disease and anthrax, and the increase of fowl pest; but these liabilities were offset by the steady progress of the Ministry of Agriculture's scheme for the eradication of tuberculosis from cattle in Great Britain, by the demonstration by the Ministry's veterinarians in the Isle of Wight that warble fly disease can be substantially reduced by co-operation between the veterinarian and the farmer, and by the evidence provided in the report of the very wide range of research that is being devoted to the diseases of domesticated animals.

The year 1956 was the worst year for foot and mouth disease since the widespread outbreaks of 1951 and 1952. In 1956 there were 162 outbreaks, but these were confined to England and Wales. Of the 162 outbreaks, thirty-two, which had no known connexion with other outbreaks, were attributed either to swill or to imported meat, bones or meat wrappers, and it was concluded that the disease came from the Continent. It was necessary to slaughter 10,547 cattle, 13,123 sheep, 4,793 pigs and 42 goats, and compensation paid amounted to £824,658.

Anthrax also increased during 1956, although the average mortality from this disease continued to be very low. The disease was very widespread and Yorkshire was especially severely affected. Circumstantial evidence suggests that the outbreaks were caused by imported concentrated foodstuffs, though the infection could not be traced to any particular ingredient of these.

Swine fever, on the other hand, showed a decline of nearly 50 per cent during 1956, when there were only 741 outbreaks, the lowest figure since 1950. In November 1956, the Swine Fever (Infected Areas Restrictions) Order came into force, the object of which is to make possible the speedy imposition of restrictions on the marketing and movements of pigs in areas in which swine fever is prevalent. Fowl pest increased during 1956 and involved the destruction of 1,205,181 birds and 1,005,023 hatching eggs at a cost of £1,371,710 in compensation. Of the 956 outbreaks of this disease, 550 occurred among the dense poultry population of Lancashire, while 121 occurred in Lincolnshire and 84 in Essex; but twenty-one English counties and the whole of Scotland were free from this disease.

A review of suggestions for the control of warble fly led to the conclusion that, until a dressing can be found that will kill the maggots of this fly while they are in the bodies of cattle, the only method of control is to achieve greater compliance with the Warble Fly (Dressing of Cattle) Order of 1948, and a campaign for this purpose was conducted, which included the showing of a film and announcements by poster, in the Press and on the radio. The fine summer of 1955 favoured the laying of eggs by the warble fly on the hairs of cattle, and measures were taken to meet the expected increase in 'warbles' which occurred in 1956. There are in the Isle of Wight about 600 herds of cattle, and the report shows that, as a result of the work of the Ministry's veterinarians, the numbers of herds in the island completely free from warble infestation were 97 in 1954, 374 in 1955 and 500 in 1956, with a corresponding reduction each year in the numbers of individual animals affected. A considerable degree of control has thus been effected by means of effective dressings applied at the right time and by co-operation between the veterinarians and the farmers.

An important section of the report describes the good progress that has been made towards the complete eradication of tuberculosis from British cattle. The Tuberculosis (Attested Herds) Scheme, started in 1935, is entirely voluntary, and the report shows that, by the end of 1956, there were 7 million attested cattle in Britain, representing 67 per cent of the total. A map shows the attested areas in the west of Scotland, the Lake District and south and mid-Wales as they existed on January 1, 1957, and the areas in which free tuberculin tests have been available in 1955 and 1956. These include north Wales, an area south of the Lake District and the counties between the Devon border and the east coast of Kent. The testing of cattle is supported by veterinary detection of tuberculous cows liable to infect the milk supply, though these are now rarely found.

Another section of the report describes the work being done on the incidence of *Brucella melitensis*, which causes human Malta fever in the Mediterranean area. This organism has been found either in milk or in the aborted fœtuses of cows, on forty-two farms in Britain, but there is no evidence that it has ever caused human illness in the United Kingdom. The slaughter of cattle infected with it has therefore been discontinued. It is not known why this organism, which is a near relative of *Brucella abortus*, the cause of contagious abortion in cattle (Bang's disease), should cause human illness in the Mediterranean area but not in Britain.

The very detailed regulations designed to protect animals in transit to and from the United Kingdom are emphasized in the report, which discusses, with valuable statistics, the export and import of horses, asses, mules, pigs and cattle. A Government inquiry into the export of cattle to the Continent was initiated in 1957, from which developments may be expected in the next report.

The report also describes the wide range of research that is going on at the Ministry's centres of research and veterinary investigation. This research includes studies of every disease or infection that may be encountered in Britain and some that are found elsewhere.

G. LAPAGE

REDUCTION OF ORGANIC HYDROPEROXIDES BY MICRO-ORGANISMS AND ANIMAL TISSUES

By DR. D. M. UPDEGRAFF and DR. F. A. BOVEY

Minnesota Mining and Manufacturing Co., Saint Paul 6, Minnesota

DURING the course of investigations of the bactericidal and bacteriostatic action of organic hydroperoxides, it was observed that 0·01 per cent solutions of several hydroperoxides, including *t*-butyl, *p*-menthane and cumene hydroperoxide, in nutrient media, inhibited the growth of *Escherichia coli* and *Bacillus subtilis* only temporarily. Analysis of the cultures showed that the hydroperoxide had disappeared less than 24 hr. after growth began. The known peroxide-decomposing enzymes, catalase and peroxidase, are not reported to decompose the peroxides employed here, but only methyl and ethyl hydroperoxides in addition to hydrogen peroxide itself, and it therefore appeared to be of interest to investigate this reaction further.

The concentration of hydroperoxide in bacterial cultures was determined directly with a manual polarograph, using a voltage of 1·0 V. vs. sat. calomel electrode; calibration curves showed that the waves for all the peroxides employed were fully developed at this voltage. Bacteria were grown on the surface of tryptone–glucose–yeast extract agar, harvested in 0·1 *M* *p*H 6·9 phosphate buffer, centrifuged down, and resuspended in fresh phosphate buffer.

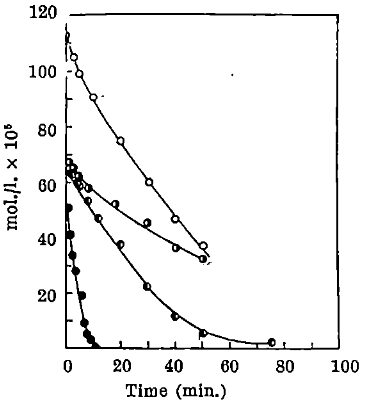

Fig. 1. Decomposition of organic hydroperoxides by *E. coli*. ○, *t*-butyl hydroperoxide; ◑, *p*-menthane hydroperoxide; ◐, cumene hydroperoxide (2×10^9 cell/ml.); ●, cumene hydroperoxide (10^{10} cells/ml.)

Plant and animal tissue homogenates were prepared in the same buffer by means of a Virtis homogenizer.

Determinations of catalase activity were also carried out on these same suspensions, suitably diluted when necessary, by measuring the rate of disappearance of hydrogen peroxide polarographically at 1·5 V. As hydrogen peroxide is decomposed by catalase, the oxygen produced gives a wave which almost exactly replaces that of the disappearing hydrogen peroxide, and it was therefore ordinarily necessary to sweep out the oxygen with a stream of nitrogen before measuring the hydrogen peroxide wave. If this was not done, the current at 1·5 V. underwent little or no change. In many cultures, however, the endogenous uptake of oxygen was at least as fast as the decomposition of hydrogen peroxide by catalase, and in these circumstances, nitrogen sweeping could be omitted. Peroxidase activity was measured similarly in the presence of 0·04 *M* pyrogallol; this measurement is grossly inaccurate unless the peroxidase activity is at least comparable to the catalase activity, since the two enzymes compete for the hydrogen peroxide. If the catalase and peroxidase activities are comparable, the peroxidase activity is given approximately by the increase in the rate of disappearance of hydrogen peroxide when pyrogallol is added. When endogenous respiration is very small or zero, peroxidase activity can also be measured as the apparent rate of decrease of the hydrogen peroxide wave at 1·5 V. in the presence of pyrogallol, for oxygen is not produced when hydrogen peroxide is decomposed by peroxidase. Since the measurement of peroxidase activity is often rather uncertain, the reporting of a zero activity only means that it was too small to be measurable by these means, and also that no visible purpurogallin colour developed in the culture on adding pyrogallol.

Control experiments established that beef-liver catalase (Armour), even in concentrations as high as 0·075 K.U. per ml., does not decompose the organic hydroperoxides employed in this study, either in the presence of cells (made inactive by heating) or in the buffer alone. However, 10^{-3} times this concentration of the same catalase preparation rapidly decomposed hydrogen peroxide. Likewise, horseradish peroxidase has no effect in buffer or cell suspensions containing 0·04 *M* pyrogallol, or in cell suspensions without pyrogallol.

In Table 1 are presented the rates of decomposition of cumene hydroperoxide, purified by preparation of the sodium salt, by 17 species of bacteria, yeasts, moulds, preparations of mammalian tissue, and plant tissue. The bacterial activities are reported as moles per minute per cell ($\times 10^{18}$), whereas the activities of the other systems are given only qualitatively. Catalase activities are reported in all cases, and peroxidase activities for eleven systems. Fig. 1 illustrates the rate of decomposition of cumene, *t*-butyl and *p*-menthane hydroperoxides by *Escherichia coli* suspensions. Initial peroxide concentrations were usually made approximately $6{\cdot}5 \times 10^{-4}$ *M*. The rates are neither exactly zero nor first order, but are intermediate and vary somewhat with the peroxide concentration and the cell count. It can be seen that cumene hydroperoxide is decomposed by fourteen of the seventeen species of bacteria tested, by the yeasts and by the animal tissues, but not by the mould, *Aspergillus niger*, or the plant tissues. Catalase activity is usually accompanied by cumene hydroperoxide-decomposing activity, but this is not necessarily so, as these three last-mentioned examples show. On the other hand, no clear evidence was obtained that cumene hydroperoxide-decomposing activity can occur without accompanying catalase activity, although there is no quantitative correlation between these activities. Consequently, anaerobic organisms, which usually show no catalase activity, show likewise no activity toward cumene hydroperoxide. A possible exception is the obligate anaerobe *Veillonella gazogenes*, which shows very strong cumene hydroperoxide-decomposing activity and only very weak catalase activity. This last observation strongly suggests that the cumene hydroperoxide-decomposing system has little or no effect on hydrogen peroxide.

Table 1. CUMENE HYDROPEROXIDE DECOMPOSING ACTIVITY IN MICRO-ORGANISMS AND TISSUES

Organism or tissue	Activity, mol./min./cell × 10^{18}		
	Cumene hydroperoxide decomposing activity	Catalase activity	Peroxidase activity
1. *Micrococcus pyogenes* var. *aureus*	4	3	0
2. *Escherichia coli*	5	50	0
3. *Erwinia carotovora*	0·9	5·3	0
4. *Bacillus subtilis*	7	6·2	0
5. *Streptococcus faecalis*	0	10	0
6. *Leuconostoc mesenteroides*	0	0	0
7. *Pseudomonas aeruginosa*	4	4	1
8. *Serratia marcesens*	2	24	0
9. *Alcaligenes viscosus*	4·2	5	–
10. *Alcaligenes faecalis*	1·1	2·7	5·3
11. *Aerobacter aerogenes*	0·47	7·5	–
12. *Neisseria catarrhalis*	0·83	4·1	–
13. *Proteus morganii*	0·45	86	–
14. *Micrococcus lysodeikticus*	2·3	+	–
15. *Veillonella gazogenes*	6·3	weak	–
16. *Propionibacterium pentosaceum*	16	+	–
17. *Clostridium perfringens*	0	0	–
18. *Saccharomyces cerevisiae*	strong	strong	–
19. *Saccharomyces carlsbergiensis*	strong	strong	–
20. *Candida albicans*	strong	strong	weak
21. *Aspergillus niger*	0	strong	0
22. Beef liver (fresh)	strong	strong	–
23. Pigeon liver (acetone powder)	strong	strong	–
24. Hog kidney (acetone powder)	strong	strong	–
25. Hog pancreas (acetone powder)	strong	strong	–
26. Spinach (fresh)	0	strong	–
27. Oak leaves (fresh)	0	strong	–

+ Not tested by us, but known from the literature to be positive.
– Not known.

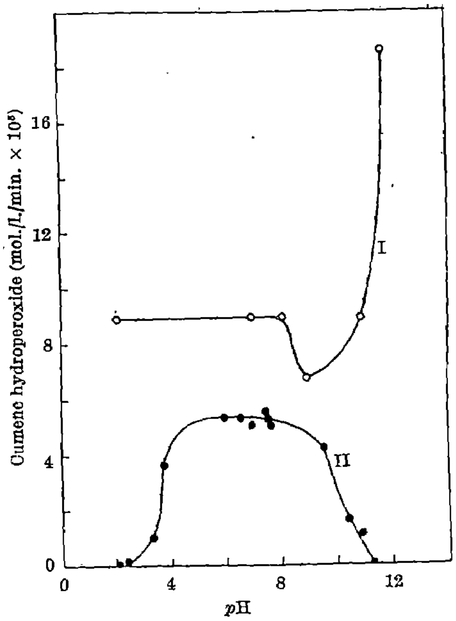

Fig. 2. Effect of pH on rate of reduction of cumene hydroperoxide. O, ascorbic acid in 0·1 *M* phosphate buffer; ●, *E. coli* and glucose in 0·1 *M* phosphate buffer

It appears likely that the hydroperoxide-decomposing activity of animal cells is to be attributed to ascorbic acid, which is known to be widely distributed in mammalian tissues, and which is capable of rapidly decomposing cumene hydroperoxide even when both are at low concentrations. Curve I of Fig. 2 shows the initial rate of reduction of cumene hydroperoxide, initially 0·00055 *M*, by initially 0·00095 *M* ascorbic acid in 0·1 *M* phosphate buffer, as a function of pH. (Trace amounts of copper are required to achieve an appreciable rate; it is well known that the autoxidation of ascorbic acid likewise requires copper.) This behaviour is in contrast to the broad bell-shaped curve of dependence of the rate of decomposition by *E. coli* on pH (Curve II, Fig. 2). The activity of mammalian cells is also distinguished from that of bacteria or of yeast in being undiminished by heating for 10 min. at 100° C.; the activity of *E. coli* and of baker's yeast is destroyed by heating to 70° for 1 min.

The activity of *E. coli* was found to be dependent on the presence of cofactors found in yeast extract. It has been observed that 'old' cells of *E. coli*, that is, those harvested after more than 24 hr. growth, show greatly reduced or no activity toward hydroperoxides, but that activity can be restored by the addition of a dilute solution of yeast extract. More than fifty different substances of biochemical interest were then tested, and their potencies in restoring activity, measured as initial rate of cumene hydroperoxide decomposition, were determined. Many carbohydrates were active, including mannitol, glucose, galactose, mannose, sucrose, arabinose, fucose, glucosamine, glucuronic acid, glucuronolactone, galacturonic acid, ribose, rhamnose, acetyl-α-amino glucose, fructose, dextrin and glucose-1-phosphate. Sodium formate and hydrogen were also active. Compounds tested and found inactive included the following carbohydrates and related compounds: α-methyl glucoside, α-methyl mannoside, lactose, pentaerythritol, 2,3-butylene glycol, trimethylene glycol, sorbose, dulcitol, sorbitol, glucose-6-phosphate, fructose-6-phosphate, fructose-1,6-diphosphate, phosphoglyceric acid, dihydroxyacetone, dehydroascorbic acid, glycerol and sodium pyruvate; also inactive were: all the known B vitamins, cysteine, reduced glutathione, and all the common amino-acids normally occurring in proteins. In buffer alone, only ascorbic acid, of all the compounds tested, was capable of decomposing cumene hydroperoxide in the dilute solutions in which they were tested.

Experiments in which glucose was added to an 'old' and inactive *E. coli* suspension showed that approximately 2·7 moles of peroxide were reduced per mole of glucose added. The added carbohydrate does not thus take a merely catalytic role, but is consumed at a rate which is of the same order of magnitude as that of the peroxide. In pH 6·9 buffer alone, one mole of ascorbic acid was found to reduce two moles of cumene hydroperoxide.

The effective substances are those which can be readily fermented by *E. coli*, but it is not clear whether the Embden–Meyerhof glycolytic system is involved in view of the very broad pH range over which rapid reaction of cumene hydroperoxide can be observed. It appears possible that bacteria and many other organisms and tissues contain an enzyme system capable of converting fermentable carbohydrates to an intermediate form which can react rapidly with organic hydroperoxides. Ordinarily, this intermediate may occur in equilibrium at very low concentrations, and its existence may become evident only when organic hydroperoxides or other strong oxidizing agents are present. In this connexion, the dienol glucose reported by Nath and Bhattathiry[1] may be recalled.

The activity of formate and of molecular hydrogen may be attributed to the hydrogenlyase and hydrogenase systems, respectively[2]. The fact that hydrogen and formate give a lower rate of cumene hydroperoxide reduction than some of the carbohydrates is probably attributable to the extremely low solubility of hydrogen in water. Formate could be rapidly converted to hydrogen and carbon dioxide, and some of the hydrogen might be lost from the cell into the nitrogen atmosphere above the liquid.

The reduction of organic hydroperoxides might be accomplished by an enzyme system of broad pH

Table 2. RELATION BETWEEN CARBOHYDRATE FERMENTATION AND COFACTOR ACTIVITY

Organism	Fermentation of carbohydrate listed			Cofactor activity of carbohydrate listed		
	Glucose	Glycerol	Inositol	Glucose	Glycerol	Inositol
Micrococcus pyogenes	*A*	*A*	0	+	+	0
Alcaligenes faecalis	0	0	0	0	0	0
Alcaligenes viscosus	0	0	0	0	0	0
Pseudomonas aeruginosa	0	0	0	0	0	0
Proteus morganii	*AG*	?	0	+	+	0
Aerobacter aerogenes	*AG*	?	*AG*	+	0	+
Escherichia coli	*AG*	0	0	+	0	0
Saccharomyces cerevisiae	*A*	–	–	0	–	–

A, acid (or carbon dioxide) only produced; *G*, hydrogen gas produced; ?, fermentation reaction variable or not known range capable of producing formate or hydrogen from carbohydrate, accompanied by a system (hydrogenlyase or hydrogenase) capable of transferring hydrogen from formate or molecular hydrogen to the hydroperoxide. Such a system could only be active in carbohydrate-fermenting, hydrogenlyase-positive organisms such as *E. coli* and the other Enterobacteriaceae. Yeasts and non-carbohydrate-fermenting bacteria such as *Alcaligenes faecalis* and *Pseudomonas aeruginosa* must reduce hydroperoxides by quite a different mechanism. In support of this suggestion, experiments were performed with a number of micro-organisms, as shown in Table 2. It will be noted that in every case where an organism was known to ferment a given carbohydrate, that carbohydrate served as a cofactor for the reduction of cumene hydroperoxide. Conversely, where a carbohydrate was known not to be fermented, no cofactor activity was found. *Micrococcus pyogenes* produces acid but no gas from glucose and glycerol, and hence shows no hydrogenlyase activity; nevertheless, these compounds show cofactor activity with *M. pyogenes*.

Probably, as in the case of methylene blue reduction, a wide variety of different mechanisms may be found, in different types of organisms and tissues, for the reduction of organic hydroperoxides.

The significance of organic hydroperoxides in the metabolism of bacteria is uncertain. Probably they do not ordinarily play an important part. However, Imelik[3] has suggested that the initial product of the oxidation of hydrocarbons by bacteria is a hydroperoxide. It further appears likely that organic peroxides may play a part in the effects produced by high-energy radiation. Thus, Scholes, Weiss and Wheeler[4] were able to detect hydroperoxides in ribonucleic and deoxyribonucleic acids exposed to ultra-violet radiation, and the formation of organic peroxides in proteins exposed to high-energy radiation has been reported[5]. We suggest that the peroxide-decomposing system we have described may be important in protecting the cell against radiation-induced damage.

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THE AGROTYPE CONCEPT IN TEA TAXONOMY

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THE special taxonomic problems posed by the tea plant are not generally known, nor was their satisfactory resolution apparent when they were first investigated at Tocklai. A classical system of nomenclature does not deal adequately with the cultivated tea plant[1].

Populations of tea bushes, nominally referred to[2] as *Camellia sinensis* L., which are used for the manufacture of tea, have a life of half a century or more. In India they are raised from seed produced in orchards of phenotypically mixed trees of the cross-bred origin described by Hunter and Leake[3]. This origin probably stems from earlier species hybrids[2]. A seed orchard is perennial, and thus genetically similar progenies of various ages come to be widely dispersed among numerous tea estates; but the orchard itself may have been forgotten or destroyed. The relative frequency of phenotypes differs greatly between progenies of disparate orchards.

Shoots from all bushes in a population are plucked and manufactured in bulk. Provided that the overall impression of 'quality' is satisfactory and the gross yield sufficiently high, wide phenotypic variation affecting *inter alia* yield and quality may be tolerated, and may possibly be a safeguard against excessive incidence of pests and diseases. There are big yield (and quality) differences between disparate progenies, yield per unit ground area being an essential criterion of agricultural efficiency.

Pure lines have not been used and are likely to have an impracticably low vigour: first-generation crosses between clones are known[4], but have not come into general use. There is accordingly great practical need for an efficient method of defining and discriminating between the mixed populations in current cultivation. Without this, it is impossible to investigate satisfactorily the influence of cultural practices and local conditions on yield, while even the most precise analysis of tea made from undefined populations is necessarily restricted in meaning.

Both quality of the made tea and yield of plucked shoots from which the tea is made differ between phenotypes; but in practice each of these attributes of individual phenotypes is automatically integrated into a single population value by the normal processes of bulk manufacture, and the integrated value becomes the yardstick by which the effect of manures and cultural treatments is measured. Investigation would be facilitated if there were important differentiating features of the phenotypes that could be integrated into a single numerical value by which the population could be given position in a taxonomic array.

To connote the concept of an integrated or average phenotype numerically defined, we have for some years used the term 'agrotype', originally proposed by Gregor[5] in connexion with the typification of crop plants. He suggested that crop populations (agrotypes) should be defined by stating the mean values and the variability of the characters, including characters of agricultural importance, chosen for typification.

A population average is possible provided the constituent individuals can be given numerical values corresponding to their expressions of the typifying feature. The condition is readily satisfied by number of unit organs exhibited, frequency of stamens, for example, or frequency of a specified type of cell. Where such a frequency is the only criterion of a phenotype employed, the agrotype of a population is simply defined by the mean frequency with its standard error.

The purpose of the present article is to show that frequency of calcium oxalate crystals in a specified

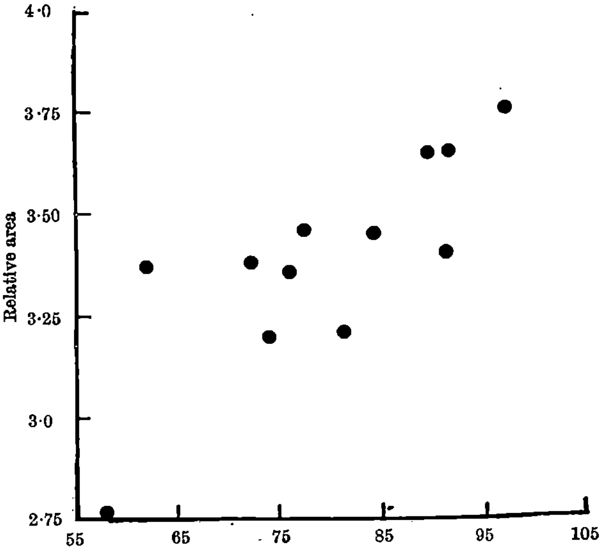

Fig. 1

region of the plant is a valuable criterion for the typification of tea populations. The crystals are in fact druses, and as only one druse occupies the lumen of a cell as seen in cross section, crystal frequency is a frequency of unit organs (cells) characterized by a particular set of chemical reactions.

Crystal frequency has been defined as total number of crystals in the phloem parenchyma of a complete cross-section of the leaf petiole[6]. Statistical analysis by Barua[7] shows that errors of counting can be kept within narrow limits. Crystal frequency has been shown to differ significantly between clones raised from seedlings of chance origin[6]; and in view of the cross-bred nature of commercial tea seed orchards, it seems likely that every tea seedling has its characteristic crystal frequency. Further, different tea populations in cultivation have been shown to differ significantly in mean crystal frequency[6].

Other mean attributes of a population have been shown to be related to the mean crystal frequency. There is a positive correlation with the number of standard shoots that can be obtained by repeated cropping or plucking[6]. This relation is subject to large seasonal and sampling errors. A similar but closer relation (shown in Fig. 1) holds between mean crystal frequency of a population and mean surface area of a bush ($r = +0.74 : P < 0.01$). The values shown in Fig. 1 are of relative area, square of the bush radius in feet (mean of two diameters). The Indian system of pruning and plucking results in a flat horizontal surface[8], and the method indicated has been shown to give a satisfactory measure of relative bush area.

The foregoing observations show that crystal frequency is indicative of a nature of growth (growth form) that must have an important bearing on the yield of a tea plantation: they suggest that crystal frequency may be closely related to a frequency of important genes.

In order to study the inheritance of the factors determining crystal frequency, it has been necessary to examine cross-bred progenies, since satisfactory progenies by self-pollination are difficult to obtain. Six cross-bred progenies were obtained by controlled pollination within pairs of parents indicated in Table 1. The parents originated as seedlings from commercial orchards the cross-bred nature of which has already been noted. Depending on the amount of experimental seed obtained, varying numbers of progeny plots, each of twenty-four seedlings, were established. Mean crystal frequencies for each progeny were determined by taking one leaf from each of five seedlings, chosen at random, in each plot, in accordance with the sampling method used in earlier investigations[6]. Analysis of variance showed the progenies to differ significantly in respect of mean crystal frequency ($P < 0.001$). Seedling differences within progenies were found to be significant ($P < 0.001$) when tested against the variation shown by replicate microtome sections of the same leaf. The more stringent test, against field variation of vegetative replicates of the seedlings, has not yet been carried out, but real differences between seedlings would undoubtedly be expected.

Table 1. Crystal Frequency of Progenies: June 1956

Mating	Parents ♀	♂	Number of plot repeats of progeny	Crystal frequency of a mean plant of the progeny
1	19/29/13 ×	19/35/2	7	101·3
2	19/35/2 ×	19/31/14	2	99·6
3	19/29/13 ×	19/31/14	5	100·8
4	19/37/2 ×	19/39/7	5	60·0
5	19/37/2 ×	19/36/15	2	50·3
6	24/7 ×	24/6	3	58·8
7	19/36/15 ×	19/39/7	5	39·2

Estimates of parental crystal frequency, given in Table 2, were obtained by sampling vegetative replicates, one leaf being taken from each of twelve plants, chosen at random, within a set of forty-eight vegetative replicates that had been produced from each parent.

At the time of the crystal counts the progenies were all the same age, 6 years, and the vegetative replicates of the parents were all 9 years old except for mating 6 (8 years). Parents at the time of vegetative propagation were all 30 years old except for mating 6 (10 years). All parental clones had received a common treatment, similarly all progenies; but there had earlier been differences of pruning and plucking between parents and progenies. Practical management of the plots had made it impossible to avoid a difference of about three months between the age (following annual prune) of parental shoots and those of their progeny; but it is our experience that this would have a negligible effect on the relative crystal frequencies.

Table 2. Crystal Frequency of Parents determined from Vegetatively Propagated Replicates in May 1956

Parent	Mean crystal frequency	Standard error	Name of orchard and year of seed origin of parent	Location of orchard lat. N.	long. E.
19/37/2	98·8	4·64	Bhatkhowa, 1917	26°40′	89°30′
19/35/2	128·1	4·63	Subong, 1917	24 55	92 50
19/29/13	117·9	3·91	Cinnamara, 1917	26 45	94 15
19/39/7	48·5	2·77	Huloonguri, 1917	26 40	94 25
19/31/14	108·9	3·95	Jaipur, 1917	27 15	95 25
24/6	77·4	5·12	Bazaloni, 1938	27 25	95 30
24/7	40·6	2·78	Bazaloni, 1938	27 25	95 30
19/36/15	26·4	1·78	Jadoo, 1917	27 30	95 35

Table 3. Crystal Frequencies of Parents and Progeny

Mating	Mean value of the two parents	Mean value of the progeny
1	123·0	101·3
2	118·5	99·6
3	113·4	100·8
4	73·6	60·0
5	62·6	50·3
6	59·0	58·8
7	37·4	39·2

The mean crystal frequencies of the two parents for each mating and the mean frequencies of their progeny are given in Table 3 and the correlation is shown in Fig. 2. The correlation coefficient of + 0·98 ($P < 0{\cdot}001$) shows that the crystal frequencies of progenies can be predicted from their parents with some precision. More recent observations on matings indicate that the relation continues to hold for matings between parents of even lower crystal frequency than any shown in the figure.

The foregoing observations show that the frequency of calcium oxalate crystals is an important method of defining tea agrotypes. Such agrotypes do not bear a simple relation to the varietal types of classical nomenclature; but in our experience crystal frequency is a necessary definition of tea plants for many theoretical and practical purposes. It is of similar importance as a definition of the processed shoots sold as dry tea. The frequency of calcium oxalate crystals fixes the position of individuals and populations on a scale which has a genetic basis. Use of such a scale simplifies investigation of problems connected with heterogenous populations.

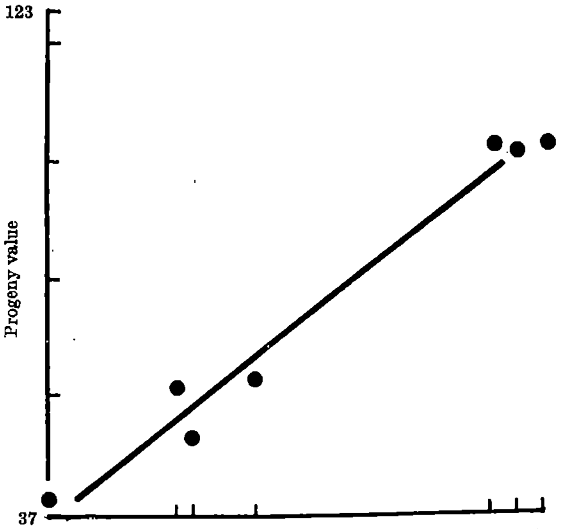

Fig. 2

I am indebted to Dr. J. W. Gregor and his staff when at Craigs House, Corstorphine, for many helpful discussions on the nature of plant populations, and to Prof. E. J. Maskell for valuable comments on presentation of the paper.

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INTERMEDIATES AND COMPETING REACTIONS IN THE PHOTODESTRUCTION OF INDOLEACETIC ACID

By PETER M. RAY* and GEORGE M. CURRY†
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THE changes in ultra-violet spectrum during photodestruction of aqueous solutions of indole-3-acetic acid by monochromatic ultra-violet light of 280 mμ, in air, have been followed in parallel with the decrease in Salkowski reaction intensity and in *Avena* coleoptile growth-promoting activity. The changes in spectrum lagged behind the disappearance of indole-3-acetic acid, as estimated by either of the latter methods, in such a way as to indicate the accumulation of an intermediate having an ultra-violet spectrum similar to that of the acid. This intermediate, which will be called *M*, appears to be stable in the absence of radiation, and it undergoes further photodestruction to give the spectrum shown in curve 3 of Fig. 1. When indole-3-acetic acid labelled with carbon-14 in the 2-carbon of the indole ring was irradiated, the tracer appeared in part in a chromatographic spot (*M'*, ref. 1) of R_F somewhat greater than indole-3-acetic acid, and which gave a weak pink nitrite reaction. The amount of material in this spot (as estimated from its radioactivity), at different times during the course of the reaction, corresponded approximately with the amount of *M* which was calculated, from the spectrophotometric changes, to be present; it disappeared by the time all the indole-3-acetic acid had been destroyed. The chromatographically detected intermediate *M'* may thus be the substance *M* indicated by the spectrophotometric observations, though this remains to be proved. It appears to be the same as substance '*E*' detected chromatographically by Fischer[2] in the photo-oxidation of indole-3-acetic acid which he regarded as indole-3-glycolic acid. In our hands, however, synthetic indoleglycolic acid ran at an R_F lower than indole-3-acetic acid[3]; the intermediate *M'* appears to be neither indoleglycolic nor indoleglyoxylic acid. Its identity is not yet established.

The spectrum of the final product (Fig. 1, curve 3) shows unmistakable similarity to the spectrum of indole-3-carboxaldehyde (indolealdehyde) shown in curve 2 (Fig. 1). This compound could readily be detected on chromatograms of the reaction product[1],

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† National Science Foundation Postdoctoral Fellow.

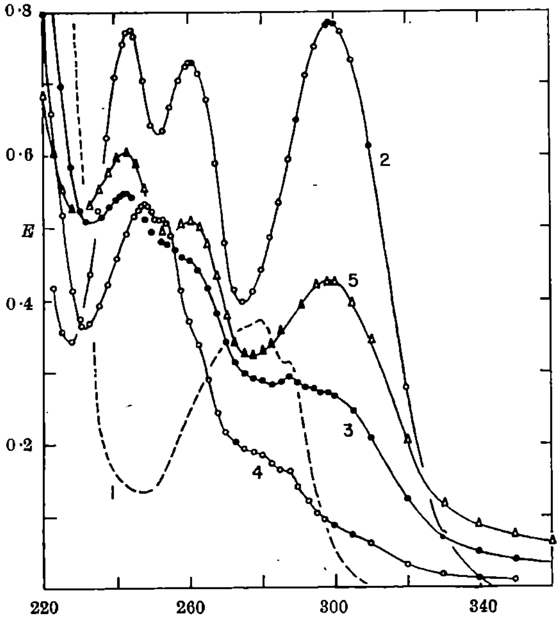

Fig. 1. Ultra-violet spectra (6·9 × 10^{-5} *M* solutions) of indole-3-acetic acid (curve 1), indole-3-carboxaldehyde (curve 2), and photodestruction products of indole-3-acetic acid (curves 3 and 4) and indoleglycolic acid (curve 5). Curve 3, irradiation of indole-3-acetic acid at 280 mμ (90 min., 5,600 ergs/sec.) or for 4 min. at 10 cm., from an unfiltered General Electric *H*85*C*3 100-watt mercury lamp (quartz). Curve 4, irradiation of indole-3-acetic acid at 302 mμ (180 min., 16,800 ergs/sec.) or for 95 min. at 10 cm., from an unfiltered General Electric *AH*-5 250-watt mercury lamp (glass). Curve 5, irradiation of indoleglycolic acid for 4 min. at 10 cm. from the *H*85*C*3 lamp. Photodestruction was carried out using 1·7 ml. of solution in a quartz cuvette of 1-cm. light path, as described previously (ref. 6) except that slit-width was 3·0 mm.

and the spot of colour corresponded with a peak of radioactivity when 2-labelled indole-3-acetic acid was used as substrate. Although these observations confirm the finding of Fischer[2] that indolealdehyde is a product, it can be seen from curve 3 (Fig. 1) that other light-absorbing materials than indolealdehyde were present in the product, and that taking these into account, indolealdehyde could have been formed at most in about 25 per cent yield from indole-3-acetic acid. The remaining products ran close to indolealdehyde on chromatograms, and were presumably neutral substances also. They were not products of photodestruction of indolealdehyde, because the latter itself was relatively little affected by a radiation dose sufficient to convert an equal amount of indole-3-acetic acid entirely into the products of curve 3 (Fig. 1). They appear to be formed from *M* along with indolealdehyde.

Irradiation of synthetic indoleglycolic acid gave the spectrum shown in curve 5 (Fig. 1). This indicates a considerably higher yield of indolealdehyde than from indole-3-acetic acid, perhaps approaching 50 per cent of stoichiometric, but there are evidently other light-absorbing materials present. Comparison of curves 3 and 5 (Fig. 1) indicates that were indoleglycolic acid an intermediate in photo-oxidation of indole-3-acetic acid, it could be formed initially only in partial yield. No direct evidence for its occurrence in photo-oxidation of indole-3-acetic acid has been obtained.

It was found, surprisingly, that when the wave-length of irradiation was varied, the spectrum of the final product also varied, even though phenomena indicative of the formation of *M* were still observed. The spectrum of the product formed by irradiation at 302 mμ or 313 mμ (curve 4) is almost identical with that of the enzymatic oxidation products of indole-3-acetic acid[4]. At 289 mμ and 297 mμ, spectra intermediate between curves 3 and 4 resulted. Neither of these products was convertible into the other by irradiation at any wave-length, so neither of them constitutes an intermediate step in the formation of the other. However, when irradiation intensity at 280 mμ was decreased, a portion of the final products also appeared in the form of curve 4. The proportion of the latter product formed at different irradiation intensities corresponded closely with what could be predicted from the kinetics of competing light- and dark-reactions acting on a second intermediate, *N* :

$$\begin{tikzcd}
 & & & \text{indolealdehyde + other products} \\
\text{Indole-3-acetic acid} \arrow[r, "k_1 I"] & M \arrow[r, "k_2 I"] & N \arrow[ur, "k_3 I"] \arrow[dr, "k_4"'] & \\
 & & & B \text{ (enzyme reaction products)}
\end{tikzcd}$$

Curve 3 corresponds to a light intensity *I* so great that essentially all of *N* is decomposed by the light-reaction governed by k_3. The extinction of *N* is evidently negligible at 302 mμ and 313 mμ, where indole-3-acetic acid still absorbs slightly and undergoes photodestruction, so that only *B* is formed. That *N* is not indoleglycolic or indoleglyoxylic acid is shown by the fact that these are stable, under the present conditions, in the absence of radiation. It was found afterwards that the difference in reaction products described above can be obtained simply by comparing the effects of mercury lamps with quartz (curve 3) and glass (curve 4) envelopes.

These observations indicate that the photo-oxidation process is complex, and preclude its being formulated simply as a stepwise conversion of indole-3-acetic acid into indoleglycolic acid, indoleglyoxylic acid, and indolealdehyde. At the same time they indicate a much closer chemical relationship between photodestruction and enzymatic oxidation of indole-3-acetic acid than has hitherto seemed likely, and complement nicely the recent finding of Stutz[5] that the enzymatic reaction can be diverted to the formation of indolealdehyde when cytochrome *c* and a cytochrome oxidase preparation are present in addition to 'indole-3-acetic acid oxidase'.

We wish to thank Prof. K. V. Thimann for his interest in this work, Dr. Bruce B. Stowe for synthesis of indolealdehyde and indoleglyoxylic acid, and Dr. M. D. Armstrong for the sample of indoleglycolic acid. The work was supported in part by grants to Prof. K. V. Thimann from the American Cancer Society on recommendation of the Committee on Growth, and from the National Science Foundation (*NSF*–G182).

[1] R_F values in *iso*propanol: 28 per cent ammonia: water, 10 : 1 : 1 (cf. Stowe, B. B., and Thimann, K. V., *Arch. Biochem. Biophys.*, **51**, 499; 1954): indole-3-acetic acid, 0·26; *M'*, 0·38; Ehrlich- and 2,4-dinitrophenylhydrazine-positive product of indole-3-acetic acid photodestruction, 0·74; indolealdehyde, 0·75; indoleglycolic acid, 0·18; indoleglyoxylic acid, 0·25.

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STUDIES OF UROCANIC ACID

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Intermediate Products in the Enzymatic Degradation of Urocanic Acid

UROCANIC acid (β-imidazoleacrylic acid) is the first intermediate formed in the catabolism of histidine to glutamic acid by mammalian liver[1]. The only other intermediate which has been well characterized is N-formiminoglutamic acid.

In order to study how the imidazole ring is opened, purified beef liver urocanase was allowed to act on α-^{14}C-urocanic acid (prepared enzymatically from α-^{14}C-histidine). The enzyme was purified 30-fold by a procedure which included adsorption with bentonite, precipitation with ammonium sulphate and fractional extraction of the ammonium sulphate precipitate. The enzyme activity was assayed by the spectrophotometric method of Tabor and Mehler[2].

Upon fractionation of the radioactive incubates, evidence was found for the formation of two products, one having an ultra-violet absorption peak at approximately 264 mμ (I), and the other (II) having an end-absorption. Comparison by paper chromatography showed that neither of these products was N-formiminoglutamic acid (Table 1), nor was N-formiminoglutamic acid found in any of the incubation mixtures, even when the incubation was allowed to proceed until no urocanate remained.

Spots of I and II on paper gave no colour when sprayed with Pauly's diazo reagent or with alkaline ferricyanide-nitroprusside reagent (an amidine test)[3]. Compound II was found to give a delayed ninhydrin reaction upon prolonged heating. It can be separated from I and purified by paper electrophoresis at *p*H 4·6 (Table 1). At this *p*H it is negatively charged, while I is approximately neutral. Synthetic formyl-L-isoglutamine was not separable from II by paper chromatography (with two solvents), or by paper electrophoresis (Table 1). Consequently, II appears to be formylisoglutamine.

Isolation of formyl-D,L-isoglutamine as a product of urocanase action was reported by Oyamada[4]. Formyl-L-isoglutamine has been synthesized and found to be microbiologically inactive[5,6]. Thus, probably it is not on the enzymatic pathway.

Table 1. RELATIVE ZONAL MOVEMENT WITH CHROMATOGRAPHY AND ELECTROPHORESIS ON PAPER

Substance	Chromatography Solvent *A* R_{uro}	Chromatography Solvent *B* R_{uro}	Electrophoresis *p*H 4·6 R_{pic}
Urocanic acid	1·0		0, 0·05
N-formiminoglutamic acid	0·52		0·82
Formylglutamic acid	0·82		
Glutamic acid	0·26		
Formyl-L-isoglutamine	0·93	0·95	0·75
I	0·95		0·01
II	0·91	0·97	0·74

Solvent *A*, propanol–1*N* acetic acid (3 : 1); solvent *B*, *t*-butanol–formic acid–water (14 : 3 : 3)

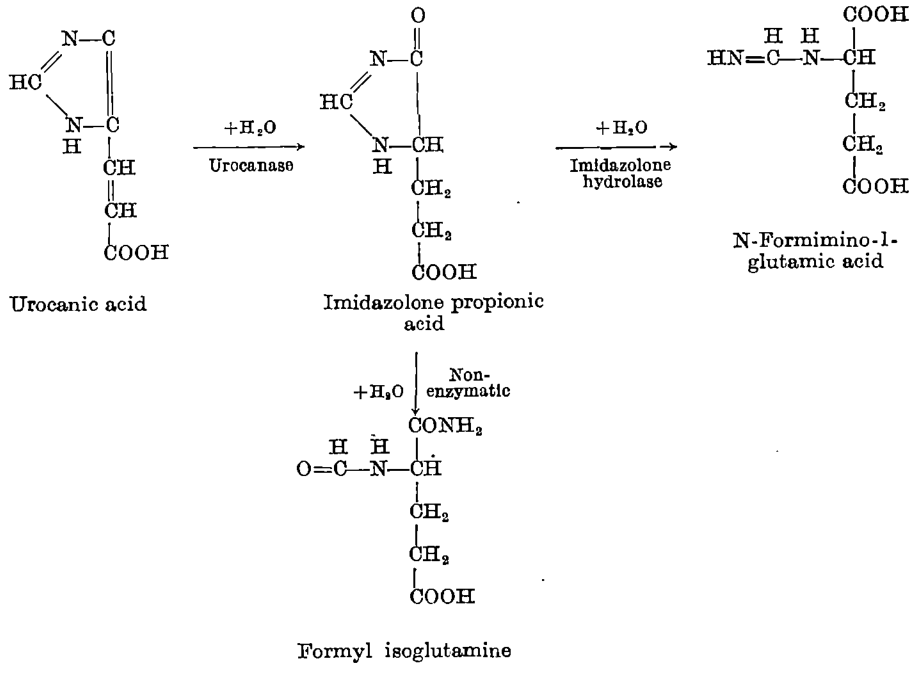
Electrophoresis medium: 0·2 *M* triethyl ammonium acetate. R_{uro} and R_{pic} are movements relative to urocanic acid and picrate, respectively

Formation of I was found to parallel the disappearance of urocanic acid, with no observable time lag. The ultra-violet absorption of I rapidly disappeared when it was mixed with crude liver extract. Neutral solutions of I are unstable at room temperature. Aged solutions of I contained large amounts of II.

The ultra-violet absorption, electrophoretic behaviour and instability of I lead us to propose that it is 4,(5)-imidazolone-5, (4)-propionic acid[7] (see scheme of reactions). The formation of formylisoglutamine by non-enzymatic hydrolysis is consistent with this proposal.

The reactions shown below account for our findings. They are similar to the proposals of others[4,5].

This work was aided by a research grant from the National Cancer Institute (*CY*-3175), United States Public Health Service.



Urocanic acid

Imidazolone propionic acid

N-Formimino-l-glutamic acid

Formyl isoglutamine

---

[*] Present address: Palo Alto Medical Research Foundation, 333 Channing, Palo Alto, California.

We are indebted to Dr. H. Tabor, National Institutes of Health for a sample of N-formimino-glutamic acid, and to Drs. A. Miller and H. Waelsch, of the College of Physicians and Surgeons, Columbia University, for a sample of formyl-L-isoglutamine.

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Dye Reduction by a Metabolite of Urocanic Acid

Miller and Waelsch[1] have reported that mixtures of urocanate with cat liver urocanase reduce such hydrogen acceptors as 2,6-dichlorophenol, indophenol and ferricyanide. This led them to propose a step involving oxidized urocanate and reduced enzyme as an intermediate of urocanase action.

Our preparation of partially purified beef urocanase when incubated with urocanate and the above dye reduced the dye at a higher rate than Miller and Waelsch reported. Further investigation showed that the dye reduction proceeded rapidly and non-enzymatically in neutralized trichloracetic acid deproteinized incubation mixtures in which urocanate was exhausted. Potassium ferricyanide was used in spectrophotometric studies to show that addition of this hydrogen acceptor caused an immediate reduction in the 264-mμ peak of imidazolone propionic acid presumed to be present in the mixtures.

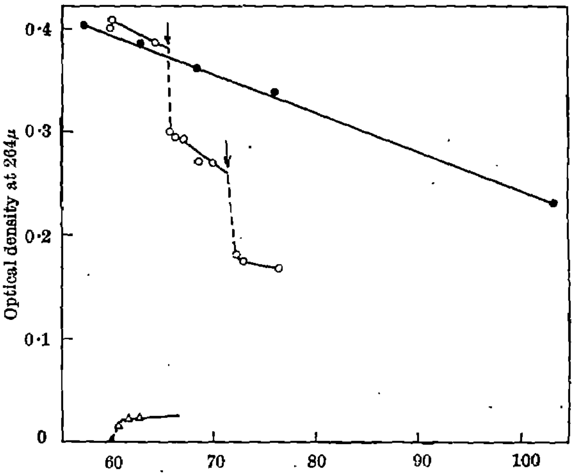

Fig. 1. Effect of addition of ferricyanide on the absorption of incubation mixtures of urocanic acid at 264 mμ.
The incubation mixture contained 0·5 μmole of urocanate, 40 μmoles of phosphate buffer, *p*H 7·1, and 2 mgm. of purified urocanase in total volume of 2·9 ml. Urocanate was exhausted at about 40 min. (in line designated by ○). At the points indicated by arrows, 0·1 ml. (0·05 μmole) of potassium ferricyanide was added; ●, same with no ferricyanide added; △, same with urocanate omitted. Readings are against enzyme blank at 25° C.

The rapid reduction of dye by imidazolone propionic acid indicates that this metabolite is susceptible to oxidation as well as hydrolysis. This suggests that imidazolone propionic acid may be an intermediate of the oxidation of urocanic acid described by Ichihara *et al.*[2].

Our results do not bear out the proposal of Miller and Waelsch that an oxidation product of urocanic acid is an intermediate of urocanase action.

This work was aided by research grants from the National Cancer Institute (*CY*-3175 and *C*-2869C), United States Public Health Service.

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DEALKYLATION OF N-ALKYLAMINES BY MODEL SYSTEMS

By JAMES R. GILLETTE, JAMES V. DINGELL and BERNARD B. BRODIE

Laboratory of Chemical Pharmacology, National Heart Institute, National Institutes of Health, Public Health Service, U.S. Department of Health, Education and Welfare, Bethesda, Maryland

A MAJOR pathway of drug metabolism is the oxidative dealkylation of N-alkylamines to yield a primary amine and an aldehyde. This reaction is catalysed by enzyme systems in liver microsomes and requires both reduced triphosphopyridine nucleotide and oxygen[1]. Since microsomes oxidize reduced triphosphopyridine nucleotide to yield triphosphopyridine nucleotide and peroxide-like material, it has been suggested that the peroxide moiety participates in the dealkylation of drugs as well as in their oxidation along other metabolic pathways[2]. However, a clear picture of the precise mechanism of dealkylation is not yet evident.

Unpublished work in this laboratory has shown that the demethylation of monomethyl-4-aminoantipyrine by liver microsomes was inhibited by α,α′-dipyridyl, suggesting the possibility that iron participates in the reaction. Furthermore, preliminary studies demonstrated that methæmoglobin and a hydrogen peroxide generating system catalysed the demethylation of monomethyl-4-aminoantipyrine. These findings have led us to investigate the action of a number of iron-containing model systems in the hope that some insight into the mechanism of microsomal dealkylation might be obtained.

The present communication describes studies with monomethyl-4-aminoantipyrine, N-methylaniline and their dimethyl congeners which demonstrate that a number of iron-containing model systems promote the demethylation of the alkylamines at physiological *p*H and temperature, and that dealkylation may occur by a number of mechanisms.

Three hæmoproteins—methæmoglobin, cytochrome *c* and horseradish peroxidase—were incubated with the amines in the presence of hydrogen peroxide generated by means of glucose and glucose oxidase ('Notatin'). Demethylation, as measured by the amount of formaldehyde trapped by semicarbazide[1], was catalysed by all three systems. As the reaction did not occur in the absence of the hydrogen peroxide

Table 1. DEMETHYLATION OF MONOMETHYL-4-AMINOANTIPYRINE (MMAP) AND 4-AMINOANTIPYRINE (AAP) BY MODEL SYSTEMS

	Formaldehyde from MMAP	Formaldehyde from AAP
Methæmoglobin ($1\cdot4 \times 10^{-5}$ *M*)	(μmoles)	(μmoles)
In air	0·0	0·0
Plus H_2O_2 generating system	2·1	1·1
Cytochrome *c* ($6\cdot2 \times 10^{-5}$ *M*)		
In air	0·0	0·0
Plus H_2O_2 generating system	1·0	0·3
Horseradish peroxidase (1×10^{-6} *M*)		
In air	0·1	0·0
Plus H_2O_2 generating system	2·4	1·2
Hæmatin (1×10^{-3} *M*)		
In air	1·1	0·6
Plus H_2O_2 generating system	1·0	0·6
$FeCl_3$ (6×10^{-3} *M*) under nitrogen	5·8	3·7

Experimental conditions. (*A*) Porphyrin systems. 10 μmoles substrate, 1 ml. of 0·2 *M* phosphate buffer, *p*H 7·4, 60 μmoles semicarbazide and water to a final volume of 5 ml. were incubated in a Dubnoff metabolic shaker for 1 hr. at 37° C. under air. The hydrogen peroxide generating system consisted of 500 μmoles of glucose and 0·5 mgm. of glucose oxidase ('Notatin'). The reaction was terminated by addition of 15 ml. of 6·67 per cent trichloracetic acid. After removal of protein by centrifugation, aliquots of supernatant were assayed for formaldehyde by the chromotropic acid method of MacFadyen (ref. 3) as described in previous paper (ref. 1). (*B*) Ferric chloride system. 10 μmoles substrate and 30 μmoles of ferric chloride in 5 ml. of water were incubated for 0·5 hr. at 25° C. under nitrogen. Aliquots of reaction mixture were assayed directly for formaldehyde.

system it may be concluded that the systems functioned as peroxidases.

Hæmatin also catalysed the demethylation of the amines. It is of interest that the porphyrin could act both as a peroxidase and as an oxidase. For example, at low concentrations of hæmatin (about 2×10^{-5} *M*) hydrogen peroxide was required for appreciable activity. In contrast, at high concentrations (1×10^{-3} *M*) of hæmatin, dealkylation did not require hydrogen peroxide. Since no activity was observed anaerobically it was concluded that hæmatin at the higher concentration functioned as an oxidase.

The amines, with the exception of dimethylaniline, were also demethylated by inorganic iron when more than stoichiometric amounts of ferric chloride were used. Of particular note was the finding that this system was as active anaerobically as aerobically, showing that ferric ions served as electron acceptors in a dehydrogenase-like mechanism.

The effects of the various model systems on monomethyl-4-aminoantipyrine are summarized in Table 1. Results of a similar nature were obtained with the other amines. It is of interest that formaldehyde was also formed when 4-aminoantipyrine was the substrate, indicating that the dealkylation of monomethyl-4-aminoantipyrine and dimethyl-4-aminoantipyrine resulted in part from removal of the N-methyl group from the pyrazoline ring.

The results presented here indicate that iron-containing model systems can promote dealkylation by three types of oxidation :

(1) A peroxidase reaction :

$$R\text{—NH—CH}_3 + H_2O_2 \xrightarrow{\textit{peroxidase}} R\text{—NH—CH}_2\text{OH} + H_2O$$

$$R\text{—NH—CH}_2\text{OH} \longrightarrow R\text{—NH}_2 + \text{HCHO}$$

(2) An oxidase reaction :

$$R\text{—NH—CH}_3 + \tfrac{1}{2}O_2 \xrightarrow{\textit{hæmatin}} R\text{—NH—CH}_2\text{OH}$$

$$R\text{—NH—CH}_2\text{OH} \longrightarrow R\text{—NH}_2 + \text{HCHO}$$

(3) A dehydrogenation reaction :

$$R\text{—NH—CH}_3 + 2\text{Fe}^{3+} \rightarrow R\text{N=CH}_2 + 2\text{Fe}^{2+} + 2\text{H}^+$$

$$R\text{N=CH}_2 + \text{HOH} \longrightarrow R\text{—NH—CH}_2\text{OH}$$

$$R\text{—NH}-\text{CH}_2\text{OH} \longrightarrow R\text{—NH}_2 + \text{HCHO}$$

A hydroxymethyl intermediate has been postulated as an intermediate in the dealkylation of methylamines[4]. Our studies have provided evidence in favour of the formation of such an intermediate. When monomethyl-4-aminoantipyrine was incubated with the methæmoglobin system in the absence of semicarbazide, both formaldehyde and the primary amine were formed ; on the other hand, in the presence of semicarbazide only a trace of the primary amine appeared (Table 2). These results could be explained by postulating the formation of a hydroxymethyl derivative which is stable in the incubation mixture when semicarbazide is absent, but would yield 4-aminoantipyrine when the reaction is stopped by the addition of trichloracetic acid. In the presence of semicarbazide, however, the hydroxymethyl intermediate would react, as formed, to yield formaldehyde semicarbazone and 4-aminoantipyrine. But 4-aminoantipyrine as well as aniline has been found to be very unstable in the various peroxidase model systems whether or not semicarbazide was added. This would explain the failure to find the primary amine in the incubation system which contained semicarbazide, since removal of formaldehyde would expose the free amine to destruction by the peroxidase systems.

Table 2 EFFECT OF SEMICARBAZIDE ON ACCUMULATION OF 4-AMINOANTIPYRINE (AAP) FORMED FROM MONOMETHYL-4-AMINOANTIPYRINE

	AAP formed (μmoles)	Formaldehyde formed (μmoles).
Methæmoglobin ($1\cdot4 \times 10^{-5}$ *M*) plus		
H_2O_2 generating system		
without semicarbazide	2·3*	2·8*
with semicarbazide	0·2	1·9

Incubation conditions: 10 μmoles substrate, 1 ml. of 0·2 *M* phosphate buffer, *p*H 7·4, the hydrogen peroxide generating system (500 μmoles glucose and 0·5 mgm. glucose oxidase) and water to a final volume of 5 ml. were incubated with and without 60 μmoles of semicarbazide for 1 hr. at 37° C. in an atmosphere of air. The reaction was terminated by addition of 15 ml. of 6·67 per cent trichloracetic acid. After removal of protein by centrifugation, aliquots of supernatant were assayed for 4-aminoantipyrine as described in a previous paper (ref. 1).

* Semicarbazide added at end of incubation period just before addition of acid.

Previous studies[5] have shown that hydroxylation of aromatic rings and cleavage of ethers can be brought about by a model system consisting of ascorbic acid, oxygen and inorganic iron chelated with ethylenediaminetetracetic acid. Evidence was adduced that the actual oxidant may be an unstable complex of hydrogen peroxide with the chelated iron. Since the methæmoglobin protein system also forms a hydrogen peroxide complex[6], it is possible that a hydrogen peroxide complex is also involved in the dealkylation of the alkylamines. Studies on the action of both types of model systems on other oxidative pathways of drug metabolism are being continued.

The material in this communication has appeared in a thesis by James V. Dingell in partial fulfilment of the requirements for the degree of master of science in the Department of Chemistry, Georgetown University, Washington, D.C.

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LETTERS TO THE EDITORS

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Determination of Orbital Characteristics of an Earth Satellite from Single-Station Radio-Transit Observations

Meridian transit radio observations have been made of the Satellite 1958α by means of a modified Minitrack Mark II interferometer located at the Sohio Research Laboratories east of Cleveland, Ohio (lat. 41° 26·3′ N., long. 81° 32′ W.). Because of the generally low altitude of the satellite at this station, the horizontal dipoles were replaced with commercial Yagi antennas, following a suggestion of G. W. Swenson, jun., of the University of Illinois. The completed system acts as a compound interferometer in that two pairs of Yagis are separated by 2·5 wave-lengths from each other and 55 wave-lengths from the other two pairs. This was done to minimize lobe ambiguities. The antenna system deviates about 0·3 deg. from the true east–west base-line as determined by solar transit observations. The receiving system consists of a low-noise preamplifier, triple-conversion receiver, *WWV* time-marking circuit and a dual-channel recorder which was kindly loaned by the Brush Instrument Co. More than 120 transits have been observed to date. Fifty-six transits between Feb. 15 and Feb. 27 were selected for further analysis, as the multiple interferometer was in operation during that time.

The time between successive meridian passages (the synodic period) was found to give a considerable amount of information on the orbital characteristics of the satellite. In the interval between the sidereal and synodic periods the satellite covers about 30 deg. of arc in its orbit. The time to cover a given arc depends on the orbital angular velocity, which is a function of the period, eccentricity and true anomaly. The length of the arc depends on the time interval, the longitude of the node and the inclination. Values for the period, ρ ; R.A. of ascending node, Ω ; argument of perigee, ω ; eccentricity *e* and inclination *i* at epoch (Feb. 1, 0358 U.T.) were adopted from *Harvard Announcement Card* 1393. The inclination was afterwards found to require correction. The instantaneous values of ρ, Ω and ω at the time of observation depend on the time-rate of change of the period, the regression of the node and the advance of the line of apsides respectively. The 56 transits gave 43 observed values of the synodic period. These were compared with values of the corresponding synodic periods computed on an *IBM* 650 for various values of $\dot{\rho}$, $\dot{\Omega}$, $\dot{\omega}$ and *i*. The change in the eccentricity had a minor effect on the angular velocity in the time-interval considered, and a mean value was used.

The following values were adopted on the basis of minimizing the sums of squares of the residuals :

$$\dot{\rho} = -\,0{\cdot}0209 \pm 0{\cdot}0007 \text{ min./day}$$
$$\dot{\Omega} = -\,4{\cdot}242 \pm 0{\cdot}025 \text{ deg./day}$$
$$\dot{\omega} = +\,6{\cdot}255 \pm 0{\cdot}018 \text{ deg./day}$$
$$i = 32{\cdot}08 \pm 0{\cdot}18 \text{ deg.}$$
$$\sqrt{\sum_i \frac{(O-C)_i^2}{n}} = 0{\cdot}18 \text{ min.}$$

The 'errors' or lack of fit refer to the change in the parameter necessary to change $\Sigma(O-C)^2$ by 0·01 min.², while keeping the other three parameters constant. The rate of change in period implies that the lifetime of the satellite will be of the order of two years.

The observed and computed synodic periods are plotted against the mid-point in Eastern Standard Time (E.S.T.) of the observation in Fig. 1. As 23 periods are only slightly less than two days, observations separated by this interval may be closely compared. The major change in the orbit during that time is due to the regression of the node. This causes the synodic periods west of the north point of the orbit (earlier in the day) to become shorter because of the shortening length of arc in the orbit. Correspondingly, periods east of the north point will lengthen because of the increasing orbital length of arc. Periods near the north point will be changed only slightly. On Feb. 15, the north point crossed the meridian at about 1530 E.S.T., shifting to about 1130 E.S.T. by Feb. 27 due to the regression of the node. Clearly some systematic residuals remain ; a further analysis is planned to improve the parameters. The accuracy of the present results cannot compare with those determined from many Minitrack stations, at which direction cosines of the satellite itself are found. What is of interest is the information attainable from meridian observations at a single station.

A detailed account of the observations and interpretation will be published elsewhere. The project was under the direction of A. L. Jones. The design of the system and recording of the observations were due to R. W. Burhans, P. S. Fay, Warren Jackson and many others of the Sohio Research Staff. Interpretation of the data was carried out by Gordon Grant. David Frazier was in charge of the *IBM* 650

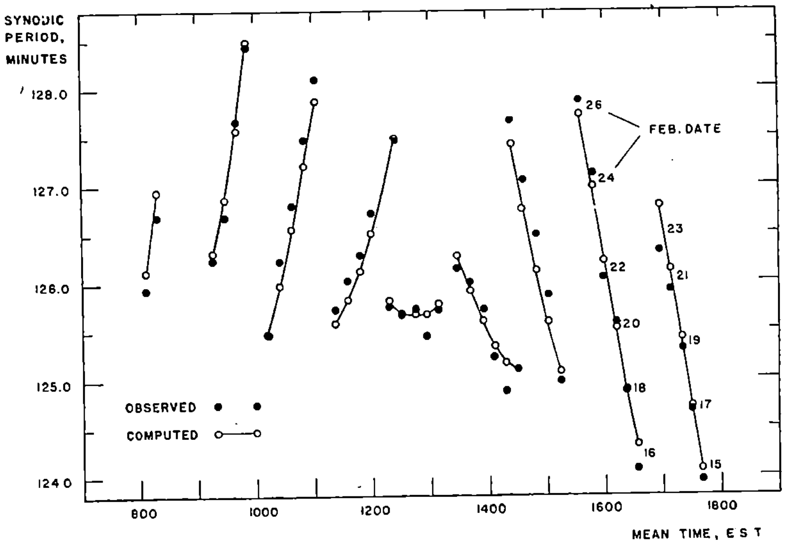

Fig. 1

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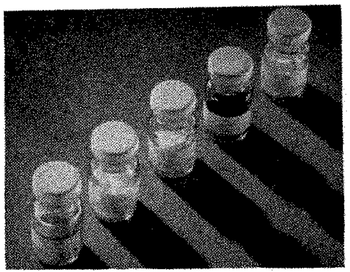

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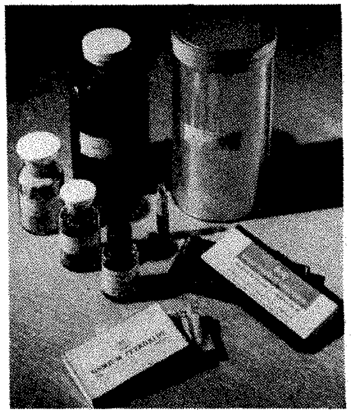

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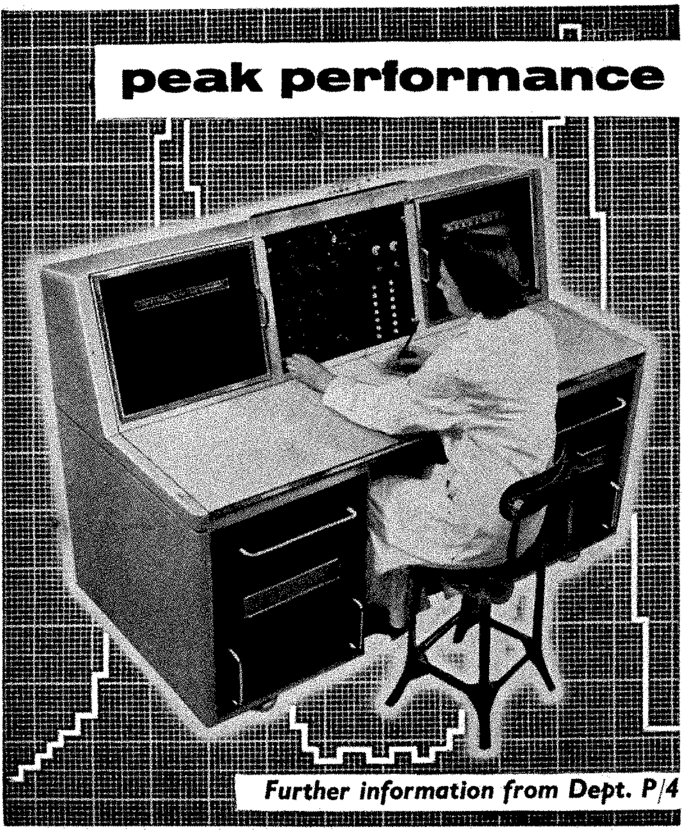

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March 3.

Electron Micrographs of Monolayers of Stearic Acid

AT the second International Congress of Surface Activity held in London during April 1957, we presented results of a study with film balance and electron microscope of monolayers of *n*-hexatriacontanoic acid[1]. This compound shows small islands irregular in size and shape at low surface pressures (15 dynes/cm.), a continuous monolayer with discontinuous uncovered areas at intermediate pressures (25 dynes/cm.), a continuous homogeneous monolayer at high pressures (40 dynes/cm.), and long flat structures two molecules thick after collapse.

Monolayers of other compounds have since been examined: stearic, arachidic, *n*-hexacosanoic and *n*-dotetracontanoic acids give, as expected, monolayer structures much like those of *n*-hexatriacontanoic acid; *n*-octadecyl alcohol and cholesterol show related structures. Of principal interest is the behaviour of stearic acid at low surface pressures. It is the classical compound in monolayer research; but because of the small thickness of its monolayer it is more difficult to study in the electron microscope than *n*-hexatriacontanoic acid.

Monolayers of stearic acid were successfully transferred from the film balance at surface pressures as low[2] as 3 dynes per cm. An electron micrograph of such a sample is shown in Fig. 1. The direction of shadow-casting is indicated by an arrow; shadows appear as light areas. Many small islands, irregular in shape and about 1000 A. in diameter, are observed. Shadow widths establish that the islands are about 25 A. or one molecule thick. Close examination reveals that the spaces between islands actually contain many small structures. Presumably, smaller aggregates and individual molecules beyond the limit of the electron microscope may also be present.

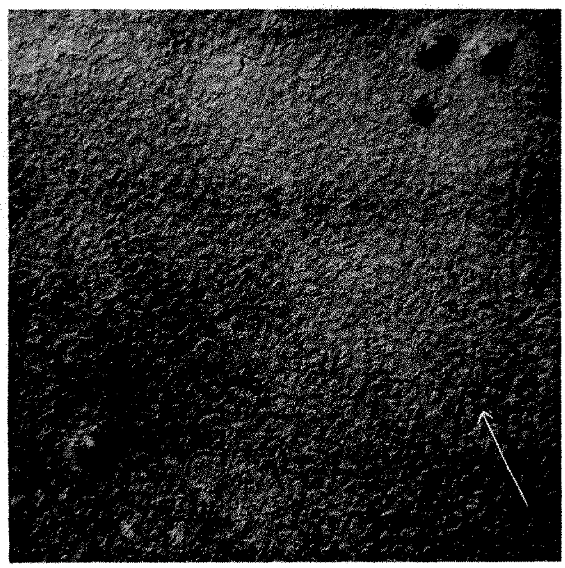

Fig. 1. Monolayer of stearic acid at 3 dynes per cm.

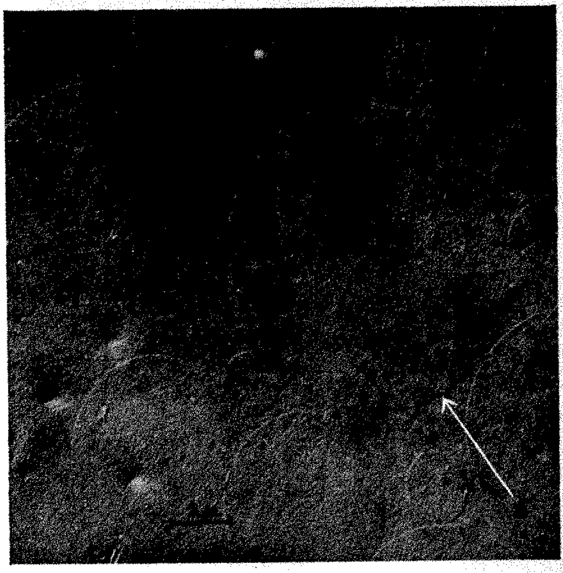

Fig. 2. Monolayer of stearic acid at 10 dynes per cm.

At greater surface pressures, less area remains uncovered. Fig. 2 is an unusual micrograph of a stearic acid monolayer transferred from the film balance at 10 dynes per cm. Most striking is the circular geometry of many of the islands, diameters of which range from 3000 to 50,000 A. In related monolayer studies, approximately circular islands, circular holes, and circular platelets on top of monolayers have been observed.

Circular islands that resemble flattened liquid droplets are somewhat surprising when one considers that the melting point of stearic acid is 69° C. and that the experiments were conducted at 25° C. However, forces at an edge of a 'two-dimensional' monolayer may be analogous to forces in the surface of a 'three-dimensional' system. Just as spheres with minimum surface energy appear in bulk liquid systems, circular disks may be expected in monolayers with sufficient mobility. Possible effects of droplets forming in the water film sandwiched temporarily between the monolayer and the collodion support used in transfer must also be considered; new transfer techniques now under study may resolve such effects. Experiments at higher temperatures should help define the role of surface mobility in the formation of monolayer islands.

HERMAN E. RIES, JUN.
WAYNE A. KIMBALL

Research Department,
Standard Oil Co. (Indiana),
Whiting, Indiana. Jan. 10.

[1] Ries, jun., H. E., and Kimball, W. A., Proc. Second Internat. Cong Surface Activity, 1, 75 (Butterworths Scientific Pub., London 1957). See also Res and Kimball, *J. Phys. Chem.*, 59, 94 (1955).

[2] For the complete pressure-area isotherm, see Ries, jun., H. E., and Cook, H. D., *J. Colloid Sci.*, 9, 535 (1954).

Effect of Hydrogen on the Deformation Characteristics of Alpha-Titanium

It is well known that when iodide titanium containing more than 10 p.p.m. by weight of hydrogen is slowly cooled from 300° C. to room temperature, a second phase, titanium hydride, is precipitated in the alpha-titanium matrix.

X-ray and microscopical studies on single crystals have revealed that the precipitate is in the form of platelets, which lie mainly along the $\{10\bar{1}0\}$ slip planes. It is therefore natural to associate the precipitation with dislocations on the $\{10\bar{1}0\}$ system, especially as preferential precipitation occurs in regions of high plastic strain. If it is assumed that a $\{10\bar{1}0\}$ dislocation can dissociate as postulated by Churchman[1], the stacking fault structure associated with this dissociation requires only small additional movements of the titanium atoms to arrange these as the titanium atoms in either of the published structures for titanium hydride[2–5].

Evidence that hydrogen atoms do segregate around dislocations is provided by the observation of a very rapid strain ageing phenomenon in titanium during tensile experiments at 250° C. Calculations reveal that of the common impurities only hydrogen could diffuse at a fast enough rate to explain this effect. Experiments were carried out on both single crystals and polycrystalline titanium, which had previously been hydrogenated, the oxygen and nitrogen content being less than 0·01 weight per cent.

Little or no strain age-hardening was observed, and the work-hardening was of a parabolic nature with no significant increase in flow stress due to the presence of hydrogen. This differentiates the present deformation characteristics from those caused by 0·1 weight per cent oxygen plus nitrogen, where there is a very low linear rate of work hardening with an increased flow stress[6]. This difference suggests there is some fairly weak barrier to dislocation movement in titanium containing only low amounts of oxygen and nitrogen. Examination of the possible dislocations in the hexagonal lattice shows that two dissociated $\{10\bar{1}0\}$ dislocations on intersecting planes can combine to form a stable barrier of the Cottrell–Lomer type[7,8], which could hinder subsequent slip.

Embrittlement under impact-testing conditions occurs by the propagation of cracks which are associated with the hydride platelets. These cracks are caused by interference of the hydride phase with subsequent slip and twinning processes.

The above results will shortly be published in greater detail elsewhere.

I wish to thank Dr. A. T. Churchman for his encouragement and many valuable discussions.

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Occurrence of Beryllium Oxide in Polycrystalline Beryllium

Sloman[1] has claimed to have found, using optical microscopy in conjunction with chemical analysis, that a beryllium oxide/beryllium eutectic forms at grain boundaries in vacuum-cast beryllium containing 0·3 per cent oxide by weight. By contrast, other workers[2] have since been unable to detect such oxide, either in the grain boundaries or present as inclusions in metal of comparable purity. It is still generally agreed, however, that the brittleness of beryllium is probably associated with some impurity, and our current results support the original claims by Sloman.

Our beryllium specimens were fabricated from electrolytic flake beryllium which had been vacuum-cast (~ 1,400° C.). The ingots were extruded at about 1,000° C. to form both rod and tube of about 1 in. diameter and by analysis were found to contain approximately 0·25 per cent beryllium oxide by weight. Our electron-diffraction study shows that specimens prepared from four different batches of such beryllium contain variable amounts of the oxide, which is probably concentrated at grain boundaries: it is clearly in the form of relatively large crystals (greater than 500 A. in diameter). It has been shown[3] that beryllium oxide is crystalline when formed or heated at temperatures above about 280° C., and develops as relatively large crystals (greater than about 500 A. in diameter) when the metal is heated in air above 600° C. for half an hour or more. The beryllium oxide in the present case must therefore have been formed at, or subjected to, temperatures in excess of 600° C., probably above 800° C., during the electrolytic preparation, vacuum casting or extrusion.

The beryllium oxide is distributed throughout the material, as the following example shows. A 1-in. rod was turned down to 1 cm. diameter, and flat surfaces of transverse and longitudinal sections were prepared by grinding, followed by abrasion on emery papers down to grade 0000, then on fine (3μ) diamond powder. The final distorted surface layer was removed by electropolishing[4], which further smoothed the surface and showed the grain size to be about 40μ. Etching the surface in 10 per cent aqueous sulphuric acid for 30 sec. dissolved the metal preferentially at about 100 A. thickness per sec., but a beryllium oxide surface produced by heating another such sample of the metal in air (for example, at 400° C. for half an hour) was passive in the solution. Fig. 1, obtained by electron diffraction after etching the metal, shows arcs due to the beryllium (which we found has a

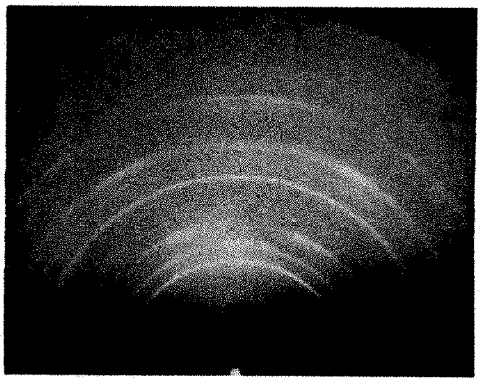

Fig. 1

pronounced <210> fibre texture with the orientation axis parallel to the rod axis), and in addition strong sharp rings indicating randomly orientated beryllium oxide crystals of at least 500 A. in diameter. Such oxide was found repeatedly after re-surfacing in the manner described.

When preparing single-crystal surfaces in this way, clear Kikuchi-line and spot patterns were obtained with no sign of sharp diffractions from oxide. Thus the oxide observed on the polycrystalline surface was not produced as a result of the method of surfacing. Clearly, therefore, in the case of the hot-extruded material described above, the preferential solution of the beryllium by the etchant must have left the oxide crystals projecting above the metal, thus increasing their relative contribution to the diffraction pattern.

Further investigations, particularly of the penetration of oxygen into beryllium at high temperatures and the existence of oxide films in coarse and fine-grain vacuum-cast metal, are in progress.

We wish to thank Mr. G. C. Ellis and Dr. A. Moore for the provision of specimens and for helpful discussions. One of us (V. D. Scott) is on detached duty from the Atomic Weapons Research Establishment, Aldermaston; we are indebted to the Director of this Establishment for permission to publish these results.

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Kinetics of the Trigonal-to-Cubic Transition in Crystals of Cæsium Nitrate on Muscovite

It is well known[1] that the epitaxial orientation of cubic cæsium nitrate on muscovite is

$$\text{CsNO}_3\ (100)\ [010] = \text{muscovite}\ (001)\ [010]$$

whereas the orientation of trigonal cæsium nitrate is

$$\text{CsNO}_3\ (11\bar{2}1)\ [10\bar{1}0] = \text{muscovite}\ (001)\ [010],\ [130]\ \text{and}\ [1\bar{3}0]$$

From a general point of view, the possibility of obtaining definite orientations on definite crystallographic planes means that, of the many possible arrangements, there are some for which nucleation is more probable. In the language of statistical thermodynamics, this probability is $p = \exp\left(-\frac{\Delta F}{kT}\right)$. Consequently nucleation which gives rise to epitaxial crystals corresponds to a value of ΔF less than that for other possible arrangements. The interface between epitaxial crystals and the substrate crystal presents a smaller discontinuity than any other possible arrangement. In other words, this smaller discontinuity corresponds to both a smaller interfacial free energy and a smaller elastic strain energy.

Any polymorphic transformation undergone by the oriented crystals will involve an increase in this free energy. A shift of the equilibrium temperature, with respect to that of non-epitaxial crystals, may be foreseen. If the transformation takes place between phases of which only one is epitaxial, the shift will be large. If both phases are epitaxial, the shift will be in general smaller, and its direction will indicate the more stable epitaxy.

We have made simultaneous observations of the kinetics of the polymorphic transformation of cæsium nitrate from trigonal to cubic, on crystals of the same size obtained by evaporation of the same solution, (i) on a glass substrate and (ii) on a crystalline substrate (muscovite), in order to correlate the two processes. The two supports were placed in a Weigand heating apparatus[2] fitted to a Leitz microscope, so that the crystals oriented on the mica and the non-oriented crystals on the glass were in view simultaneously. The temperature of transformation was clearly defined by the disappearance (or appearance) of birefringence on heating (or cooling) uniformly (2 deg. C. per min. at first). We have established, in many experiments, that on heating, the birefringence appears first in the crystals on the glass substrate, and on cooling it appears later. The interval between the appearance of the birefringence in the two cases has never been more than 45 sec.

The difference in behaviour described above is quite small in comparison with that observed in other experiments. For example, for the transformation $\text{NaBr} \rightarrow \text{NaBr.2H}_2\text{O}$, in which only one phase (NaBr) is epitaxial on galena, the time difference with respect to sodium bromide unoriented on glass is almost two hours. In this case the hydration brings about an appreciable increase of the interfacial discontinuity. In the case of cæsium nitrate, however, the interfacial discontinuity varies little from one phase to the other. The direction of the variation indicates that the epitaxy of the trigonal phase is more stable and more probable.

We have recently shown[3] that the preponderant factor in determining the interfacial discontinuity is the amount of difference in symmetry. For cæsium nitrate, the change in the dissymmetry is almost negligible and shift in equilibrium is minimal.

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An Electronic Mechanism of Addition Reactions

A recent communication from Mr. Lakhbir Singh[1] seems to require a reply based rather more firmly on conventional theoretical chemistry. He refers to the decrease in reactivity of acetylene compared to ethylene, and implies that this shows that an increase in the number of π-bonds leads consequently to a decrease in reactivity. Duchesne[2] has, however, pointed out that the greater reactivity of ethylene compared to acetylene is due to the fact that the torsional oscillations in ethylene uncouple the π-electrons, whereas this cannot happen in acetylene. Singh also describes allene as "very much strained". It is difficult to see why this should be so, unless reliance is placed on the Baeyer[3] strain theory. In modern terms the central atom may be described as having two σ-bonds in an *sp*-hybrid, with two *p*-orbitals available to form two π-bonds, the planes of which are at right-angles to each other. The low reactivity in cumulenes compared to polyenes can be attributed to the small effect of torsional oscillations on the environment of the central atoms.

Mr. Lakhbir Singh's arguments concerning the effect of electron-attracting and repelling groups can easily be replaced by the usual arguments involving hyperconjugation, and there is no need to postulate that the σ-electrons are all-important. If in addition reactions the attack is on the σ-electrons, it is difficult to see why there is any difference in reactivity between unsaturated and saturated compounds. In these and in benzene derivatives, Mr. Lakhbir Singh does not apparently distinguish between inductive and electromeric effects.

In his explanation, Mr. Lakhbir Singh apparently ignores the fundamental principle that the total electronic wave function must have the symmetry of the nuclear framework. His *p*-orbitals inclined at an angle are certainly not in accordance with this principle. He also suggests that "the distortion of the σ-electron orbits would be unsteady and non-uniform". This view seems to ignore the principle of stationary states.

It may well be, as he remarks, that the "quantum mechanical approach has not succeeded in solving this problem", but any explanation must not be contrary to the fundamental principles of quantum mechanics.

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The Pigment of *Micrococcus lysodeikticus*

While culturing cells of *Micrococcus lysodeikticus*[1], white cells, resistant to lysozyme, were often produced in liquid media containing relatively high carbohydrate. Resistant cells remained Gram-positive and were not lysed by lysozyme in the presence of ethylenediaminetetraacetic acid[2]. Optimal concentrations of cultural sodium chloride for growth improved the yellow colour of the organisms[3]. These observations suggested a relationship of the yellow pigment to the polysaccharide substrate of lysozyme.

Extraction of the pigment directly from dried organisms[1] with petroleum ether (b.p. 40–60° C.) provided a lipid extract and poor pigment yield. The pigment failed to migrate on MgO–'Celite' (1 : 1) and disappeared rapidly from this adsorbent. The following method, however, gave good quantities of pigment. *M. lysodeikticus* was grown at 28° C. in 250-ml. shake flasks, each containing 100 ml. medium[3]. After 48 hr., cells were centrifuged and washed with 0·85 per cent saline. The equivalent of 4·2 gm. cell dry weight was used in a typical experiment. Cells were suspended in 50 ml. 0·85 per cent saline and 150 ml. *M*/15 phosphate buffer, *p*H 6·3. 40 mgm. Armour egg white lysozyme were added and lysis was carried out for 1 hr. with occasional shaking; 400 ml. cold acetone were added. Extraction was continued for 48 hr. (5° C.) with frequent shaking. The clear yellow supernatant was decanted and filtered by gravity (Whatman No. 1). Extraction was repeated with acetone. The second extract was more highly coloured. This was combined with the first fraction and evaporated to dryness in a stream of air at 25° C. The residue was extracted with 100 ml. petroleum ether, concentrated to 3 ml. (25° C.) and transferred to a 1 cm. × 12 cm. activated calcium carbonate column. (The non-extractable residue contained a yellow-orange pigment which was also insoluble in carbon disulphide but soluble in water. This has not been studied further.) The eluant was petroleum ether. Two yellow bands migrated on the calcium carbonate column[4], a fast-moving component, *A* (distribution coef. is about 1·9) and a low-moving component, *B* (distribution coef. is about 2·7). The distribution coefficient was calculated as K = vol. of eluant flowed into column ÷ fraction of column-length migrated by the band × gm. of adsorbent. Band *A* was eluted with petroleum ether. Band *B* was obtained by extruding the column and extracting the yellow segment overnight with absolute ethanol at 5° C.

Table 1. Visible Spectra of Fractions *A* and *B* in Various Organic Solvents

Fraction	Solvent	$E_{\text{max.}}$ (mμ)			
A	Petroleum ether (b.p., 40–60° C.)	468	440	414	(329)
B	,,	470	440	410	
A	Carbon disulphide	494	462	440	375
B	,,	490	460	378	
A	Calcium carbonate	477	447	423	
B	,,	470–80	440–50		

Characteristic $E_{\text{max.}}$ for the carotenoids are shown in Table 1. Although we have not seen reports concerning the pigments of *M. lysodeikticus*, Sobin and Stahly[4] have isolated carotenoids from several other species. Those species which have two yellow carotenoid alcohols similar to the pigments from *M. lysodeikticus* are *Sarcina lutea* and *M. flavus*. These pigments are dissimilar from a carotenoid from *M. aquivivus*, *M. maripuniceus* and *M. infimus*[5].

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Bacterial Oxidation of Lactose and Melibiose

During an investigation of bacteria isolated from blocks of whale meat, two distinct strains of paracolon bacteria (*B*1*x*, urease-positive; and *C*6, urease-negative) were obtained, the sugar metabolism of which was interesting. Tested in the normal way with Durham tubes, these organisms produced acid from lactose within 5–12 days at 30° C. and were accordingly recorded as late lactose fermenters. Tested by Hugh and Leifson's[1] method, both strains fermented cellobiose, maltose, sucrose, trehalose, galactose, glucose, mannitol and sorbitol, producing acid and gas anaerobically within 48 hr. at 30° C.

Lactose, melibiose and glycerol, however, were not fermented but oxidized, that is, acid was produced from these sugars within 48 hr. under aerobic conditions only.

In shaken, aerobic cultures at 30° C. of strain *B*1*x*, containing 2 per cent (w/v) of lactose or melibiose, all reducing power disappeared within 48 hr. Paper chromatograms of culture filtrates, using *n*-propanol/ammonia (70 : 30) as solvent and sprayed with ammoniacal silver nitrate or thymol blue, showed respectively spots corresponding to lactobionic acid and melibionic acid (prepared by the method of Levene and Jorpes[2]), which were absent from control cultures without sugar. Comparison of the sizes of the spots with those of known concentrations of the acids suggested that the conversion of sugar to acid had, in each case, been nearly quantitative.

Confirmatory evidence of the identity of the acids was obtained by subjecting the filtrates, after passage over 'Zeo-Karb 225', to hydrolysis with *N* hydrochloric acid at 100° C. for 2 hr., removing the acid with silver oxide and running the resultant solutions on paper using the same solvent. On spraying with ammoniacal silver nitrate, spots corresponding to galactose and gluconic acid, absent from the original filtrates, were obtained. The acids present in the original culture filtrates have therefore been provisionally identified as lactobionic and melibionic.

It seems that this paracolon strain is able to oxidize lactose and melibiose to lactobionic and melibionic acids respectively. The oxidation of lactose by paracolon bacteria[1], and the oxidation of lactose and maltose to the corresponding acids by oxidative *Pseudomonas*[3,4] and *Achromobacter*[5] spp. have been reported, but so far as is known, this is the first recorded instance of the production of melibionic acid from melibiose. The wider use of the Hugh and Leifson technique would probably reveal more cases of this kind. This work emphasizes the inadequacy of the traditional fermentation tube technique in which both aerobic and anaerobic conditions exist.

I wish to thank Dr. F. A. Isherwood and Mr. F. C. Barrett for their help and advice.

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Role of Oxygen in the Formation of α-Amino-butyric Acid by a Staphylococcus

The formation of α-amino-butyric acid by animal cells has been studied[1,2], but little is known of the method of its formation by staphylococci[3].

It has been shown here, using shaken flasks, that the formation of α-amino-butyric acid by staphylococci is a function of the amount of oxygen available to the culture. It has been confirmed that the acid can be derived from threonine and it has been shown that, presumably by a similar process, alanine can be formed from serine.

The organism used was the *V*8 strain of staphylococcus employed by Gladstone and van Heyningen[4]. The culture medium, consisting of 'Bacto Casamino-acids', 2 per cent; yeast diffusate, 20 per cent; sodium lactate, 0·75 per cent; sodium glycerophosphate, 2 per cent; and mineral salts was the same as that used by Gladstone and van Heyningen. The organisms were grown at 37° C. in 500-ml. conical flasks plugged with cotton wool, the oxygen solution-rate being varied by varying the volume of medium in the flask. When shaken on the bottom shelf of a Kantorowicz[5] shaker the flask containing 1/5 its volume of liquid gave an oxygen solution-rate determined by sulphite oxidation[6] of 29 m.moles O_2/l./hr. and the flask containing 1/20 its volume of liquid gave a value of 75 m.moles O_2/l./hr.

Changes in amino-acid composition of the medium during growth were followed by two-way chromatography.

While no new amino-acids appeared during growth in the flasks containing 1/20 their volume of medium, a fresh acid appeared early in the logarithmic growth-phase in the flasks containing 1/5 their volume of medium. This was shown to be α-amino-butyric acid.

Cells from flasks with the lower oxygen solution-rate incubated with threonine formed α-amino-butyric acid; with serine, alanine was formed, while with aspartic acid, glutamic acid or methionine, no new material appeared. Cells from flasks with the higher oxygen solution-rate similarly treated produced no changes.

When nitrogen was substituted for air in sealed flasks with 1/20 vol. medium, α-amino-butyric acid was formed during growth. When both sodium lactate and sodium glycerophosphate were omitted from the medium, the staphylococci still grew well. It was shown that growth in such a medium in the flasks containing 1/5 vol. medium failed to produce α-amino-butyric acid, whereas with lactate and glycerophosphate present it was formed. Replacement of air by nitrogen when lactate and glycerophosphate were absent from the flasks containing 1/5 vol. medium brought about formation of α-amino-butyric acid.

When glucose or glycerol was substituted for lactate and glycerophosphate on an equimolar basis, α-amino-butyric acid was still formed during growth in flasks containing 1/5 vol. medium. The use of pyruvic acid, malic acid, formic acid, succinic acid or α-keto-glutaric acid as a substitute for lactate and glycerophosphate failed to bring about α-amino-butyric acid formation. Addition of pyruvic acid to the lactate-containing medium in the flasks with the lower oxygen solution-rates suppressed the formation of α-amino-butyric acid.

It would seem from these results that the formation of α-amino-butyric acid by this staphylococcus is due to the use of threonine as a hydrogen acceptor under conditions of low oxygen supply, serine presumably functioning in a similar manner.

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An Alternative Pathway for the Degradation of Cholic Acid by Micro-organisms

Since the publication of the first report[1] on the microbiological degradation of cholic acid (I) to 7α-hydroxy-3 : 12-dioxo-Δ^4-*bis*-norcholenic acid (VII) by *Streptomyces gelaticus* 1164, additional investigations have been continued and two possible pathways[2] for cholic acid degradation have been proposed.

S. gelaticus 1164 can grow on a medium containing the *bis*-nor acid (VII) as the sole source of carbon. On the other hand, *Streptomyces rubescens*[3] is able to utilize cholic acid as the sole source of carbon as well as *S. gelaticus* 1164, but is unable to utilize this *bis*-nor acid.

Though interpretation of such experiments is not simple, we suggest that cholic acid degradation by *S. rubescens* proceeds through an alternative pathway different from that found with *S. gelaticus* 1164.

Recently, it was found[4] that *S. rubescens*, cultured in a medium containing cholic acid as the sole source of carbon, produced various intermediates such as 7α : 12α-dihydroxy-3-oxo-Δ^4-cholenic acid (III), 7α-hydroxy-3 : 12-dioxo-Δ^4-cholenic acid (IV), 12α-hydroxy-3-oxo-$\Delta^{4,6}$-choladienic acid (V), 3 : 12-dioxo-$\Delta^{4,6}$-choladienic acid (VI) and some unidentified compounds different from the *bis*-nor acid (VII).

Considering the structures of these intermediates, an oxidative pathway of cholic acid by *S. rubescens* may be deduced as follows (Fig. 1), though the acid II has not yet been isolated.

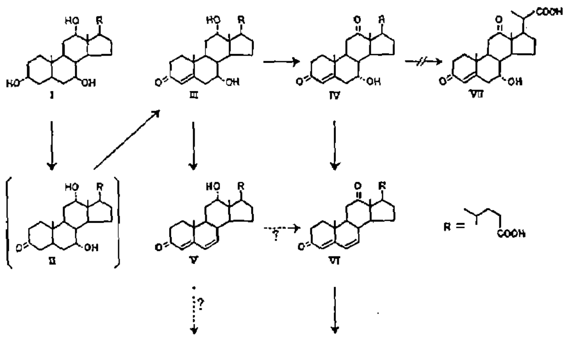

Fig. 1

S. rubescens cultures in a cholate medium give a light absorption peak at 246 mμ at the earlier incubation period, and a parallelism between an increase of the optical density and the incubation period is observed. After the optical density at 246 mμ reaches its maximum, it decreases in parallel with continuation of the incubation, and, simultaneously, a new peak at 290 mμ appears ; finally, both the peaks at 246 and 290 mμ disappear at an almost equal rate at the end of the incubation period.

These findings may be interpreted as follows : an appearance of a peak at 246 mμ in the cholate culture begins with the conversions $\mathrm{I} \rightarrow \mathrm{II} \rightarrow \mathrm{III} \rightarrow \mathrm{IV}$; a decrease of the optical density at 246 mμ and an appearance of a peak at 290 mμ are due to the conversion $\mathrm{III} \rightarrow \mathrm{V}$ or $\mathrm{IV} \rightarrow \mathrm{VI}$; and further degradation of V or VI accelerates the conversion $\mathrm{III} \rightarrow \mathrm{V}$ or $\mathrm{IV} \rightarrow \mathrm{VI}$. This process will finally lead to the disappearance of both the peaks at 246 and 290 mμ.

Much of the representation of our proposed pathway for cholic acid degradation by *S. rubescens* is still largely hypothetical. However, the isolation and identification of the acids V and VI in this experiment demonstrate for the first time a microbiological introduction of the $\Delta^{4,6}$-3-ketone structure into the cholane nucleus of cholic acid.

Further study on the proposed pathway is in progress and will be reported in detail elsewhere.

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Uridine Diphosphate Amino-sugar Compounds from *Staphylococcus aureus* inhibited by Penicillin

In 1952, Park[1] showed that three uridine diphosphate amino-sugar compounds were accumulated in *Staphylococcus aureus* inhibited by penicillin. Compound I contained no amino-acid residue. Compound II contained one alanine residue and compound III contained a peptide which was composed of one glutamic acid, one lysine and three alanine residues. Recently, Strominger indicated that, even though in much smaller amount, these compounds are contained also in normal cells[2], and that the amino-sugar component is 3-O-carboxyethyl glucosamine[3], which is known as one of the main components of cell walls[4].

We have found a variety of similar uridine diphosphate amino-sugar compounds, some of which contained aspartic acid and glycine. Cells of *S. aureus* strain 209 *P* treated with penicillin were extracted with trichloracetic acid. After removal of trichloracetic acid, barium hydroxide and sufficient sodium hydroxide were added to the extract to adjust the *p*H to 9, and the precipitate was removed. To the concentrated supernatant, ethanol was added to 50 per cent by volume and the precipitate was separated. More ethanol was added to the supernatant to make it 90 per cent and the precipitate was separated. Each precipitate was fractionated by ion exchange chromatography with 'Dowex 1' in the chloride form. The fractions with the same peak of optical density at 260 mμ were pooled, concentrated by adsorption on 'Norit' and subsequent elution with ammoniacal ethanol, and were analysed for components. After hydrolysis with 6 *N* hydrochloric acid at 120° for 6 hr. in a sealed tube, amino-acids were separated and estimated by two-dimensional paper chromatography with butanol/acetic acid/water (4 : 1 : 5) and phenol/*m*-cresol/borate buffer *p*H 9·3 (25 : 25 : 7) as solvent systems[6]. The result of paper chromatography on fractions containing appreciable amounts of all the three components, uridine, N-acetyl-amino-sugar and amino-

Table 1. AMINO-ACID DETECTION BY PAPER CHROMATOGRAPHY

Preparation	Fraction No.*	Elution medium	Alanine	Lysine	Glutamic acid	Aspartic acid	Glycine
Precipitated at 0–50 per cent ethanol	1	0·01 *N* HCl 0·01 *N* NaCl	–	++	++++	+++	++++
	2	0·01 *N* HCl 0·01 *N* NaCl	–	++	++	–	++++
	3	0·01 *N* HCl 0·01 *N* NaCl	++	+	++	+	+
	4	0·01 *N* HCl 0·01 *N* NaCl	+++	++	+	–	–
	5	0·01 *N* HCl 0·05 *N* NaCl	–	+	+	+	+
	6	0·01 *N* HCl 0·1 *N* NaCl	+	+	+	–	–
	7	1·0 *N* HCl	++	++++	++	–	trace
Precipitated at 50–90 per cent ethanol	1	0·01 *N* HCl 0·01 *N* NaCl	+	+	+	–	–
	2	0·01 *N* HCl 0·05 *N* NaCl	–	+	+	–	–
	3	0·01 *N* HCl 0·1 *N* NaCl	+	trace	trace	–	–

* This represents peak and shoulder of absorption at 260 mμ. They were analysed for nucleoside components, N-acetyl-amino-sugar and amino-acid components, and the only fractions containing all three components in appreciable amounts have been included.

acids, is shown in Table 1; the amounts of samples were adjusted to give about the same amino-sugar content. When normal cells were treated similarly, much smaller amounts of amino-acid-containing uridine derivatives were obtained, in which the same species of amino-acid residues were detected as in the case of the penicillin-treated cells.

The result suggests that there may be a number of compounds containing some of the five amino-acids in various combinations. Further attempts to separate each fraction into components are in progress. In connexion with the present results, it is to be noted that alanine, lysine and glutamic acid have been found in cell walls of Gram-positive micro-organisms as the main components[3,4,6], whereas glycine has been discovered in cell walls of *Staphylococci*[4] and aspartic acid in cell walls of *Lactobacilli*[4]. This is additional evidence for Strominger's hypothesis[3] that these uridine diphosphate amino-sugar compounds are possible precursors of cell walls.

Further details of this work will be reported elsewhere.

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An Antibiotic produced by a *Bacillus* sp., active against *Haemophilus pertussis*

A STRAIN of *Bacillus* (probably *B. subtilis*) has been found to produce an antibiotic effective against *H. pertussis* and *Neisseria* spp. The antibiotic spectrum is somewhat unusual, and although attempts at purification achieved little, the following is a summary of the results[1].

The antibiotic is produced in highest concentration (titre 1 in 128 against *N. meningitidis*) in aerated culture at 22° in a medium containing horse-meat and potato extracts. Growth in a synthetic medium based on that of Hills *et al.*[2] yielded an antibiotic of different properties; this material was not further investigated. The antibiotic was extracted from the enriched medium by extraction with *n*-butanol at *p*H 4·5. Removal of the butanol and extraction with *n*-hexane yielded an amorphous brown powder (petrin) containing most of the activity (titre 1 in 125,000 against *N. meningitidis*).

Extraction of petrin with a number of organic solvents yielded several fractions, all with the same activity, and with the same composition as determined chromatographically.

Paper chromatography of petrin, using a chloroform/*n*-butanol/water (46 : 4 : 50) solvent mixture, indicated the presence of at least three fractions: (*a*) antibiotic, (*b*) hæmolytic, (*c*) fluorescent in ultra-violet light. Active material could not readily be extracted from the paper.

Emulsion formation precluded the use of a Craig countercurrent extraction apparatus, but by repeated centrifugation a ten-tube distribution was accomplished. The principal antibiotic-containing fraction did not contain nitrogen. A smaller antibiotic-containing fraction did contain nitrogen.

The *LD*50 for 20-gm. mice injected intraperitoneally was 5 mgm.

A summary of the antibiotic spectrum of petrin is given in Table 1.

Table 1. ANTIBIOTIC SPECTRUM OF PETRIN

Organism	Dilution of antibiotic	
	growth at	inhibition at
N. meningitidis	150,000	125,000
N. gonorrhoeae	75,000	50,000
N. catarrhalis	5,000	1,000
H. pertussis	125,000	100,000
H. influenzae	50,000	25,000
H. parapertussis	100,000	50,000
C. diphtheriae	25,000	5,000

No inhibition at 1/200 of *E. coli*, *A. aerogenes*, *Sh. sonnei*, *Sh. flexneri*, *Salm. typhi*, *Ps. pyocyanea*, *Prot. vulgaris*, *Kleb. pneumoniae*, *Staph. albus*, *Staph. aureus*, *Clostridium* spp., *Candida albicans*, *Aspergillus niger*, *Penicillium notatum*.

The physical and chemical properties of petrin are: soluble in water above *p*H 4·5; stable at room temperature in the range *p*H 4·5–11; boiling at *p*H 8·0 reduced the activity by 66 per cent in 10 min., thereafter it remained constant for 50 min.; stable to pepsin and trypsin; stable to dry heat (100°); adsorbed on to charcoal but not readily eluted; partially soluble in chloroform, ethanol; insoluble in acetone, ether.

Comparison of petrin with 26 other antibiotics attributed to *B. subtilis*, and 29 antibiotics attributed to other members of the Bacillaceae, indicated that petrin has not previously been described.

My thanks are due to Prof. J. W. McLeod and Prof. C. L. Oakley for their interest and encouragement.

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Flavofungin, a New Crystalline Antifungal Antibiotic: Origin and Biological Properties

DURING the systematic study of actinomycetes antagonizing fungi pathogenic in man, a species of *Streptomyces* (*SA*-IX/1) was found from desert sand that markedly inhibits growth of *Cryptococcus neoformans* and *Trichophyton mentagrophytes* used for screening[1]. In laboratory deep fermentation, besides the antifungal antibiotic, an antibacterial one was produced also by this species. A natural stable variant (*SA*-IX/3) differing morphologically from the original strain isolated was selected that is capable of producing increased quantities of the antifungal and decreased quantities of the antibacterial agent. This proved to be a new species and has been named *Streptomyces flavofungini*. The antifungal, crystalline antibiotic (Fig. 1) was isolated as a uniform product from the mycelium and fermentation fluid of this asporogenic, chromogenic variant. From its colour and effects, the new antifungal agent has been called 'flavofungin'.

Pure flavofungin has no influence upon growth of *Streptomycetes* and common bacteria; but the growth of *B. subtilis* and of a few strains of *M. pyogenes* var. *aureus* is inhibited by relatively high concentrations of more than 100 μgm./ml. Marked inhibition is exerted *in vitro* upon the growth of pathogenic and non-pathogenic yeasts and yeast-like fungi, dermatophytes, and also of saprophytic and plant pathogenic fungi; inhibitory concentrations are shown in Table 1. Assays were carried out by serial dilutions in Czapek–Dox, Sabouraud, Jensen and mush media. Its diffusion into agar is rather slow.

In aqueous suspension, given *per os* or subcutaneously, in dosages up to 250 mgm./kgm., to the mouse, no acute or late symptoms were evoked; *LD*50 is 25 mgm./kgm. in aqueous suspension given by the intraperitoneal route.

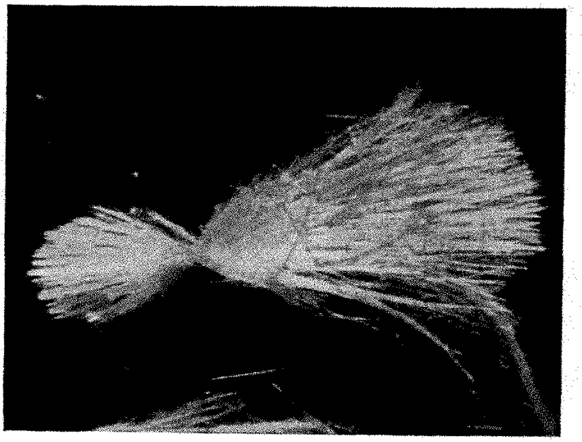

Fig. 1. Flavofungin crystals

Table 1

Micro-organism	Inhibitory conc. (μgm./ml.)
Fungi	
Aspergillus clavatus	15
Penicillium chrysogenum	8
Penicillium novum hybrid	8
Penicillium sp. (two strains)	10–20
Scopulariopsis sp.	15
Cephalosporium sp.	15
Monosporium apiospermum	15
Helminthosporium sp.	10
Trichoteceum roseum	15
Mastigocladium sp.	10
Yeasts and yeast-like fungi	
Candida albicans (three strains)	4–5
Candida krusei	6
Candida tropicalis	15
Saccharomyces cerevisiae (three strains)	3–20
Saccharomyces niger	2
Cryptococcus neoformans	2
Torula utilis	10
Hansenula anomala	10
Rhodotorula sp.	2
Torulopsis pulcherrima	2
Pathogenic fungi	
Trichophyton mentagrophytes	20
Trichophyton tonsurans (two strains)	8–30
Trichophyton rubrum (two strains)	10
Trichophyton gypseum (two strains)	20
Trichophyton sulfureum	8
Epidermophyton kaufmann-wolf (three strains)	15–20
Epidermophyton inguinale	10
Microsporum canis	8
Microsporum gypseum	8
Achorion quinckeanum	8
Ceratinomyces	10
Phialophora verrucosa	20
Histoplasma capsulatum	10
Sporotrichum schenkii	10
Hormodendrum compactum	8
Nocardia asteroides	20
Geotrichum sp.	20

In the fæces of mice fed with *Candida albicans*, no colonies, or only a few, can be demonstrated after having received flavofungin *per os*, in marked contrast to untreated controls.

Flavofungin is strongly bound to serum proteins, but can be liberated.

According to its chemical, physical and biological properties, flavofungin is not identical with formerly known antifungal antibiotics[2]. Its isolation and chemical properties will be described in detail elsewhere.

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Effect of Heparin on Pathologically Decreased Serum Esterase in Carcinoma

PLASMA and serum esterolytic activity may be considerably decreased in pathological conditions. The substrates most often used for the determination of esterolytic activity are acetylcholine[1], tributyrine[2] and procaine[3]. Decreased activity is found most often in cirrhosis of the liver and carcinoma. In our work ethyl butyrate was used as the substrate and esterase activity was determined by the titrimetric method[4]. The values are given in ml. of 0·05 *N* sodium hydroxide required to neutralize the acid liberated in 24 hr. In agreement with other workers we found low values, especially in some forms of carcinoma and cirrhosis. These low values are in sharp contrast to the increase in esterase activity

Table 1. Effect of Heparin on the Esterase Activity of Serum in Carcinoma

Case No.	Diagnosis	Esterase activity (ml. 0·05 *N* sodium hydroxide)	Rise of esterase activity after heparin injection (per cent)
1	Bronchiogenic carcinoma	0·42	780
2	Carcinoma of the stomach	0·44	259
3	Carcinoma of the stomach	0·78	203
4	Adenocarcinoma of the kidney	1·40	113
5	Bronchiogenic carcinoma	1·46	95
6	Bronchiogenic carcinoma	2·08	93
7	Bronchiogenic carcinoma	1·66	81
	Average in 25 controls	3·16	35

after administration of heparin. Five minutes after intravenous injection of heparin in amounts of 100 units per kgm. body-weight, the increase reached as much as 780 per cent (Table 1).

This increase is much greater than in normal persons, in whom esterase activity has an average value of 3·16 ml. 0·05 *N* sodium hydroxide[5] with a dispersion of 2·00–4·85, by our method. There is a definite increase after administration of heparin in normal persons[6], but it rarely exceeds 70 per cent and we found no increase greater than 100 per cent.

No explanation can at present be given for the great increase of the pathologically low values of esterase in carcinoma. There are, however, the following possibilities: (1) that there is an esterase inhibitor in the blood of the patients which is inactivated by heparin; (2) that heparin washes out from the tissues into the blood stream an esterase which, in carcinoma, is not, or is only partly, damaged and which is able to break down ethyl butyrate.

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Effect of a Lethal Electric Shock during Hypothermia

In our experiments we applied direct current at 220 V., or alternating current, through a resistance with which the potential could be varied between 10 and 220 V. The current passing through the animals was registered by milliammeter. Copper electrodes were attached to the forelegs of mice weighing 20–25 gm., the shaved limbs of which had been moistened by a solution of sodium chloride. The mice were cooled by Giaja's method. The temperature of the colon was registered by a thermistor thermometer.

Table 1 summarizes our results, from which it can be seen that hypothermia has a protective action. Increasing the potential enabled the hypothermic animals to withstand a higher current. We found that with a direct current hypothermic animals withstood a current lethal for controls at only 150 V.; whereas with alternating current, the lethal current was obtained at a potential of 120 V. Histological examination of the mice which were killed by the electric current revealed no essential or characteristic changes in the nervous system or in the heart.

Table 1. Effect of Electric Shock on Normal and on Hypothermic Mice

Current	Colonic temperature	Current passed through the animals (mean value)	Dead/shocked
Direct current (80 V.; 10 sec.)	37–39° C.	62 m.amp. ♂	46/50
	37–39° C.	100 m.amp. ♀	48/50
	15–20° C.	40 m.amp. ♂	1/50
	15–20° C.	56 m.amp. ♀	3/50
Alternating current (80 V.; 10 sec.)	37–39° C.	100 m.amp. ♂	50/50
	37–39° C.	118 m.amp. ♀	50/50
	15–20° C.	40 m.amp. ♂	1/50
	15–20° C.	55 m.amp. ♀	2/50

The conductivity of males under normal conditions is $7 \cdot 8 \times 10^{-4}$ ohm^{-1}; in a hypothermic state it is 5×10^{-4} ohm^{-1} (decrease, 36 per cent). The conductivity of control female mice is $12 \cdot 5 \times 10^{-4}$ ohm^{-1}, that of cooled females 7×10^{-4} ohm^{-1} (decrease, 44·1 per cent). Putting the mean temperature of mice as 20° C., the thermal coefficient of male mice is 1·86 per cent/degree, that of female mice is 2·2 per cent/degree, which corresponds very well with the thermal coefficient of ion activity. Therefore the main reason for the decrease in conductivity is probably the change of ion activity with temperature.

Full details of this work will be published in *Acta Physiol. Hungarica*.

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Effect of Muscular Activity prior to Venepuncture on the Respiration of Leucocytes *in vitro*

During an investigation of the respiration of human leucocytes we noticed that moderate exercise by the donor prior to venepuncture seemed to be associated with a high rate of leucocyte oxygen consumption. Determination of the oxygen consumption of leucocytes (resuspended in a modified Krebs No. 2 buffer) was made by the direct method in Warburg respirometers at 37° C. Results were expressed as μmoles oxygen consumed per hr. per 10^7 leucocytes, so that the effect of any variation in total white cell count was eliminated.

We therefore compared the oxygen consumption of white blood cells taken before and after exercise from six normal subjects. All were members of the clinical or laboratory staff, aged 18–29 years. The subjects were fasting, and had rested on a bed for 30 min. before the first blood sample was obtained by venepuncture. A moderate walking exercise lasting 3–4 min. was then performed. Leucocytes obtained by venepuncture 5 min. after the walking exercise showed increased oxygen consumption 36–71 per cent above the control value before exercise (Table 1). Estimations of the subjects' oxygen consumption

Table 1. Effect of Exercise on Respiration of Leucocytes *in vitro*

Subject	Estimated surface area (m.²)	Before exercise		After exercise		Percentage increase in oxygen consumption	
		White blood cell oxygen consumption*	Subject's oxygen consumption†	White blood cell oxygen consumption	Subject's oxygen consumption	White blood cells	Subject
1	1·82	0·036	226	0·148	246	62	9
2	2·01	0·138	359	0·202	437	46	22
3	1·86	0·112	199	0·190	298	57	49
4	1·88	0·155	203	0·265	279	71	37
5	1·92	0·091	272	0·136	390	49	43
6	1·78	0·096	218	0·130	235	36	8

* μmoles oxygen/hr./10^7 leucocytes. † ml. oxygen/min.

(using a Benedict–Roth apparatus) confirmed that exercise had been moderate. Differential white cell counts were made before and after exercise: there was no significant alteration in the count.

The possibility that the change in leucocyte oxygen consumption was due to venepuncture was considered. Blood samples were taken from three normal subjects, with a similar time interval between samples as before, but without exercise. The change in oxygen consumption between first and second samples was − 11, + 5 and − 3 per cent.

We conclude from these results that: (1) a substance may appear in the blood as a result of moderate exercise which has the property of stimulating the metabolic rate of the leucocytes *in vitro*; (2) in previous work on respiration of leucocytes the effect of preceding muscular activity was not taken into account, and this may explain some of the discordant results reported.

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Effect of Acetylcholine on the Membrane Resistance and Threshold of Atrial Muscle Fibres

THERE is substantial indirect evidence that acetylcholine increases the conductance of the atrial muscle membrane probably by increasing the permeability to K+ and Cl−[1,2]. In addition, acetylcholine has an effect on the sodium-carrying system[3]. These two actions form the basis of a hypothesis suggested by us[3] for the possible explanation of the excitatory and inhibitory actions of acetylcholine on atria described by Burn[4].

It seemed vital to determine what effect acetylcholine had on the membrane resistance and on the threshold. We have attempted the following experimental techniques to examine this problem. (*a*) One microelectrode was used for stimulating and recording; (*b*) a double-barrelled microelectrode was used and (*c*) two microelectrodes (stimulating and recording) were inserted into the same muscle fibre. All methods proved extremely exacting. Indeed, Trautwein, Kuffler and Edwards[1] discarded methods (*a*) and (*c*) and used a method employing external electrodes which demonstrated changes in the membrane resistance and time constant. They were not able to determine changes in the threshold. In the present work method (*a*) was abandoned, method (*b*) is being further developed and method (*c*) was found to be entirely successful in only one of twenty experiments.

In view of the implications of the findings, we are reporting the results of this single experiment.

Two microelectrodes were inserted into a single muscle fibre of rabbit right atrium driven electrically at a rate of 3·6/sec., current being passed through one electrode and the resultant membrane potential changes recorded through the other. Square pulses of depolarizing current applied through the stimulating microelectrode between every eighth–ninth externally applied stimuli produced membrane changes of the form shown in Fig. 1. Acetylcholine 10^{-6} reduced the amplitude and time constant of rise of this potential.

This is interpreted as being direct evidence of a fall in membrane resistance. There was no concomitant change in membrane resting potential or maximum rate of depolarization. At the same time the threshold was decreased, that is to say, the membrane had to be depolarized to a lesser extent to initiate an extra response. A slight increase in current was required to stimulate. This was due to the fact that the decrease in threshold did not entirely compensate for the fall in membrane resistance.

The decrease in threshold could be due to a direct effect on the sodium-carrying system. Alternatively, it is conceivable that if the membrane time constant were of the same order or slightly greater than that of the inactivation of the sodium-carrying system, then a reduction in time constant of the membrane to a value lower than that of the sodium inactivation could result in a decrease in threshold.

We are endeavouring to confirm these findings with the double-barrelled microelectrode technique; but as they further support our recently suggested hypothesis[3] it does seem that in considering the

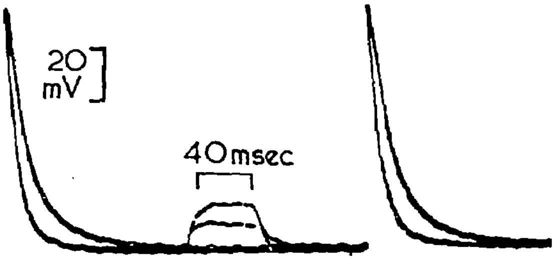

Fig. 1. This consists of two superimposed photographs, one before and one after the application of 10^{-6} acetylcholine to isolated rabbit right atrial muscle. A recording and a stimulating electrode are inserted into the same cell. The changes in membrane potential following the application of a current pulse via the stimulating electrode is shown between the eighth–ninth action potentials. The amplitude of the responses are just subthreshold (the larger is before the acetylcholine was applied). It can be seen that the acetylcholine has decreased the time constant of the membrane and decreased the threshold, the duration of the two action potentials being decreased at the same time. (Photograph retouched to correct losses in photography)

effects of acetylcholine on atrial muscle one must take into account not only its effects on membrane resistance (K^+ permeability and rate of repolarization) but also the possible direct–indirect effects on depolarization mechanisms.

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Sites of the Physiological Breakdown of the Red Blood Corpuscles

IF erythrocytes labelled with iron-59 in their hæmoglobin are transfused from a donor rabbit to a sister animal, and, after a lapse of some hours, the labelled iron is located in the depot iron fraction, in the ferritin and hæmosiderin of organs, we can conclude that erythrocytes were broken down in these organs.

Since the plasma contains no radioiron, the only source of iron-59 present in the depot iron fractions is radioiron liberated from the transfused labelled red corpuscles.

This line of thought induced us to replace red corpuscles contained in 20 ml. of rabbit blood with the corresponding amount of washed red blood corpuscles all labelled with iron-59 from a sister animal.

The results of one of our experiments are given in Table 1.

Table 1. DISTRIBUTION OF IRON-59 IN THE DEPOT IRON (FERRITIN + HÆMOSIDERIN) OF ORGANS

Organ	Total depot iron (mgm.)	Total radio-activity of depot iron (c./min.)	Depot iron radioactivity per gm. organ (c./min./gm.)	Percentage distributed *
Liver	10·9	9,830	154	8·4
Spleen	0·681	2,340	2,600	2·0
Red bone marrow†	5·9	86,500	2,470	74·0
Kidneys	0·850	4,300	314	3·7
Lungs	0·590	9,250	1,050	7·9
Small intestine	0·807	4,600	79	4·0

* Total radioactivity of the depot iron of all organs investigated = 100 per cent.

† The total amount of the red bone marrow was assumed to comprise 1·1 per cent of the body-weight.

It is seen that the depot iron-59 content of 1 gm. of spleen is higher than that of an equal amount of any other organ studied. Considering the total organs, however, the red bone marrow contains more iron-59 than any other organ investigated. In seven other experiments the ratio of the depot iron-59 content of the red bone marrow and the spleen varied between 6 and 50, the corresponding ratio of the red bone marrow and liver figures being 0·6–9.

In view of the fact that the spleen of the rabbit is very small, its weight being only 1/35 that of the red bone marrow, we cannot expect the ratio of the amount of erythrocytes broken down in the bone marrow and the spleen to be as high in other mammalian species as it is in the rabbit. Our results suggest, however, that even in man presumably a third or more of the number of erythrocytes terminating their physiological life-cycle is broken down in the bone marrow.

Miescher[1] published results similar to those reported here. He transfused red corpuscles labelled with chromium-51 into rabbits and found that, after a lapse of 25–35 days, about 30–75 per cent of the chromium-51 was located in the bone marrow, 23–49 per cent in the liver and 6–40 per cent in the spleen. The finding of Miescher that the spleen accumulates a larger percentage of the chromium-51 than found by us is possibly due to a large part of the chromium-51 leaking out from intact erythrocytes. A part of this chromium may accumulate in the spleen. We arrived to the same conclusion as Miescher concerning the importance of the bone marrow for the physiological breakdown of the red corpuscles. In this connexion it is of interest to recall that Mann *et al.*[2] found that the main part of the bilirubin is formed in the bone marrow.

The interest taken by Prof. G. Hevesy in this investigation is gratefully acknowledged.

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Anticholesterol Activity of α-Lipoic Acid

SINCE α-lipoic acid is known to affect lipid metabolism, we have investigated the effect of this acid on the lipid content of plasma, liver and aorta from rabbits which had been fed on a diet containing an excess of cholesterol[1]. Rabbits weighing 2·5–3 kgm. were divided into four groups, each containing five animals. Group *A*, the control group, received a diet of ordinary commercial rabbit food. Each animal in groups *B*, *C* and *D* received this diet, supplemented for seven days with 1 gm. daily of cholesterol mixed with 9 gm. of shredded carrot. Group *B* received no further treatment. Group *C* received daily intramuscular injections of α-lipoic acid (5 mgm./kgm. of the sodium salt in saline). Group *D* received the same treatment as *C*, except that the injections were not started until the day after the high cholesterol diet had been stopped. After fifteen days from the start of the experiment, the animals were killed by bleeding, and samples of blood, liver and aorta were taken aseptically and weighed. Total lipids, phospholipids and neutral lipids were determined by the method of Bloor[2], and cholesterol by the method of Schoenheimer and Sperry[3].

The results (Table 1) show that the high cholesterol diet alone (group *B*) caused a clear-cut increase in plasma total lipids and cholesterol, and a less marked increase in plasma phospholipids and neutral lipids. The liver lipids showed a similar behaviour, but here the increase was larger for cholesterol and neutral lipids than for phospholipids. The aorta cholesterol was also increased, but phospholipids and total lipids were not much changed.

Table 1. Lipid Content from Tissues from Rabbits fed on a Normal Diet (Group *A*), on a High Cholesterol Diet (Group *B*) and on a High Cholesterol Diet and treated with α-Lipoic Acid (Groups *C* and *D*)
Values are given in gm./100 gm. or ml., as means ± standard error

Group	Tissue	Phospholipids	Neutral lipids	Total cholesterol	Total lipids
A	Liver	3·79 ± 0·51	0·33 ± 0·06	0·19 ± 0·03	4·67 ± 0·41
	Plasma	0·16 ± 0·01	0·13 ± 0·01	0·11 ± 0·02	0·46 ± 0·04
	Aorta	1·03 ± 0·09	11·31 ± 1·16	0·19 ± 0·02	12·68 ± 1·36
B	Liver	3·94 ± 0·56	1·24 ± 0·08	2·24 ± 0·31	8·72 ± 0·94
	Plasma	0·57 ± 0·06	0·49 ± 0·06	1·33 ± 0·14	2·98 ± 0·32
	Aorta	1·09 ± 0·13	9·71 ± 1·07	1·87 ± 0·22	13·18 ± 1·68
C	Liver	3·87 ± 0·49	0·37 ± 0·06	0·39 ± 0·05	5·48 ± 0·67
	Plasma	0·24 ± 0·02	0·15 ± 0·01	0·26 ± 0·03	0·89 ± 0·11
	Aorta	0·98 ± 0·08	9·46 ± 0·89	1·24 ± 0·17	12·46 ± 1·38
D	Liver	3·41 ± 0·58	0·46 ± 0·04	0·62 ± 0·13	6·19 ± 0·72
	Plasma	0·37 ± 0·04	0·31 ± 0·03	0·72 ± 0·08	1·80 ± 0·21
	Aorta	0·95 ± 0·12	10·92 ± 1·27	1·64 ± 0·16	12·59 ± 1·34

Treatment with α-lipoic acid from the beginning of feeding with the high cholesterol diet (group *C*) limited the increases in the lipids of the plasma, liver and aorta to a much smaller extent. When the treatment with α-lipoic acid was started at the end of the high cholesterol feeding (group *D*) it produced a similar though somewhat smaller effect. Even so, the plasma cholesterol values were only about half those of animals which had received cholesterol but no α-lipoic acid.

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Effect of Testosterone Propionate upon the Incorporation of Labelled Glycine into Homogenates of Mouse Kidney

It was shown recently[1] that the rate of incorporation of glycine-1-^{14}C into kidney slice protein of *A*/*Jax* mice treated with testosterone propionate was significantly higher than into slices from untreated animals. The maximum increase (35–80 per cent) appeared 48 hr. after beginning daily injections of 1 mgm. testosterone propionate, after which the difference between the treated and control series gradually disappeared. A study of some of the characteristics of this response revealed that the difference in incorporation-rates was greatest at low glycine concentrations, and diminished when the glycine concentration of the incubation medium was raised to 4–8 m*M*. It was postulated that under these conditions the effect of this steroid was to facilitate the intracellular accumulation of glycine from a relatively glycine-deficient environment.

As a test of the above hypothesis, experiments were conducted to compare the effects of testosterone propionate upon incorporation of glycine by slices and homogenates of mouse kidney. Female *A*/*Jax* mice (from Jackson Memorial Laboratories, Bar Harbor, Maine) were given two injections of testosterone propionate (0·1 ml. of a solution containing 10 mgm./ml. in sesame oil) 24 hr. apart, and killed 24 hr. after the second injection. The kidneys were removed and weighed; one was sliced and the slices incubated for 2 hr. in Krebs–Ringer phosphate containing isotopic glycine. The other kidney of a pair was homogenized in nine times its weight of the same medium previously cooled to 0°, and the homogenate incubated for 30 min. The bath temperature was 38·4°. After incubation, the slices were removed, blotted and processed as described previously[1]. The reaction in the flasks containing homogenate was terminated by the addition of 2/3 volumes of 25 per cent (w/v) trichloracetic acid. The precipitate was redissolved in dilute alkali and reprecipitated four more times with 5 per cent trichloracetic acid. Before the last precipitation, 10 mgm. non-radioactive glycine was added to ensure removal of adsorbed glycine. The protein precipitated by trichloracetic acid was washed successively in water, acetone, a mixture of chloroform, ethyl ether and ethanol (1 : 1 : 2), and benzene, and finally plated for counting from benzene. Each sample was counted long enough to limit the counting error to a maximum of 5 per cent.

Table 1. Effects of Testosterone Propionate upon Incorporation into Kidney Slices and Homogenates*

	No. of mice	Kidney weight percentage of body-weight	Incorporation-rate†	
			Slices	Homogenates
Untreated	18	1·23	1·22±0·035	0·087±0·006
Treated	17	1·33	1·65±0·042	0·138±0·006
Increase (per cent)		8	36	57

* The medium used for these experiments contained 1·19 m*M* glycine, specific activity 0·17 mc./m*M*.

† Micromoles of glycine carbon incorporated per gm. protein per hr. Average ± standard error.

Results obtained in two experiments, in which a total of 35 animals was used, are summarized in Table 1. It is clear that although incorporation into mouse kidney homogenate is less than one-tenth as rapid as incorporation into slices, the two processes are stimulated to approximately the same degree by administration of androgen. That the effect of testosterone propionate is specific for incorporation into kidney protein is indicated by the results in Table 2, wherein it may be observed that incorporation by mouse liver homogenate is unaffected by testosterone propionate.

As noted above, earlier experiments with kidney slices showed that the effect of testosterone propionate upon incorporation decreased with increasing glycine concentration. Thus, in one series of experiments, the average increases in incorporation-rates for treated animals were approximately 47 per cent and 13 per cent for concentration ranges of 0·125–1·0 m*M* and

Table 2. EFFECTS OF TESTOSTERONE PROPIONATE UPON INCORPORATION INTO KIDNEY AND LIVER HOMOGENATES*

	No. of mice	Incorporation rate†	
		Kidney	Liver
Untreated	10	0·036 ± 0·003	0·020 ± 0·002
Treated	10	0·068 ± 0·005	0·020 ± 0·001
Increase (per cent)		86	0

* Kidneys and liver from each group of animals were pooled in three lots and homogenized; two to three samples of each pool were incubated 0·5 hr. at 38·4°. Glycine concentration: 1·07 mM, 0·2 μc./ml.

† Micromoles of glycine carbon incorporated per gm. protein per hr. Ave. ± S.E.

Table 3. RESPONSE OF MOUSE KIDNEY HOMOGENATES TO TESTOSTERONE PROPIONATE AT VARIOUS GLYCINE CONCENTRATIONS

Glycine concentration mM	Glycine concentration μc./ml.	Incorporation rate*		Increase (per cent)
		Untreated	Treated	
0·25	0·20	0·027 ± 0·001 (5)	0·041 ± 0·004 (5)	51
0·50	0·20	0·049 ± 0·004 (5)	0·077 ± 0·011 (5)	57
1·19	0·20	0·087 ± 0·006 (18)	0·138 ± 0·006 (17)	59
2·00	0·60	0·112 ± 0·010 (5)	0·192 ± 0·020 (5)	71
4·00	0·60	0·157 ± 0·025 (5)	0·232 ± 0·025 (5)	48

* Micromoles of glycine carbon incorporated per gm. protein per hr. Ave. ± S.E. Numbers in parentheses indicate the number of kidneys used for each concentration.

4·0–8·0 mM, respectively. In contrast, the effect of testosterone propionate upon incorporation in homogenates is not significantly affected by changes in glycine concentration within these limits (Table 3).

Our results do not support the hypothesis that stimulation of glycine incorporation by androgen is mediated through an effect upon a concentrative process operating at the level of the cell membrane, since such an effect should be inoperative in cell-free systems. An analogous process, functioning at the subcellular particulate level, is not excluded, however. In view of the considerable difference between incorporation-rates found for slices and homogenates, as well as the difference in the effect of substrate concentration upon the response to testosterone propionate, there remains the possibility that another androgen-sensitive, concentration-dependent component of the incorporation process disappears upon homogenization. Further experimentation, involving studies of the effects of testosterone propionate upon intracellular amino-acid levels, may provide an answer to this problem.

Other anabolic steroids, including testosterone, androsterone, methyl testosterone and methylandrostenediol, also increase the rate of incorporation into mouse kidney homogenates. Hydrocortisone, on the other hand, was distinctly inhibitory, while deoxycorticosterone was devoid of appreciable effect.

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Ribonuclease Activity and Ribonucleic Acid Content of Homologous Human Normal and Cancer Cells

A RELATIONSHIP between the level of ribonuclease activity and ribonucleic acid content has recently been found to exist in the human placenta[1] and in hyperplastic bone marrow of the mouse[2]; such a relationship has also been shown to exist in different normal organs of the mouse[3], as well as different epitheliomas in mice or rats[4]. On the other hand, results obtained with solid[4] and ascites tumours[5] suggest that cancerous epithelium might have less ribonuclease activity than a normal one. We have undertaken a study of the properties of the human uterine cervix, from which homologous normal and cancerous tissues can easily be obtained.

In the present work, superficial biopsies of the uterine cervix epithelium were removed from human uteri presenting a stage I or II carcinoma. In each case, a biopsy was also taken from nearby normal tissues of the same cervix. Each sample was homogenized in distilled water. An aliquot was treated with 0·15 N sulphuric acid for 1 hr., and used for the estimation of ribonuclease activity. Another sample was used for the determination of nucleic acids and protein content by the methods already described[3].

The results obtained with these samples, together with samples taken from non-cancerous patients, are shown in Fig. 1. It can be seen that there is a significant correlation between ribonuclease activity and ribonucleic acid content (per unit of protein) for normal and cancerous tissues. The correlation is, however, different in the two cases; for the same ribonucleic acid/protein ratio in both cases, the ribonuclease activity/protein ratio is lower in cancer cells. It can also be seen that, as a rule, the tumour cells contain more ribonucleic acid per unit of protein than the normal cells; they show less ribonuclease activity than the homologous normal control cells. These results, although they are difficult to evaluate owing to the heterogeneity of the material used, suggest that ribonuclease probably plays an important part in cellular ribonucleic acid metabolism.

In respect of cancer cells, it should be noted that exogenous ribonuclease produces a marked inhibition of the growth of spontaneous mammary carcinoma in $C+$ mice[6] and of certain experimental tumours[6,7], while it has no effect on the normal tissues of the host. There may be a correlation between these

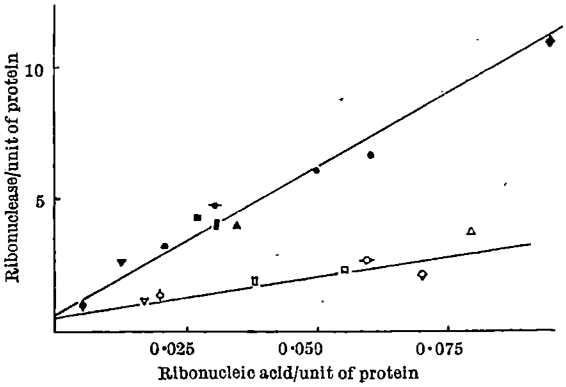

Fig. 1. Relations between ribonuclease activity (measured at pH 5) and ribonucleic acid content of homologous normal and cancerous epithelium in the human uterine cervix. Upper curve, normal epithelium; lower curve, cancerous epithelium. Black signs, normal tissues; white signs, cancerous homologous tissues.

findings and the fact that activity of ribonuclease is lower in neoplastic than in normal tissues.

Since the action of exogenous ribonuclease on ascites tumour cells *in vivo* and *in vitro*[8] begins with a stimulation of ribonucleic acid synthesis and an increase in pyrimidine metabolism, endogenous ribonuclease activity might be related to a selective orientation of the metabolism of ribonucleic acid; if so, the decrease of ribonuclease activity observed in the cancerous uterine cervix might correspond to different ribonucleic acid metabolisms in normal and in cancer cells.

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Retention of Sodium-22 in Rat Bone

Three groups of male rats, of about 50, 150 and 300 gm. body-weight respectively, were placed on a low sodium diet, and 5 µc. sodium-22 chloride per kgm. body-weight injected intraperitoneally on day 1. On days 3 and 5 a further injection of 2 µc. per kgm. was given, and on day 7 all were replaced on the stock diet (0·5 per cent sodium). Six female rats each weighing 250 gm. were mated on day 1, and the diet and sodium-22 administered as above; three were replaced on the stock diet on day 14 and the others maintained on the low sodium intake until term. Approximately each 10 days, commencing on day 11, one male from each group was bled from the tail to obtain a plasma sample; humeri and femora were then removed and scraped as clean as possible and weighed. The four bones from each animal were placed in 0·05 *M* silver nitrate in 5 *N* nitric acid, and after standing in the cold for some days the mixture was heated at 100° C. to effect complete solution of organic matter. This method was designed to avoid formation of volatile organic compounds containing chlorine[1,2].

Total sodium was measured by EEL flame photometer, sodium-22 was counted with a scintillation counter, and chloride was measured by Volhard's method[3]. The sodium in the extracellular fluid of the bone was then calculated from plasma sodium and chloride and bone chloride, and its radioactivity from the plasma radioactivity. These values were subtracted from the total sodium and radioactivity found in the bones to obtain an estimate of the true bone sodium and radioactivity. From tables[4] estimates were obtained of the total bone-weight of the rats at the various times, and from these and the radioactivity measurements estimates have been made of the percentage retention of sodium-22 in the total skeleton (see Table 1). While on the low sodium diet, the rats gained weight less rapidly than the tables suggested, so that the estimates of total bone activity may be slightly too high, especially for the first two times. In some large rats the bones of which were analysed 24 hr. after injection about 10 per cent of the administered dose was initially deposited in the skeleton.

Only two females of each group delivered litters, and the young were allowed to grow to about 100 gm. body-weight. Then the blood and bones of six young from each group were treated as above, pooling all the samples in each of the two groups. When the mothers had been exposed to the sodium-22 and low sodium diet during only the first two weeks of pregnancy, the mean retention of the isotope in the four bones of each offspring two months later was 10^{-5} µc. ($P < 0·01$); this corresponds to approximately 0·005 per cent of the dose administered to the mother per fœtus. When the mothers had been kept on the low sodium diet throughout pregnancy, the mean retention of sodium-22 in the four bones of the offspring was 3×10^{-5} µc. ($P < 0·001$), or approximately 0·015 per cent of the dose per fœtus. There was no demonstrable sodium-22 in the plasma of any of these offspring at death.

It is impossible to draw any detailed conclusions from these preliminary figures, but some sodium-22 was laid down relatively permanently in the growing bones of the rats—more in the younger animals the growth-rate of which was higher. This would appear to be about 0·5–1 per cent of the administered dose, or of the order of 5–10 per cent of the fraction originally laid down in the bone at the end of 24 hr. The specific activity of the plasma declined far more rapidly as expected, with a half-period of about three days in the large rats and one and a half days in the small ones. Whether the whole of the isotope would ultimately have been lost, as suggested by accumulation experiments[5], cannot be decided from the above figures.

How relevant these findings with rats (the bones of which were still growing during the entire experimental period) are to adult humans is not known, but certainly the growing bone of the child may be expected to behave in a similar manner.

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Table 1

Initial body-weight	50 gm.			150 gm.			300 gm.		
Time killed (days)	Estimated total bone weight (gm.)	Bone activity (mµc./gm.)	Bone activity Per cent of dose	Estimated total bone-weight (gm.)	Bone activity (mµc./gm.)	Bone activity Per cent of dose	Estimated total bone-weight (gm.)	Bone activity (mµc./gm.)	Bone activity Per cent of dose
11	9·2	1·23	2·5	17·8	2·15	2·6	25·4	1·85	1·7
20	12·0	0·91	1·3	18·9	0·75	1·0	25·4	0·91	0·85
29	14·1	0·41	1·0	19·8	0·41	0·6	25·5	0·41	0·4
43	16·6	0·47	0·9	21·0	0·47	0·7	25·5	0·47	0·45
54	18·1	0·55	1·1	21·8	0·46	0·7	25·6	0·55	0·5
63	19·2	0·35	1·0	22·2	0·24	0·4	25·6	0·35	0·3

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Lesions in the Hypertensive Rat Kidney produced by Hydralazine

THE use of hydralazine (1-hydrazinophthalazine) for the control of human hypertension was followed by the recognition of serious and undesirable side-effects. The similarity of some of these effects to disseminated lupus erythematosus led to the investigation of the influence on the normal dog of toxic doses of this drug[1,2]. These experiments failed to provide satisfactory evidence for the production in the dog of an experimental model of disseminated lupus erythematosus.

To reproduce more closely the conditions under which the desired changes are found clinically, increasingly large amounts of hydralazine have been given by single daily intramuscular injection to rats previously subjected to a regime shown to cause systemic hypertension. The regime comprised left nephrectomy, the subcutaneous implantation of 100 mgm. of slowly absorbed deoxycortone acetate, and the substitution for drinking water of 1 per cent sodium chloride. The development of hypertension was suppressed by the hydralazine injections, each injection being followed by an abrupt fall in blood pressure succeeded by a linear rise continuing throughout the following 24 hr.

In these circumstances the intact kidneys of the treated animals were found to contain a surprisingly large number of focal glomerular lesions. The lesions were usually confined to one segment of the glomerular tuft, and varied from focal necrosis, with aneurysmal capillary dilatation, to segmental replacement fibrosis; they were not accompanied by arterial or arteriolar changes.

In control animals subjected to the same hypertensive regime and injected daily with an inert fluid the tubular effects of deoxycortone were recognized but were accompanied only by glomerular enlargement and seldom by the characteristic glomerular lesion seen when larger amounts of deoxycortone are more rapidly absorbed. Similar deoxycortone effects were also present in the hydralazine-treated animals.

Hydralazine may therefore influence the integrity of the rat glomerulus under certain carefully defined conditions. The effect is indirect, and is observed neither in the normal animal nor in the animal from which one kidney has been removed but which has received no deoxycortone. The glomerular damage clearly cannot be satisfactorily explained in terms of sustained hypertension, nor is it likely to be a result of the gradual rise in blood pressure which is the sequel of the acute hypotension following each daily injection of hydralazine. It is, however, possible that the damage may be directly related to the daily hypotensive episode.

The production of these lesions in the rat glomerulus is considered to be of importance, partly because their recognition provides the first satisfactory evidence of a damaging effect of hydralazine upon the kidney in experimental hypertension, and partly because of the suggestion that episodic hypotension may be the immediate causative agent. In addition, the experiment provides some evidence for the suggestion that glomerular lesions due to deoxycortone can be distinguished from those due to variations in blood pressure, and thus that the glomerular effects of deoxycortone are not necessarily due to hypertension.

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Determination of Transaminase Activity of Serum Protein Fractions separated by Paper Electrophoresis

THE electrophoretic mobility of glutamic–oxalacetic acid transaminase in blood serum has been found to be between those for α_2- and β-globulins[1]. In our experiments[2] the glutamic–oxalacetic acid transaminase was associated mainly with α_2-globulins. This communication deals with this transaminase and glutamic–pyruvic acid transaminase and their relations to serum protein fractions.

Blood sera of six patients with characteristic activities of both enzymes were studied. 0·2-ml. samples of sera were electrophoretically separated on Whatman No. 1 filter paper strip (14 cm. × 35 cm.) in 5 hr. Barbital buffer of *p*H 8·6, ionic strength 0·1, was used with a voltage of 350 V. and a current of 0·5–0·8 m.amp. per cm. The marginal sections (3 cm.) were stained for proteins with bromthymol blue. The middle section of paper was cut into corresponding protein fractions and tested for their transaminase activity. The method for simultaneous determination of glutamic–oxalacetic acid and glutamic–pyruvic acid transaminases with an incubation mixture containing glutamate, oxalacetate and pyruvate was used. The action of enzymes was followed by determining the formation of L-aspartic acid and L-alanine, which have been estimated by the ninhydrin method after electrophoretic separation from aliquots of the incubation mixture[3]. In other experiments the middle section was, first of all, cut longitudinally into two identical parts and these were afterwards divided into strips containing the single protein fractions. One part of these strips was incubated with α-ketoglutaric and L-aspartic acid (both kindly supplied by the California Foundation for Biochemical Research, Los Angeles) and the other one with α-ketoglutaric acid and L-alanine. The activities of the glutamic–oxalacetic acid and glutamic–pyruvic acid transaminases in single protein fractions were assayed by hydrazone methods[4,5].

The distribution of transaminases on blood serum protein fractions is presented in Table 1.

Table 1

Diagnosis	Percentage of total Glutamic–oxalacetic acid transaminase activity associated with serum protein fractions					Glutamic–pyruvic acid transaminase				
	Globulins					Globulins				
	γ	β	α_2	α_1	Albumins	γ	β	α_2	α_1	Albumins
Infectious hepatitis (2 cases)										
Obstructive jaundice (metastatic carcinoma)	2	7	82	2	7	7	81	8	1	3
Acute myocardial infarction (3 cases)	7	12	75	5	1	18	43	23	8	8
Range of values	(0–8)	(4–17)	(67–89)	(0–10)	(0–10)	(5–12)	(41–90)	(2–36)	(0–21)	(0–19)

The results show that in the pathological sera used the activity of glutamic–oxalacetic acid transaminase is mainly bound with α_2-globulins, and that of glutamic–pyruvic acid transaminase with β-globulins.

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Relationship between Porphyrin and Isoniazid Resistance of *Mycobacterium avium*

IT has been reported that a decrease in catalase activity is observed when tubercle bacilli acquire isoniazid resistance[1], and later it was demonstrated that hæmin is required for growth by some of these resistant strains[2]. We have found that the amount of a red fluorescent substance in sensitive strains of *M. avium* (Jûchô, Takeo and 607) is smaller in strains resistant to isoniazid: while the sensitive organism contained 5·5 mgm. red compound/kgm. bacteria, those which were resistant to 250γ isoniazid contained only 2·1 mgm. compound/kgm. bacteria. The sensitive and resistant strains discussed in this communication were cultured in a glycerin–bouillon medium containing no isoniazid.

The red fluorescent substance was extracted with acetone from the organism. The acetone extract was concentrated *in vacuo* and the concentrate was diluted with two volumes of water, then extracted with ether. The ether extract was evaporated *in vacuo* and the residue was purified by the conventional methods for porphyrin extraction. The red material thus obtained had absorption maxima at 624, 597, 568, 529, 495 mμ (in ether solution); relative intensities $495 > 529 > 568 > 624 > 597$. The paper chromatographic analysis of this compound gave evidence that the compound was coproporphyrin III ester, a 4-carboxyporphyrin ester[3–5]. The hydrochloric acid number of the hydrolysis product was 0·09.

Todd[6] has isolated coproporphyrin III tetramethyl ester from *M. karlinski* and also reported the presence of the same porphyrin in *M. stercoris* and *M. smegmatis*. The present porphyrin was shown to be identical with that of *M. smegmatis* by paper chromatography. On account of the low yield we could not obtain the red substance in a crystalline state, but the above evidence indicates that the substance is coproporphyrin III tetramethyl ester.

We have added the free coproporphyrin obtained by the method described above to the medium of the isoniazid-resistant *M. avium* (250γ resistant Jûchô strain) and measured the catalase activity by the method of Euler and Josephson[7]. The value thus obtained was 1·236; on the other hand, the value for the resistant bacterium cultivated without coproporphyrin was 0·115. Thus the value was more than ten times greater in the presence of the porphyrin but no difference in the degree of resistance resulted. This evidence suggests that there is no decisive relation between isoniazid resistance and the lack of catalase activity of the bacteria.

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The Latent Period after Infection with Tobacco Mosaic Virus and Virus Nucleic Acid

THE process of infection by plant viruses is not so well known as that for animal viruses and bacteriophages. The main reasons are that tissue cultures are not yet available in which all cells can be uniformly infected and that the methods for determination of the activity are not sensitive enough. Experiments of this kind have been carried out with total plants or pieces of leaves. Siegel *et al.*[1] studied the early events of infection with tobacco mosaic virus by an indirect method, measuring the ultra-violet sensitivity of infective centres in *Nicotiana glutinosa*. An increase in ultra-violet resistance occurred 5 hr. after infection at 20° C. This time can be considered as the lag phase. Other results to demonstrate the increase of virus concentration directly are obscured by the fact that the adsorbed virus which has not penetrated and therefore does not participate in the infection is not removed from the surface of the leaves[2]; further, the methods of determination were not sensitive enough[3].

For the detection of small amounts of viruses the bioassay is by far the best method. Using the local lesion test on *Nicotiana glutinosa* we found that a minimal concentration of 10^{-12}–10^{-13} gm. tobacco mosaic virus/ml. was detectable. 25 leaves powdered with 'Carborundum' were used for each dilution. It seemed probable that the minimal infective dose is smaller in plants reacting with systemic symptoms. Young plants of *Nicotiana tabacum* (Samsun) were inoculated with tobacco mosaic virus solutions, again adding 'Carborundum'. The effect was variable, but using a considerable number of plants, we found a 50 per cent infection with a dilution of 10^{-16} gm. tobacco mosaic virus/ml. We applied 5 ml. per plant and this dose is equal to 10 virus particles (Table 1). This test is rather laborious and several precautions were necessary to avoid misleading results. The test may only be used for qualitative purposes.

Table 1. INFECTIVITY OF DILUTIONS OF TOBACCO MOSAIC VIRUS ON *N. tabacum*. CONTROLS WERE INOCULATED WITH PHOSPHATE BUFFER

Tobacco mosaic virus conc. (gm./ml.)	Infected plants / Total number	Percentage infected
10^{-8}	22/25	88
10^{-10}	4/25	16
10^{-12}	29/40	72
10^{-14}	51/60	85
10^{-16}	37/75	54
10^{-18}	0/10	0
10^{-20}	0/10	0
Control	0/63	0

By these methods of bioassay and other methods we have investigated the process of infection in young plants of *Nicotiana tabacum* (Samsun). We inoculated three leaves of each plant with 10^{-6} gm. tobacco mosaic virus/ml. in 0·1 *M* phosphate buffer, *p*H 7·2. The leaves were previously dusted with 'Carborundum'. In order to remove the adsorbed virus particles, the leaves were rinsed with water and then with diluted tobacco mosaic virus antiserum. The infected plants were maintained in a thermostat at 23° C. and had constant illumination. After certain intervals the primarily infected leaves of groups of five plants were harvested. The homogenates of these samples were tested on *Nicotiana glutinosa*, as described above. By means of a reference curve, the amount of virus per gm. leaves was calculated from the number of local lesions.

A typical experiment which is easily reproducible is shown in Fig. 1. After the latent period, multiplication is rapid, but it slows down when a concentration of about 10^{-7} gm. virus/ml. is reached in the tissue. For determining the latent period the curve must be extrapolated to the time when the first complete virus particle appears in the leaf. This corresponds to a concentration of 7×10^{-17} gm. tobacco mosaic virus/gm. leaf. The extrapolation led to a latent period of about 30 hr. Even with the very sensitive test in *Nicotiana tabacum*, we never found an infective virus particle before the end of the latent period. In the first 30 hr. the virus concentration is probably less than 10^{-16} gm./ml. This indicates that there is a true latent period after infection. The latent period in *Nicotiana tabacum* seems to be much longer than that in *Nicotiana glutinosa* as found by the ultra-violet method[1].

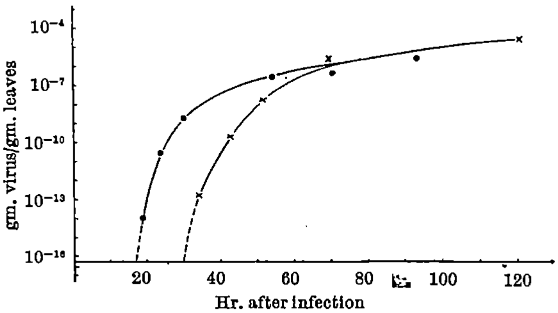

Fig. 1. Increase of virus concentration after infection with tobacco mosaic virus (×—×—×) and virus ribonucleic acid (●—●—●) in *Nicotiana tabacum*

Gierer and Schramm[4] showed that the ribonucleic acid isolated from tobacco mosaic virus by phenol extraction is infectious. Therefore it is probable that, in the cell, the external virus protein shell has to be removed before multiplication can start. If this removal is a slow process, the latent period should be reduced after infection with the isolated virus ribonucleic acid. We infected tobacco plants with ribonucleic acid solutions of the same infectivity as in the previous experiments with tobacco mosaic virus. Sometimes the ribonucleic acid and tobacco mosaic virus experiments were run parallel in the same thermostat. From Fig. 1 it can be seen that the increase of the activity of the virus occurs 10–12 hr. earlier than after infection with the virus. This is evidence that the release of ribonucleic acid from the virus takes several hours. However, it is not clear why the ribonucleic acid itself has such a long latent period. The events in this remaining latent period require further study. It should be mentioned that, by extraction of the virus particles from the leaves, the virus ribonucleic acid and other precursors can be destroyed by enzymes. Our experiments confirm the results of Siegel *et al.*[1], who also observed a reduction of the lag phase in infection with ribonucleic acid.

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Lysis of Fungal Mycelia by Bacterial Enzymes

MANY investigations have been published[1] on lysis of bacterial cells by microbial enzymes, but there seems to be few references to the lysis of fungal mycelia by microbial enzymes. A bacterial strain which caused visible lysis of *Aspergillus oryzae* mycelia has been isolated from soil. This strain belongs to the *Bacillus circulans* species ; it is Gram-negative, with spore-forming rods (spore : oval, terminal to subterminal), motile with peritrichous flagella, it reduces nitrate, is negative to acetylmethylcarbinol, and produces acid from glucose without evolving gas.

When this strain was inoculated into a flask culture of *A. oryzae* (in Czapek–Dox medium), which had been previously shaken for ·24 hr. at 30° C., almost all the mould mycelia disappeared after 80 hr. shaking at 30° C. The culture fluid was centrifuged at 7,000*g* for 30 min. to remove bacterial cells grown in the mixed culture, and a pale brownish supernatant was obtained.

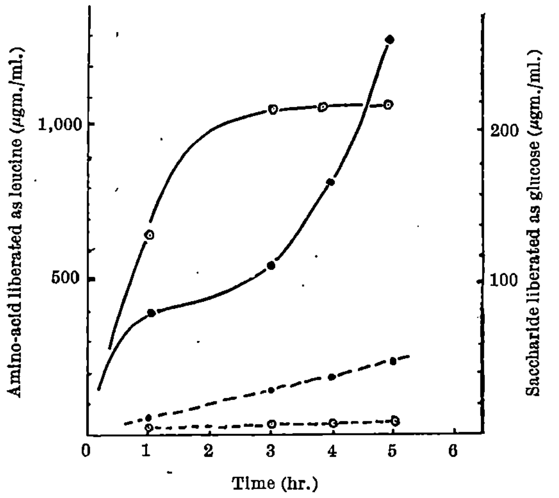

Fig. 1. Lytic action of the enzyme on living mycelial cells. 1 gm. of the living mycelial cells was suspended in 20 ml. of the lytic enzyme solution, and the mixture was incubated at 37° C. ●—●, Amino-acid; ⊙—⊙, saccharide; ●---●, amino-acid (control); ⊙---⊙, saccharide (control)

The supernatant was brought to 0·7 saturation with ammonium sulphate and stored in an ice-box overnight. The precipitate was collected by centrifugation and dissolved in $M/50$ tris-buffer (pH 6·8). The solution was dialysed against the same buffer for 48 hr. at 4° C. 1 gm. (wet weight) of living mycelial cells of *A. oryzae* was suspended in 20 ml. of this enzyme solution and incubated at 37° C. About 5-ml. portions of this mixture were sampled at 1-hr. intervals, and the hexose and amino-acid liberated were determined by the anthron method[2] and by Stein and Moore's method[3] respectively. As control, the boiled (100° C., 5 min.) enzyme solution and living mould cells were used. Fig. 1 shows the experimental results.

The cell walls of the mycelia were then used as the substrate, instead of living mycelia. The cell walls were prepared as follow: mycelia were disrupted by use of a Waring blendor, and disrupted mycelia were then treated with a crystalline bacterial protease (100 μgm./ml.). This mixture was filtered and the residual cell material (cell walls) was washed with water. The cell walls thus obtained were dried *in vacuo* over calcium chloride.

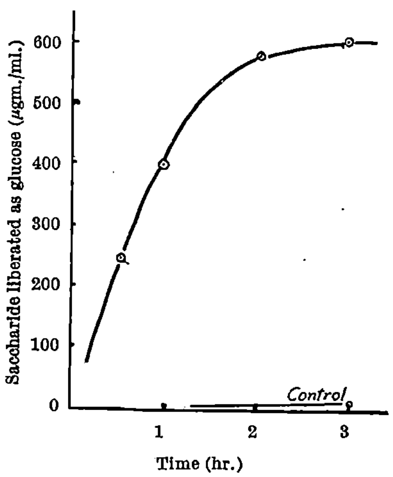

Fig. 2. Lytic action of the enzyme on the cell walls of *A. oryzae*. 25 mgm. of the cell walls was suspended in 10 ml. of the lytic enzyme solution, and the mixture was incubated at 37° C.

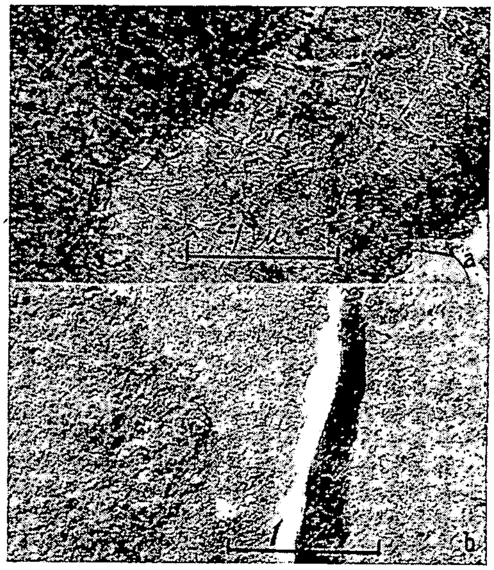

Fig. 3. (*a*) Rough layer of the cell-wall surface before treatment with the lytic enzyme; and the fibrous structure appeared on the inner side of the cell wall. (× 20,000). (*b*) After treatment with the lytic enzyme for 3 hr. The rough layer of the cell wall has disappeared, and the granular layer is observed; the fibrous structure is degraded. (× 20,000)

The course of degradation of the cell-wall material by the crude enzyme preparation from *B. circulans* is shown in Fig. 2, from which it seems that this enzyme acts on the cell walls directly. When treated with this enzyme, the rough surface layer seen before treatment disappeared, and a granular layer not visible before treatment appeared in the electron microscope (see Fig. 3).

This enzyme did not liberate either hexosamine or amino-acid (as detected by paper chromatography), but liberated a saccharide which was precipitated with 50 per cent alcohol. Paper chromatographic methods were used in attempting to identify the saccharide, but the spot remained at the origin. Hence it seems that the saccharide is a polymer of hexoses. The polysaccharide was then hydrolysed with 75 per cent sulphuric acid and neutralized with barium carbonate and chromatographed with pyridine/ethyl acetate/water (1 : 2 : 1). Glucose and galactose were identified in the acid hydrolysate.

It was further confirmed that this enzyme acts on the living mycelial cells of *A. aojae* KS., *Pen. purpurogenum* var., and *Mucor M*-5 but not on *Rhizopus R*-1-8.

We thank Prof. K. Sakaguchi, Dr. M. Amaha and Dr. M. Nomura (University of Tokyo) for their encouragement and guidance.

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Enhancement of Mouse-virulence of Group *A* Streptococci by Bactericidal Resorcinols

It seems to be generally agreed that agents capable of enhancing the virulence of bacteria, particularly mucins, do so by interfering with the defences of the host[1-3]. Recently, it was shown[4] that broth or peptone injected intraperitoneally into *W*-Swiss mice even 1 hr. after a non-lethal saline suspension of group *A* streptococci converts the non-lethal dose into an *LD*100, the time-lag pointing again to an action on the host. The present communication brings further evidence in this respect; it also shows that substances bactericidal *in vitro* can act as virulence-enhancing agents *in vivo*.

The resorcinols were the 4-*n* substituted alkyl derivatives, ethyl, propyl, butyl, amyl and hexyl resorcinol[5]. The intraperitoneal injection of 0·5 ml. of a 0·1 per cent saline solution of these compounds is without marked effect on mice.

Two strains of group *A* streptococci were used, one type 12, the other type 22; the *LD*100 was 0·5 ml. of a 10^{-2} saline dilution of culture, the culture itself containing about 2×10^7 viable cells per ml. The organisms were grown in broth consisting of 2 per cent 'Oxoid' peptone, 0·8 per cent 'Oxoid Lab. Lemco' broth powder, 0·2 per cent glucose and 0·2 per cent sodium bicarbonate made up in distilled water, sterilized by Seitz filtration and tubed in 4-ml. lots in ¼ oz. screw-capped Bijou bottles.

Two types of experiment were carried out. First, 18-hr. old cultures of streptococci were diluted 1 in 10 in 0·1 per cent solutions of the various resorcinols and kept, with occasional shaking, at room temperature, 24°, for 30 min., a 10^{-1} saline-dilution of culture serving as control; thereafter *W*-Swiss mice were injected intraperitoneally with 0·5 ml. of the suspensions from which viable counts were made[6]; all control animals and all animals injected with the ethyl and propyl resorcinol suspensions of organisms died. There were no deaths in the groups injected with the organisms exposed to butyl, amyl and hexyl resorcinol. The butyl, amyl and hexyl suspensions were found sterile whereas the ethyl, propyl and saline suspensions still contained approximately the same number of viable organisms.

In the second group of experiments the organisms were not exposed *in vitro* to the action of the resorcinols: instead, mice were first injected intraperitoneally with 0·5 ml. of 10^{-2}–10^{-6} saline dilutions of culture and immediately afterwards with 0·5 ml. of a 0·1 per cent saline solution of the resorcinols; control animals were given intraperitoneally 0·5 ml. of the saline dilutions of culture followed by 0·5 ml. of saline. Under these conditions the resorcinols proved to be not disinfectants but virulence-enhancing agents and a 100- to 1,000-fold decrease of the *LD*100 was observed (Table 1).

Table 1. EFFECT OF 4-*n* ALKYL-SUBSTITUTED RESORCINOLS ON MOUSE-VIRULENCE OF GROUP *A* STREPTOCOCCI

Strain	Alkyl resorcinol	Deaths in groups of 16 mice inoculated with the following culture dilutions*				
		10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
Cumming Type 22	None-saline control	16	8	0	0	0
	Ethyl	—	8	3	0	0
	Propyl	—	9	5	0	0
	Butyl	—	—	16	13	0
	Amyl	—	—	16	16	11
	Hexyl	—	—	16	16	9
1965 Type 12	None-saline control	16	10	1	0	0
	Ethyl	—	9	7	0	0
	Propyl	—	13	5	0	0
	Butyl	—	—	16	14	0
	Amyl	—	—	16	16	11
	Hexyl	—	—	16	16	12

* Mice injected intraperitoneally, first with 0·5 ml. of the stated saline dilutions of culture, then with 0·5 ml. of saline or of a 0·1 per cent saline solution of an alkyl resorcinol.

Thus it has been shown that the same substance can act both as a bactericide and as a virulence-enhancing agent, depending on the conditions of the experiment, and that in the alkyl resorcinols examined virulence-enhancing activity parallels bactericidal activity. The experiments rule out a true enhancement of virulence of the infecting organism and demonstrate that the action of the resorcinols is on the host.

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A Possible Source of Error in the Chemical Detection of Indolyl Acetic Acid in Plants

DURING investigations on the growth substances of fruits of cacao and bananas (*Musa* spp.), it was of interest to find that a substance was present in seeded bananas which gave a pink colour with ferric chloride/perchloric acid or *p*-dimethyl amino-benzaldehyde/hydrochloric acid, corresponding to the R_F of indolyl acetic acid and to the zone of bioassay using the wheat coleoptile straight-growth test. Subsequent experimentation showed that although the straight-growth response was probably due to indolyl acetic acid, the colour reaction was not. The technique of extraction and bioassay was essentially similar to that of Bennet-Clark and Kefford[1] with some minor modifications. Duplicate samples of the acid fraction from seeded banana fruit extracts were developed by the descending method on Whatman's 3 *MM* or No. 1 chromatography paper in *iso*propanol/ammonia/water (10 : 1 : 1). Synthetic indolyl acetic acid was developed as a marker. One sample was bio-assayed by the wheat straight-growth test and the other sprayed with ferric chloride/perchloric acid (1 ml. 0·05 *M* ferric chloride + 50 ml. 5 per cent perchloric acid).

The ferric chloride/perchloric acid spray, on heating, developed a pink or pinkish-purple spot on the chromatogram corresponding to both the zone of growth activity after bio-assay and to the indolyl acetic acid marker. The top half of the chromatogram ($R_F < 0{\cdot}5$) was usually streaked with oxidized polyphenolic substances which could be detected visually without treatment by the brown colour and confirmed by diazotized *p*-nitraniline. It was found that if synthetic indolyl acetic acid was spotted into the brown area, dried and afterwards heated with ferric chloride/perchloric acid, the final colour development was not the more typical pink but pinkish-purple, similar to the colour developed with the banana extracts. The evidence from the R_F behaviour, colour reactions with ferric chloride/perchloric acid and bio-assay activity therefore suggested that the banana auxin was probably indolyl acetic acid.

However, in a detailed series of extractions from bananas of different ages it was noted that in some experiments the colour reaction with ferric chloride/perchloric acid could be obtained but without the corresponding growth activity after bioassay. Luckwill[2] has pointed out the necessity of using more than one developing solvent in order to confirm the presence or absence of indolyl compounds in plant extracts, and of the necessity of critical bioassay. Afterwards the acidic fractions of seeded bananas were run in 70 per cent alcohol and butanol/acetic acid/water (4 : 1 : 5). In 70 per cent alcohol the results were essentially similar to that found with the *iso*propanol solvent except that the growth activity, indolyl acetic acid marker and pink spot developed by ferric chloride/perchloric acid were found in the region of R_F 0·55. However, in butanol/acetic acid/water the zone of the growth activity and indolyl acetic acid marker were found consistently at R_F 0·95, whereas the coloured product developed with ferric chloride/perchloric acid appeared at 0·79–0·80. This evidence indicated that indolyl acetic acid was present in seeded bananas but it was not responsible for the colour reaction with perchloric acid.

In order to confirm the presence of indolyl acetic acid, duplicate samples from the extracts of seeded bananas were first run in *iso*propanol/ammonia and the zone of growth activity from one chromatogram, determined by bioassay of the other, was eluted with ether. The ether extract was concentrated under reduced pressure and re-chromatographed on Whatman No. 1 paper, using distilled water as the developing solvent. The zone of growth activity appeared at R_F 0·9, corresponding very closely to the indolyl acetic acid marker at R_F 0·89. The evidence from the R_F values of the banana auxin in the various solvents mentioned provides evidence that it is either indolyl acetic acid or an indole compound very closely allied to it.

The nature of the unknown compound which gave the pink colour with perchloric acid was of interest, particularly as the R_F behaviour was similar to indolyl acetic acid in two different solvents, one of which is commonly used for the separation of the acidic auxins.

Simmonds[3] has shown that leucoanthocyanidins are present in banana fruits. It was found that the unknown compound, after spraying with 10 per cent hydrochloric acid in butanol, gave a pink colour on heating but not in the cold. Furthermore, on spraying with vanillin/hydrochloric acid (1 gm. vanillin dissolved in 15 ml. of concentrated hydrochloric acid + 35 ml. butanol), a pink colour was developed without heating. The hydrochloric acid and the vanillin reactions, modified from a method described by Bate-Smith[4], are together indicative that the compound responsible for the colour reactions is almost certainly a leucoanthocyanin. Although straight-growth promoting activity is not associated with the leucoanthocyanins, it is very possible that if a range of both temperate and tropical fruits is examined for indolyl compounds by paper chromatography and straight-growth bio-assay, confusing colour reactions with conventional chemical sprays may be found in the presence of mobile leucoanthocyanins.

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Root Diffusates of *Solanum tuberosum* and *Digitalis purpurea*

THE hatching factor of the potato root eelworm has been shown to possess certain affinities with the cardiac glycosides[1] due, presumably, to the unsaturated lactone ring it is thought to contain[2]. The factor is contained in diffusates from the roots of growing potato plants[3]; but it has recently been shown that it can also be obtained from their leaves[4]. On the other hand, although the presence of cardiac substances in the leaves of the foxglove has been known for centuries, diffusates from their roots do not appear to have been examined: I have now found that such solutions have many of the properties of the potato root diffusates.

(1) Perfusion of the isolated frog heart shows that both potato and foxglove root diffusates possess cardiotonic activity.

(2) Colorimetric assay with either alkaline picric acid or 3,5 dinitro benzoic acid, methods used for cardiac glycosides[5,6], give reasonable agreement with heart assay. (In the case of the potato root diffusate, the colorimetric methods show promise for assessing hatching activity, as will be shown in full elsewhere.) With the benzoic acid reagent, both diffusates give an absorption peak at λ 385–390 mμ as shown in Fig. 1; digitoxin also gives this peak, which, so far as I am aware, has hitherto not been recorded: but it, and *Digitalis* tinctures, give other peaks too, not shown by the diffusates.

(3) Proctor *et al.*[7] have recently shown that digitoxin behaves as a peroxide in solution: solutions of both diffusates show peroxide activity after concentration in a Towers's evaporator. In the case of potato root diffusate the treated solution is relatively at least as active in stimulating hatching as the original.

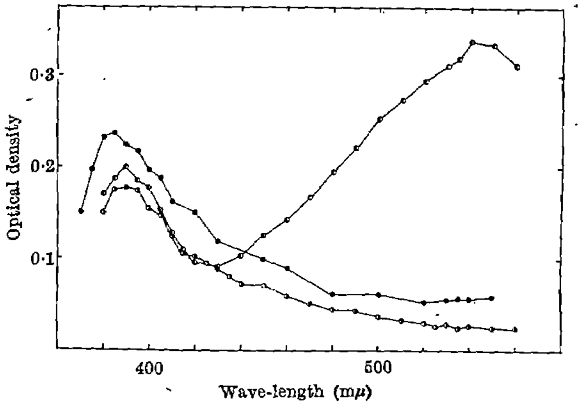

Fig. 1. 3,5 Dinitro benzoic acid reagent, and potato root diffusate (●), foxglove root diffusate (◑), and digitoxin (◐)

The diffusates probably contain a variety of substances, so that any conclusion must necessarily be provisional; moreover, none of the above points is critical evidence on its own. But, collectively, and together with the chemical evidence of Todd and his colleagues for the possible lactone structure of the hatching factor[2], the evidence is all consistent with the view that the two diffusates contain substances which have a chemical affinity with each other and with the cardiac glycosides.

Cardiac glycosides have been shown to influence sodium–potassium transport[8–11], and this property has also been demonstrated to be possessed by simpler lactones[12]. We have no direct evidence, as yet, that the hatching factor has this capacity, but, judging from the influence of ions on its activity, this does not appear to be unlikely. If this is so, one wonders whether the production of substances of this sort by plant roots may not be connected with the transport of ions by the roots themselves.

I am grateful for the tolerance and help of my chemical colleagues and for the facilities they have placed at my disposal. A grant from the Nuffield Foundation is gratefully acknowledged.

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Immune Reactions to *Trichostrongylus colubriformis* Infestation in Sheep

In infestation of sheep with *Trichostrongylus colubriformis* both the intake of larvæ and infestation with adult worms stimulate the production of antibodies. These can be detected by means of a complement fixation test with an antigen prepared from ground larvæ[1].

During studies on the immune reactions of sheep to infestation with *T. colubriformis* it was found that after challenge of infested sheep with a further dose of larvæ, the body-weights of some remained static, or even declined, although the fæcal worm-egg count was virtually negative and the serum titre remained at a high level. Several such sheep were slaughtered and although very numerous adult *T. colubriformis* were recovered from the small intestine, few eggs were present in the females. In one case, from which approximately 20,000 worms were recovered, the serum titre had risen to 1/40 three weeks after challenge with 20,000 larvæ and remained at 1/40 or 1/80 until the lamb was slaughtered nine weeks later. During this period the worm-egg count never exceeded 400 per gm. fæces.

Further experiments revealed that the worms had reached maturity in the normal time, but that the females produced very few eggs. It was apparent that, in these cases, there is a suppression of egg-production associated with a sustained high serum titre, and that the worm-egg count is not then a reliable indication of the degree of infestation. A similar phenomenon has been noted by Roberts[2] in infestations of cattle with *Haemonchus placei*.

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Dependence on Light of the Reversible Uptake of Inorganic Phosphate by *Hydrodictyon*

In the colony-forming green alga, *Hydrodictyon reticulatum*, uptake and metabolism of phosphate have been followed up by ordinary analytical methods (fractionation by the conventional trichloracetic acid technique, determination of phosphates with a modified procedure of Fiske and Subbarow[1]). The predominant feature in the changes of the phosphate fractions during a long-term culture with intermittent illumination (12 hr. light : 12 hr. darkness) is a marked increase in the large cells of the alga of the inorganic phosphate-level during the time of illumination. A comparable light-dependent accumulation of ions has been reported for other objects (reviewed by Brauner[2]), most recently for chloride by van Lookeren-Campagne[3]. In the case of *Hydrodictyon*, however, the accumulation of inorganic phosphorus in the light is reversible[4], since the low level of intracellular phosphate is completely restored during the dark time. This is shown in Fig. 1. The changes of the inorganic phosphorus have been found in the cells and, at the same time, in the surrounding nutrient solution. The differences in the phosphorus-level are not directly induced by *p*H changes in the medium.

Photosynthetically active red and blue light is more effective in phosphate accumulation than is green light of equal energy (Schott glass filters). Absence of carbon dioxide prevents the light-dependent accumulation almost completely. Persistent high

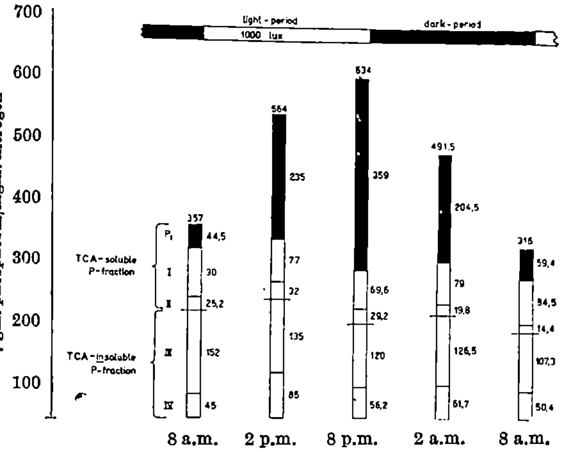

Fig. 1. Changes of phosphate fractions dependent on intermittent illumination of *Hydrodictyon*, based on total nitrogen (Kjeldahl). P_i, inorganic orthophosphate; I, stable phosphates soluble in trichloracetic acid; II, unstable phosphates soluble in trichloracetic acid (7 min.); III, unstable phosphates soluble in trichloracetic acid (7 min.); IV, stable phosphates insoluble in trichloracetic acid. Complete nutrient medium, 20° C.

levels of inorganic phosphorus can be obtained by shortening the darkness times versus times of illumination, and especially by continuation of the latter. These conditions are unfavourable for the vegetative development of the alga. The accumulation of inorganic phosphorus cannot be considered an obligatory ingredient or consequence of photosynthetic activity. This follows from the fact that low light intensities (for example, 300 lux), much below photosynthetic saturation but above compensation of respiration, are inactive in phosphate accumulation. The latter appears from about 1,000 lux on, where photosynthesis is beyond its linear dependence on light intensity. Thus we assume that phosphate accumulation and maintenance in the cell will be only exhibited at the expense of a certain surplus amount of energy available additional to the requirement of the photosynthetic mechanism proper.

Apart from the shifting of the inorganic phosphorus-level, reversible or irreversible changes in the different phosphate fractions of the algal cells during times of darkness and illumination are comparatively small, so far as they can be observed by usual analytical methods. The questions concerned will be discussed elsewhere[5]. Here it must suffice to say that polyphosphates, distributed between the fractions respectively soluble and insoluble in trichloracetic acid, can be increased by long illumination without additional carbon dioxide[6]. On the other hand, we did not obtain any evidence for an effective formation and utilization of polyphosphates in the balance of energy of the cells during changes in illumination and darkness and in the course of photosynthetic periodicity[7]. Labile phosphates of all kinds seem to be especially sensitive toward a lowering of the external supply of phosphorus.

This work was aided by the Deutsche Forschungsgemeinschaft.

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Effect of Stereoisomeric Tartrates on Root Elongation in *Lepidium*

It was shown by Tetjurew[1] that free organic acids, especially malic and citric acids, exert an inhibitory effect upon seed germination.

Evenari[2] is of opinion that the inhibition by organic acids is not caused by the hydrogen-ion concentration alone, but that "it is mainly by their intrinsic natures as specific acids that they are inhibitors". This view is supported by the results of some experiments reported here, demonstrating the specific influence of different stereoisomeric forms of tartaric acid upon early stages of root elongation in cress (*Lepidium sativum* L.).

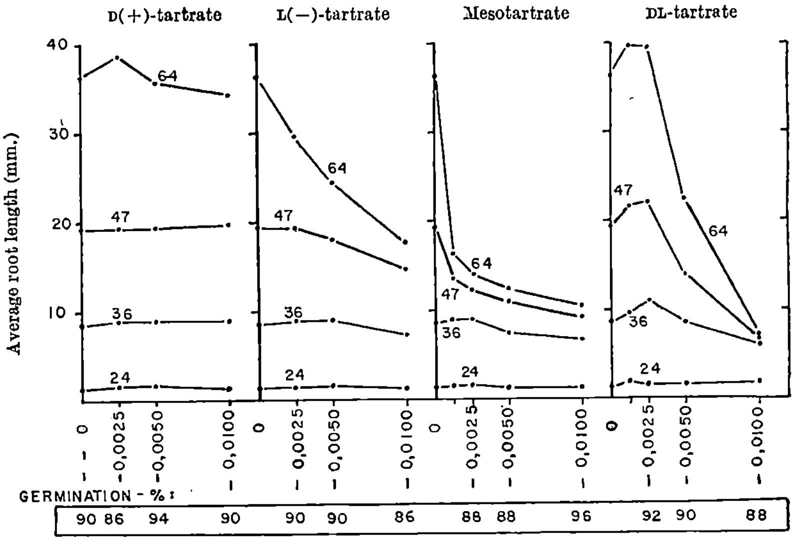

Fig. 1. Length of cress roots after 24, 36, 47 and 64 hr. in various concentrations of the different stereoisomeric tartrates. Abscissa: concentration of tartrate, moles per litre. Each point on the figure represents the average of fifty seeds. The seeds were harvested in 1955 and tested in December 1957. Below: germination percentages after 64 hr. in the different solutions

The technique was as follows. The different tartaric acids, analytical grades, were obtained from A. G. Fluka, Switzerland. As a precaution against microbiological contamination and chemical decomposition, the test solutions were made up the day they were to be used.

The seeds were germinated in Petri dishes on six layers of filter paper moistened with 10 ml. of neutralized tartaric acid. The initial *p*H value of the solution was adjusted to 6·0–7·0 by the addition of sodium hydroxide. No buffer was used. Twenty-five seeds were placed in each Petri dish and the dishes were placed in a dark-room at 21·5 ± 0·5° C.

The lengths of roots were measured to the nearest mm. The results were expressed as germination percentages and average length of root, disregarding ungerminated seeds. The latter were considered only for the calculation of the germination percentages. This procedure was chosen because certain treatments, such as irradiation by light of various wave-lengths (unpublished results), seem to influence only the germination percentage, the average length of root of those seedlings that did develop being unaffected. Other treatments, such as the addition of tartaric acids as described below, seem to influence only the average root-length and not the germination percentage.

The three stereoisomeric tartrates and the racemic DL-tartrate proved to have quite different and specific effects on the elongation of cress roots (Fig. 1).

D(+)-*tartrate*, the naturally occurring isomer, has no inhibitory effect at the concentrations tested.

L(−)-*tartrate* has little or no inhibitory effect during the first 36 hr. of germination. After 47 hr. L(−)-tartrate shows some inhibitory effect, and at 64 hr. the inhibition is considerable.

Mesotartrate is inhibitory from 36 hr. and onwards, and consistently more inhibitory than L(−)-tartrate.

DL-*tartrate*, which is the racemic mixture of D(+)-tartrate and L(−)-tartrate, was slightly stimulatory at low concentrations. At higher concentrations, it proved, unexpectedly, to be more inhibitory than the L(−) form given alone, and at the highest concentration even more inhibitory than the mesotartrate.

These effects might be related either to the metabolism of natural organic acids in the plant or to the action of growth substances, or to both. A discussion of the results must, however, be postponed until further evidence has been obtained.

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'Recurrence' of *Macroderma gigas* Dobson

It is now fifty-eight years since E. R. Waite[1] employed the above title to record what he believed to be the second specimen of this bat, remarkable alike for being the largest member of the suborder Microchiroptera, for its carnivorous habits and for grotesque appearance. Waite's specimen came from the Pilbarra district of the North Western Division of Western Australia, 1,600 miles from the locus of Dobson's type, and provided an enormous extension of range; but he overlooked the fact that the species had been obtained in the Macdonnell Ranges of Central Australia in 1890 and again in 1894.

Since Waite wrote, a belief in the great rarity of the species and its near extinction has grown and has been fostered in popular writing by dwelling upon the abundance of its mummies in caves of the arid north of South Australia. These relics, however, are probably in large part sub-fossil, and recent field work has tended to show that the living animal is much more numerous and widespread than was believed. Tate[2] in 1948 obtained a series at Johansen's Caves near Rockhampton in coastal Queensland, near Olsen's Caves which had yielded it twenty years before, and Douglas[3], Robinson[4] and Ride, W. D. L. (personal communication), have shown that it persists in at least three localities in the North West and West Kimberley Divisions of Western Australia. I am now able to add three new sites in the Northern Territory: (1) the tableland scarp in the Macallum Creek area at about lat. 13° 16′ S. and long. 130° 44′ E.; (2) caves on the Field River near the eastern edge of the Arunta desert at about lat. 23° 34′ S. and long. 137° 53′ E.; (3) the Ellery Creek gorge in the James Range at about lat. 24° 5′ S. and long. 132° 49′ E. In addition numerous reports from intermediate localities of 'white flying foxes' drowned in tanks or otherwise destroyed are strongly suggestive of *Macroderma*.

It has been claimed that the chief food of the species consists of smaller bats. I have obtained no new evidence of this from personal observation, and the accounts of the aborigines are conflicting. In some parts of the country they regard this bat with aversion and state that men have been attacked by it on entering its roosts.

The Central Australian material is in close agreement with the type as described and with the desiccated material from South Australian caves; but it may be noted that the general pallor which has earned it the modern vernacular term 'ghost bat' is not an invariable feature. I have examined Queensland specimens in which the dorsal pelage is a deep brownish drab (about Ridgway's 'hair brown') and the ventrum a decided plumbeous in place of snowy white and with a corresponding darkening of integument; the cranial characters are normal.

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A Chimæra of *Alaria* and *Laminaria* found in Nature

A CHIMÆRA of two kelps belonging respectively to *Alaria* and *Laminaria* was recently collected by one of us (M. I.) on May 18, from among a mass of seaweed which drifted ashore in the neighbourhood of the Marine Laboratory for Biological Education, Hokkaido Gakugei (Arts and Science) University, situated at Shirikishinai Village, Oshima Province, in Hokkaido. The frond of this chimæra is formed by the complete lengthwise and lateral adhesion of two half-fronds each representing one of the two quite distinct genera of Laminariales.

Our specimen, unfortunately, has lost its stipe and holdfast; it is 197 cm. in length and 13·7 cm. in width at the broadest portion. The frond is strongly curved inwardly along the margin of the *Laminaria* portion, thus indicating that this portion is markedly inferior in rate of frond-growth in length as compared with the *Alaria* portion. This latter portion is provided with a complete smooth midrib, up to 15 mm. wide and up to 3 mm. thick, and a complete lateral half of the membranous frond, up to 8·5 cm. wide and up to about 0·5 mm. thick, which is sprinkled with cryptostomata. Hairs emerging from the cryptostomata are densely infested with colonies of *Licmophora lyngbyei* (Kütz.) Grunn. In the lower part of the specimen the midrib of the *Alaria* portion coalesces directly with the *Laminaria* portion, whereas in the upper part it is separated from the latter by a narrow membrane representing the other lateral half of the *Alaria* frond (Fig. 1). On the other hand, the *Laminaria* portion is rather narrow—up to 5 cm. wide—and its upper half is reduced to a few scattered remnants attached along the margin of the *Alaria* portion. The *Laminaria* portion is nearly as thick as a normal frond of *Laminaria* growing at the same locality (up to 3 mm. thick near the outer margin where the frond is thickest). It is worth mentioning that the transition from the thin *Alaria* portion to the thick *Laminaria* portion is so smooth that the latter shows a very gradual increase in thickness in a transverse section through the border between the membranous part belonging to *Alaria* and the coriaceous part belonging to *Laminaria*. The zoosporangial sori are borne on both surfaces in the upper part of the *Laminaria* portion near the border between the two parts, in longitudinal narrow patches, 0·1–2·0 cm. broad (Fig. 1). After a further examination of several other characters, the constituents of this chimæra are concluded to be referable respectively to *Alaria crassifolia* Kjellm. and *Laminaria angustata* Kjellm.

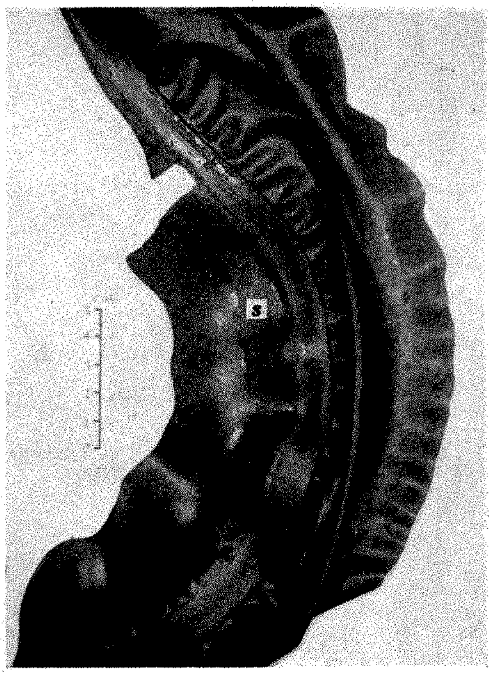

Fig. 1. Middle portion of the specimen showing a zoosporangial sorus (*S*) on the *Laminaria* portion

This sort of chimæra derived from two different genera of kelps has hitherto been unknown to science, so far as we are aware. On the other hand, two examples of malformation in *Laminaria* probably due to coalescence of fronds between two individuals of one and the same species have lately been reported from Hokkaido[1]. The origin of the chimæra reported here may be attributable to the lateral coalescence of two postembryonal plants at their damaged margins of the transition zone between the stipe and the frond, where the meristematic tissue for growth in length is situated in both the genera concerned, as in all Laminariales.

The assistance of Y. Ōiwa for photographs and preparations is gratefully acknowledged.

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Zoospore Morphology of the California Strain of *Plasmopara viticola*

ZOOSPORES were obtained from the sporangia of the California strain[1,2] of *Plasmopara viticola* (B. and C.) Berl. and De T. growing in *Vitis californica* Benth. and *V. girdiana* Munson leaves. Germination occurred in distilled water at 10°–16° C. Active suspensions of zoospores were fixed by exposure for 30 sec. to the vapour of a 2 per cent osmic acid solution. Fixation darkened the flagella and permitted them to be measured easily under the light microscope. For electron microscopy the zoospore suspension was fixed, as above, on a 'Parlodion' film covering a 200-mesh electron microscope screen and allowed to dry.

Table 1. MEASUREMENTS of *Plasmopara viticola* (CALIFORNIA STRAIN) ZOOSPORES

Zoospore body		Flagella	
Length (μ)	Width (μ)	Long (μ)	Short (μ)
10·3	8·6	20·6	12·0
12·0	10·3	17·2	*
10·3	8·6	20·6	*
13·8	8·6	20·6	10·3
12·0	10·3	15·5	8·6
12·0	10·3	20·6	12·0
Mean 11·7	9·5	19·2	10·7

* Too curled to measure

Measurements of the zoospore body and flagella are listed in Table 1. The short flagellum tended to remain coiled whereas the long flagellum remained extended (Fig. 1*a*). Electron micrographs showed cilia of about 1μ in length on the short flagellum (Fig. 1*b*), but never any on the long flagellum. In both flagella long parallel strands of more dense

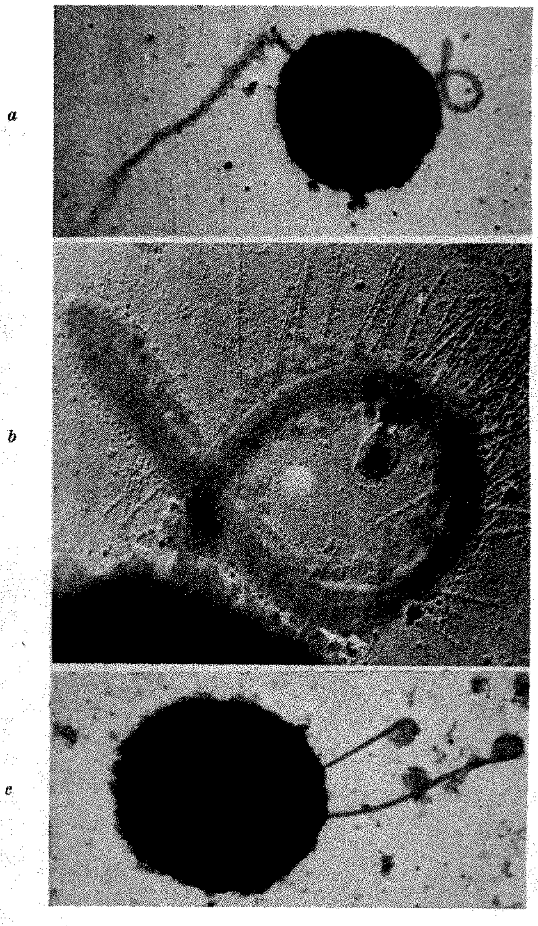

Fig. 1. Electron micrographs of *Plasmopara viticola* (California strain) zoospores and flagella. *a*, Zoospore with long and short flagella. Shadowed with uranium (× 2,030); *b*, short flagellum of *a* at higher magnification showing cilia; shadowed with uranium (× *c*. 14,060); *c*, zoospore with retracting flagella showing terminal 'knobs'; unshadowed (× *c*. 2,200)

material enclosed in a less dense matrix were present (Fig. 1*b*).

The mean dimensions of the zoospore body (Table 1) are similar to those illustrated by Arens[3] for *P. viticola* (13μ × 9·4μ). The inequality in the length of the two flagella has been noted[3,4]; but no figures have been published giving their relative dimensions. In most cases where they have been illustrated no marked difference in their lengths has been shown[4]. The one exception is Arens[3], who illustrates a long flagellum of 41μ and a short one of 26μ. The mean ratio of long to short flagellum, 1·79, is considerably greater than that for Arens's zoospore, 1·58. Lack of comparative data does not allow the attachment of any taxonomic significance to the relative length of the two flagella; however, this may be of importance.

The presence of the whiplash and tinsel-type flagella is one of the chief morphological features of the biflagellate series of the Phycomycetes[5]. The possession of these flagellar types by the California strain of *P. viticola* is the first reported for the Peronosporaceae and brings this family into conformity with the lower Peronosporales[6,7].

Zoospores with retracting flagella seen under the electron microscope (Fig. 1*c*) show that the swellings at the ends of the flagella are not the result of coiling as was reported for *Phytophthora infestans*[7]. Even though the long flagellum has retracted to half its normal length, there is no more than a portion of a loop of the dense flagellar core in the terminal swelling or 'knob'. Apparently, as the flagellum retracts the dense internal structure disintegrates and the disorganized material collects in the enlarging swelling.

I wish to thank Dr. Herbert Gold, of the Department of Plant Pathology, University of California, Berkeley, where this work was done, for help with the electron microscopy.

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Behavioural Changes in Animals after Intracisternal Injection with Adrenocorticotrophic Hormone and Melanocyte-Stimulating Hormone

A FEW pharmacodynamic effects of adrenocorticotrophic hormone do not stem from its adrenocorticotropic properties[1,2]. The crisis of muscular hypertonus (acts of stretching) observed in dogs, cats, rabbits and rats injected intracisternally with small doses of this hormone are probably another example of pharmacological effects independent of its adrenocorticotropic properties. Although the behavioural changes following the intracisternal injection of many other hormonal preparations were investigated, the modification of muscular tonus mentioned above is obtained only with small doses of adrenocorticotrophic hormone or melanocyte-stimulating hormone. The term intracisternal injection indicates the replacement of liquor drawn from the cisterna magna with saline in which the various drugs under investigation are dissolved. The volume of these injections never exceeded 2 ml. in dogs, 1 ml. in cats and rabbits and 0·1 ml. in rats. The pH of the injected solutions was made as close as possible to physiological values.

Table 1. STRETCHING CRISIS FOLLOWING INTRACISTERNAL INJECTION INTO DOGS

Substance	Source	Dose	Animals with stretching crisis/treated animals
Adrenocorticotrophic hormone	*a*	0·12 I.U./kgm.	26/26
Adrenocorticotrophic hormone	*a*	0·06 I.U./kgm.	0/2
Melanocyte-stimulating hormone	*b*	0·01 mgm./kgm.	11/11
Melanocyte-stimulating hormone	*b*	0·005 mgm./kgm.	8/9
Melanocyte-stimulating hormone	*b*	0·003 mgm./kgm.	2/10
STH	*c*	1 mgm./kgm.	0/3
Thyroid-stimulating hormone	*d*	3 I.U./kgm.	0/2
Total post-hypophysial preparation	*e*	0·25 mgm./kgm.	0/3
Oxitocin	*f*	3 I.U./kgm.	0/3
Chorionic gonadotropin	*g*	0·5 mgm./kgm.	0/2
Pregnant mare serum gonadotropin	*g*	0·5 mgm./kgm.	0/2
Insulin	*h*	1 I.U./kgm.	0/4

Sources: (*a*) Cibacthen Ciba; (*b*) beef preparation 732179 *A* Armour (5 × 10^8 U./gm.); (*c*) Armour, lot 369–766, no adrenocorticotrophic hormone activity; (*d*) Ambinon Organon; (*e*) Postipofiaan Richter; (*f*) Horm; (*g*) Vister; (*h*) Allen and Hanburys.

From Table 1 it can be seen that in the dog these two hormones were the only ones to induce the peculiar crisis of increasing muscular tonus spreading to many different muscular groups and resulting in a generalized act of stretching. In the dog the stretching crisis, illustrated in Fig. 1, appears within 1–2 hr. after the intracisternal injections as a recurrent series with intermissions of complete recovery and normal muscular tonus. 4–5 hr. after the injection not only does the crisis persist but the time between subsequent stretching acts becomes shorter and shorter so that the onset of one overlaps the end of the preceding one. This lasts for 24 hr. and more, ending with complete recovery. This phenomenon appears strictly dependent on the method of administration, for the infusion of comparatively large amounts of melanocyte-stimulating hormone (1 mgm./kgm.) into the common carotid artery is ineffective.

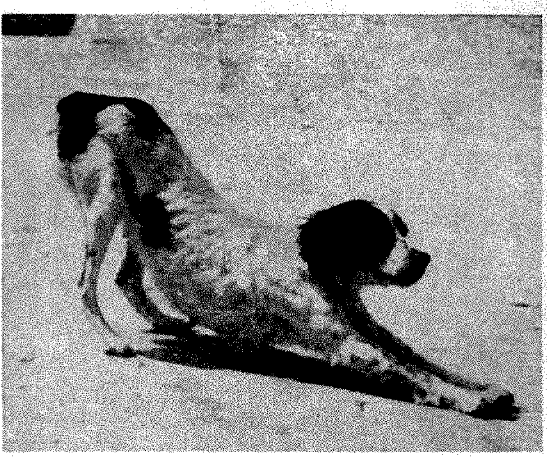

Fig. 1. Typical stretching crisis in a dog intracisternally injected with melanocyte-stimulating hormone

Stretching crises may also be seen in cats, rabbits and rats under the same conditions. However, a few characteristics may help in differentiating the symptoms caused by the two hormones in different animal species. When melanocyte-stimulating hormone is injected into the cisterna magna of rabbits a short period of convulsions precedes a state of catatonic-like stupor. Within 1 hr. the latter is interrupted by a stretching crisis often accompanied by yawning. A complete recovery occurs within 4–5 hr. Catatonic-like stupor occurs in rats, together with scratching movements of unusually long duration. In cats the stretching crisis follows a period of either drowsiness or catatonic-like stupor. Other symptoms may be associated with the intracisternal injection of these two hormones. It is important to mention that neither rectal temperature (in rabbits) nor blood-reducing substances (in dogs) vary. In dogs eosinopænia and ptyalism and in rabbits a slight arterial hypotension may occur.

The liquor drawn while the behavioural changes are in progress does not cause either the isolated guinea pig ileum or the isolated rat uterus to contract. Nevertheless the same liquor if injected intracisternally to another dog evokes the symptoms described above. In the latter case the latent period is not shortened as one would expect. The latent period lasts longer after injecting either hormone into the lumbar subaracnoidal space of dogs, but the symptoms remain unchanged.

Since in dogs adrenalectomy does not curtail the muscular hypertonus caused by intracisternally injected adrenocorticotrophic hormone, this effect cannot be due to its adrenocorticotropic activities. Moreover in dogs the intracisternal injection of a number of drugs causing eosinopænia (histamine, 0·1 ; 48/80, 1 ; serotonin creatine sulphate, 0·1 ; 1-epinephrine, 0·02 ; 1-ephedrine, 2 ; *d*-amphetamine, 1 ; mgm./kgm.) is not followed by behavioural changes similar to those described above. Finally, chlorpromazine and reserpine injected into the cisterna magna of dogs do not evoke a stretching crisis.

The possible explanations of the mechanism of this pharmacological activity of adrenocorticotrophic hormone and melanocyte-stimulating hormone lack experimental support. Nevertheless as a working hypothesis I suggest that the polypeptide chain common to both hormones is either directly or indirectly involved.

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Induction of Melanin Patterns and of Hardening as Separate Processes in the Cuticle of Albino Locusts with Internally Absorbed Phenol Substrates

THE cuticle of the albino strain of *Schistocerca gregaria* is more or less colourless because of a complete absence of melanin and apparent utilization of a phenol substrate in the hardening process which does not give rise to a coloured scleroprotein.

When protocatechuic acid was added to the hæmolymph, the extra-embryonic liquid system, or the yolk system of an albino, it was significant that it did not give rise to a coloured quinone–protein substance. On the other hand, dihydroxyphenylalanine and catechol did. These two latter phenol substances, however, failed to do so when phenylthiourea, a blocking agent of tyrosinase, was also added.

In view of a phenolase enzyme being present in the albinos, it seemed likely, therefore, that the introduction of different phenol substrates into their hæmolymph and tissues might lead to changes in the cuticle. Injection techniques, however, incur numerous disadvantages[1-4], and in this case they would be liable to invalidate at once any results that might be obtained.

An immersion technique was therefore carried out as follows. The wax layer of the epicuticle of the last few segments of the abdomen of albino nymphs was first removed by rubbing it off with cotton wool soaked in chloroform. An albino thus treated (from now on referred to as a 'dewaxed' albino) was then placed in a ring of 'Plasticine' fixed to the rim of a test tube so that the dewaxed end of its abdomen was dipped below the surface of the phenolic solution to be tested. Solutions of tyrosine, catechol, dihydroxyphenylalanine and protocatechuic acid of $N/20$ strength were used. Controls consisted of using albinos with their wax coating untouched and 'dewaxed' albinos either dipped in saline, or simply suspended in air. The test albinos were kept in position for periods ranging from 24 to 48 hr.

'Dewaxed' albinos dipped in catechol or tyrosine, as just described, developed a pattern of brown to black pigment in their cuticles. This pigment could not be removed with acid–methanol, ethyl alcohol or acid-ethanol, which showed it to be melanin[5]. Catechol, however, was responsible for a far more intense and extensive pattern than tyrosine. This pattern first developed in the dorsal region and posterior margins of the cuticular plates of the abdomen ; it then spread forward to the thorax and the head and the colour slowly intensified. Moreover, the pattern laid down resembled that of the normal strain of the same insect. The controls remained unaltered, and from this it is evident that when the 'dewaxed' albinos are suspended in a phenol solution with only the dewaxed end of the abdomen below the surface, the phenol substance passes through the dewaxed cuticle of the end of the abdomen into the hæmolymph and tissues and forward to the head region where the melanin pattern is relatively well developed.

When solutions of protocatechuic acid and dihydroxyphenylalanine were used, melanin was not deposited in the albino cuticle. In the light of other work[6], this is surprising in the case of dihydroxyphenylalanine. An examination of sections of the cuticles of albinos treated with these two substances, however, revealed that extra hardening had taken place ; the outer region of the albino cuticle, normally colourless, had been tanned to an amber colour. When catechol was used, the melanin deposits were also confined to the outer region of the cuticle. It was most significant, however, that the catechol had not caused the cuticle to turn amber colour where melanin had not been deposited. Catechol, therefore, seemed to be exclusively concerned with melanization and protocatechuic acid and dihydroxyphenylalanine with sclerotization.

The results therefore show, first, that the immersion technique described demonstrates that phenol substrates originating in the hæmolymph and tissues of an insect must reach the outer region of the cuticle before they can be oxidized in the presence of an activated phenolase. Secondly, that melanization and hardening can be induced to take place as separate processes utilizing different substrates. Thirdly, that catechol is exclusively concerned with melanization, and protocatechuic acid and dihydroxyphenylalanine with sclerotization.

We are as yet uncertain why dihydroxyphenylananine was not also utilized for the formation of melanin, as it is supposed to do[6]. However, in view of the recent finding of catechol in insects[7], it is likely, on the basis of the results reported here, that it could be a natural substrate for melanization in insect cuticles.

Work on this problem is still in progress and it is hoped to publish a fuller account in due course.

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Distant Hybrids from Parents with Reduced Immunological Reactivity

IF they hatch out at all, there is usually a high incidence of malformation in hybrids between guinea fowl hens and domestic fowl cocks[1-3]. Adult hybrids have been described only twice[4,5].

I wished to verify whether a distant cross of the above combination was favourably influenced by a decrease in the reciprocal immunological reactivity of both the parent birds. The results support this assumption, as I obtained four hybrids which have survived into maturity.

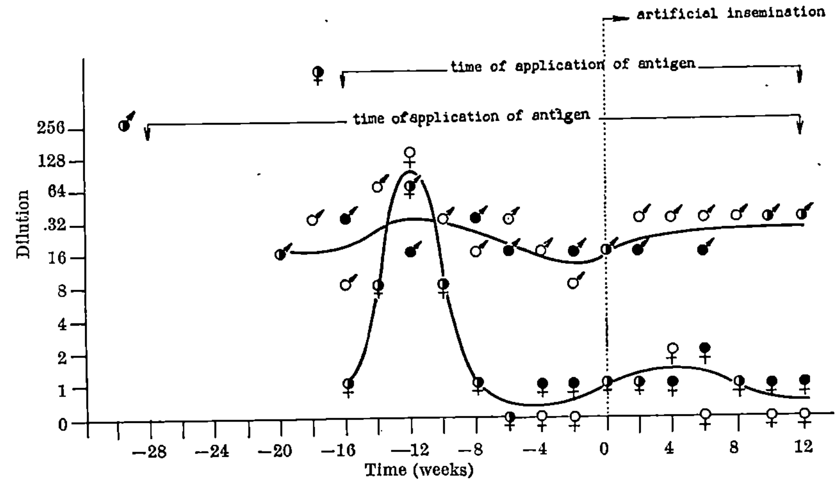

Fig. 1. Course of mean agglutinin titres in four parent birds in both experimental crossings

Procedures influencing the immunological reactivity of experimental animals (decrease of antibody production to erythrocytes of the other parent species—Fig. 1) and results of subsequent crossing using artificial insemination are compared in Table 1 with my own control results and those of other authors. The fertilization percentage in both experimental crossings far exceeds that of the control guinea fowls. Surprisingly, 4 of the 9 hybrids which hatched out have survived into maturity; they are now 14–16 months old.

In the control hens, as distinct from the experimental birds, the fertilization percentage displays a high degree of individual variability (11–74 per cent). In order to stabilize the frequency ratio n/N (n = number of fertilized eggs, N = number actually laid), the transformation of the random variate was used and Student's test was afterwards applied. Although the test cannot be regarded as absolutely conclusive in the present case, it nevertheless is almost significant at the 5 per cent level ($P < 0{\cdot}05$). It appears, therefore, that the results can be ascribed to the measures described above. In view of the high individual variability, a larger number of parent birds should be used in future work, and an attempt should be made to determine the cause of a high

Table 1. RESULTS OF DISTANT CROSSING

Crossing	Number of:				Percentage to previous columns		
	Eggs		Chicks		Fertilization	Hatching	Survival to maturity
	Laid	Fertilized	Hatched	Survived to maturity			
Control (ref. 1)	89	10	0	0	11·2	0	0
Control (ref. 2)	201	16	1	0	8	6	0
Control (ref. 3) (2 ♀, 2 ♂)	96	20	3	0	21	15	0
Control (5 ♀, 2 ♂)	83	41	1	0	49	2	0
2 ♀, long-term administration of fowl blood during maturity (1·0 ml. three times a week) 1 ♂, intra-embryonal injection of guinea fowl blood (0·2 ml. on the 11th day of incubation) + long administration of guinea fowl blood from birth	67	52	7	3	78	13	43
4 ♀, controls 2 ♂, intra-embryonal injection + long-term administration of guinea fowl blood from birth*	76	67	2	1	88	3	50

* One of these two males is the same as that in the preceding cross.

fertilization percentage in some control guinea fowl hens.

In my view, even the negative results of Ryle and Simonsen[6] do not conflict with this working hypothesis. They investigated the possibilities of distant crossing (domestic hen and turkey cock and *vice versa*), as a criterion of immunological tolerance. In most of the birds, however, they tested immunological tolerance following the intra-embryonal injection of foreign blood by the immunity response of the inoculated birds. The provocation of immunity in weakly tolerant birds may, in my opinion, have had an unfavourable effect on distant crossing.

The histological examination of the gonads of four hybrids from both experimental crossing, which died during hatching or just before or afterwards, showed that all were males. The seminiferous tubules were normally developed, but did not contain spermatogonia, so that the hybrids would evidently have been sterile.

The serological analysis showed no hybrid substance[5,7] in our hybrids apart from the common and specific antigens for both parent species.

I thank Mr. V. Matoušek, of the Institute of Hygiene and Occupational Diseases, for carrying out the statistical analysis.

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Environmental Conditioning of Flax

EXPERIMENTS carried out over a number of years have shown that remarkably large differences can be produced in the weight of flax plants as a result of the effect of the environment on previous generations of plants. In one experiment, all eight combinations of nitrogen, phosphorus and potassium fertilizer treatments were applied to forty plants of an inbred, self-fertilizing variety in the damp, dull season of 1954. The progeny, which were grown under a uniform set of fertilizer treatments, were cut at ground-level at maturity and weighed. The differences in the weights of the progeny (C_1 1955) due to the parental treatments are shown in Table 1. Some types are as much as two and three times the weights of others and, with the exception of the nitrogen plot, they are closely correlated with the weights produced by applying the fertilizers directly to the plants (Table 1, C_0 1955).

The differences were undiminished in the second generation grown in 1956 (C_2 1956), although the seed obtained from the first generation was of the highest quality in weight, appearance and germination, and the C_1/C_2 correlation was virtually complete ($r = 0{\cdot}97$). In another test on the second generation grown in 1956, 960 plants descended from plants receiving nitrogen and potassium two generations earlier weighed 0·85 cwt., and an equal number descended from plants receiving phosphorus and potassium weighed 2·63 cwt.—three times as much. The difference of 1·78 cwt. had a standard error of 4·1 lb. Again there was no difference in seed weight, germination capacity or energy, and the plants themselves within each type were highly uniform. Large differences have also been observed in the third generation and there is evidence from young plants that they occur in the fourth generation.

The experiment was repeated by applying the same set of fertilizers in the warm, sunny season of 1955, but this time the effect on the progeny grown in 1956 was much less (Table 1, C_1 1956), although the differences were still significant and, apart from the nitrogen plot which was exceptional before, substantially the same. Evidently seasonal factors are as important as nutrition. This was also demonstrated by another experiment in which plants from seed collected in 1955 were, for comparable fertilizer treatments, twice the weight of plants from seed collected in 1956, when the two sets of plants were grown together in 1957.

Table 1. WEIGHT IN LB. OF EIGHTY PLANTS. $s.D. \times t$ = LEAST SIGNIFICANT DIFFERENCE FOR $P = 0{\cdot}05$

	NPK	NP	NK	N	PK	P	K	Nil	$s.D.\times t$
C_0 1955	11·4	11·8	4·4	6·1	9·6	10·4	8·9	7·3	3·3
C_1 1955	11·1	9·5	3·7	12·1	11·3	8·4	7·8	5·9	1·2
C_2 1956	17·5	15·9	6·5	18·7	15·5	14·2	12·4	8·1	3·3
C_1 1956	11·6	9·2	8·2	7·8	10·9	9·3	8·2	8·2	2·2

The inheritance of such large differences to at least the fourth generation is likely to be due to cytoplasmic change rather than to maternal effects, and this is supported by other experiments. (i) Plants were grown from seed from capsules collected at varying stages of ripeness. Plant weight increased logarithmically with decrease in seed weight to the limit where the seed was so small that no germination occurred. (ii) Forty plants of two conditioned types which were reciprocally grafted retained their identity in both stock and scion. (iii) Reciprocal crosses between two conditioned types resembled the female parents more than the male, but there was also clear evidence of transference of effect through the pollen in both directions. (iv) The conditioned types do not produce the same relative dry weights when grown in the field in the summer as in a warm greenhouse under the lower light intensity and shorter day of winter. Presumably the types are adapted to different environments.

One of several reasonable hypotheses which can be put forward at this stage is that, with relatively high temperature and low light intensity, cell division can proceed rapidly; but the number of cytoplasmic self-duplicating particles falls, due to a shortage of photosynthetic products, the utilization of these products being also influenced by mineral supply. The altered cytoplasm stimulates the nucleus to synthesize different substances, or different amounts of the same substances, to establish a new equilibrium between nucleus and cytoplasm. The new equilibrium could be at least as stable as the old, and the new plant type to which it gives rise would have the appearance and constancy of a distinct genotype. Such a cytoplasmic – nuclear interaction may further simulate genetic change by the nuclei themselves having an effect on the difference between reciprocal crosses of environmentally conditioned types, the pollen nucleus complementing any small effect of the pollen cytoplasm. In short, plants may remain differentiated as a whole over several generations in addition to the normal differentiation of parts of plants within a generation. Temperature/light relations will probably play an important part in further investigations.

A detailed account of these studies on flax, and on other organisms, will appear in due course. This work was aided by a grant from the Agricultural Research Council.

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'Purple Pericarp' : a Monofactorial Dominant in Tetraploid Wheats

A number of varieties of tetraploid wheats originating from Abyssinia have purple- or violet-coloured grains, due to the presence of an anthocyanin in the cells of the pericarp. As part of a programme of hybridizations undertaken for the production of tester stocks carrying useful marker genes, a white-grained eligulate variety of *Triticum durum* Desf. (from Cyprus) was crossed with a purple grained variety from Abyssinia, *T. durum* var. *arraseita* Hochst. (=*T. dicoccum* var. *arraseita* Perc.). Although the F_2 family raised was only small, it is felt that the results should be put on record because they indicate that the purple pericarp colour is inherited as a simple monofactorial dominant.

The F_1 plants, when allowed to mature normally (Table 1), bore purple grains like the male parent. Of 44 F_2 plants harvested, the ears of 28 bore purple grains, 12 ears had non-coloured grains and 4 could not be classified owing to discoloration, immaturity, etc., of their grains.

Table 1

Grains	Observed (O)	Calculated (C)	Deviation ($O - C$)	$\frac{(O - C)^2}{C}$
Purple	28	30	− 2	$0{\cdot}1\dot{3}$
Non-coloured	12	10	+ 2	0·40
Total	40	40	0	$0{\cdot}5\dot{3}$

With $\chi^2 = 0{\cdot}5\dot{3}$, for 1 degree of freedom, $P = 0{\cdot}5$–$0{\cdot}3$, showing a good agreement with a 3 : 1 ratio.

The only relevant report in the literature appears to be that of Caporn[1], who studied the progeny of a cross *T. polonicum* × *T. durum* var. *arraseita* ('*T. eloboni*') made by Biffen. In this case the F_2 consisted of 28 plants with fully purple grains, 8 with the colour restricted to longitudinal streaks and 136 with non-coloured grains. In the F_3, some of the non-coloured grained plants gave streaked grained plants and non-coloured grained ones.

Although Caporn's puzzling results may perhaps be due to the introduction of additional factors affecting pericarp colour from the *T. polonicum* parent, it is felt much more likely that the streaked and impure non-coloured grained plants resulted from a shading effect of the closely investing long glumes caused by the *polonicum* gene or genes. In support of this possibility, it should be mentioned that although the ears of the F_1 plants of the present cross normally bear purple grains as noted above, it was observed that if the ears are enclosed in black paper while maturing, only non-coloured grains are produced.

Hence, in the light of the results now presented, and despite the observations of Caporn, it is suggested that the purple pericarp colour occurring in Abyssinian tetraploid wheats is inherited as a monofactorial dominant character.

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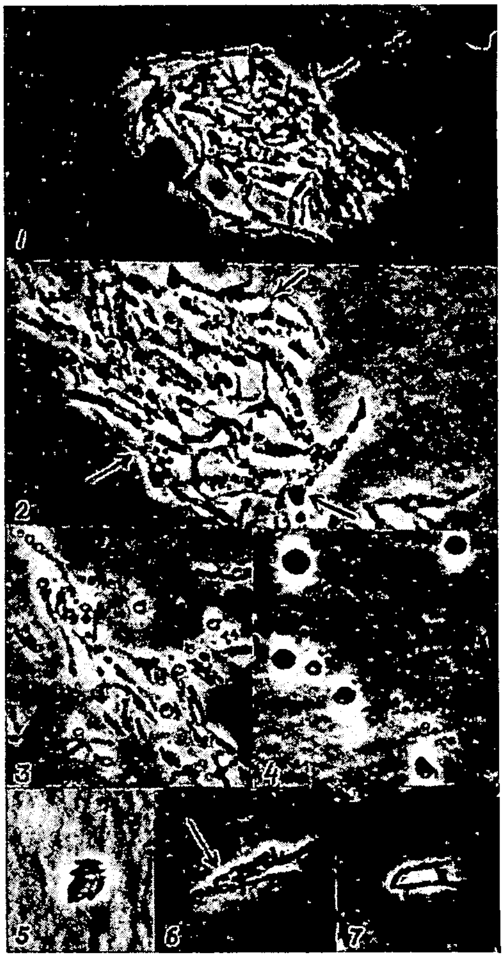
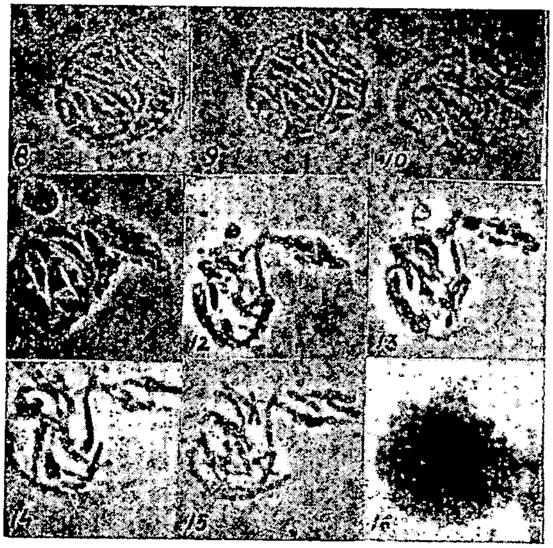
Atypical Forms of Tubercle Bacilli (Strain *B.C.G.*)

Atypical forms (granules, globules, spore-like bodies) of *M. tuberculosis* have been observed by many investigators since Koch's time[1-9]. In the present investigation the *B.C.G.* strain of *M. tuberculosis* grown on 'Tween'-agar blocks was studied by means of the light- and phase-contrast microscope.

Many of the bacilli multiplied by simple transverse fission. Some, however, branched into filaments. Granules appeared in these forms : in some instances a sufficient number of granules appeared to fill the entire rod (Fig. 1). The granules increased in size. Some which measured 0·2μ in diameter when first seen were 1–3μ or more in diameter (Fig. 2). Other



Figs. 1–7. Phase-contrast photographs. (× 1,400)



Figs. 8–15. Serial photographs of a developmental process over a period of 70 days. At the beginning, 8, 9 and 11 were taken in a bright field. 16, photograph of a hydrochloric acid/fuchsin stained smear. (× 1,400)

granules looked like empty rings and resembled spores (Fig. 3). Besides angular bodies arising from the fusion of single rods (Fig. 5), a considerable number of free globules could be observed (Fig. 4), more or less similar to large bodies or protoplasts of Enterobacteriaceae[10–11], and also protoplasts of aerobic spore-forming bacteria[12].

It was considered important that granules and globules of different sizes may arise from the conjugation of two or more individual rods (see arrows in Figs. 2, 6). Conjugation of rods without the subsequent formation of globular bodies, as previously described[9], was also observed (Fig. 7).

In some instances the 'large bodies' could be seen to break into rods (Figs. 8–15). Although this alone would point to their abundance in nuclear material, the application of different nuclear staining methods seems to confirm this point (Fig. 16).

The assumption that in the process of fusion of different rods into large bodies, genetic material might be assembled, and that their breaking up into rods would result in a redistribution of this material, makes further investigations necessary.

We are indebted to Dr. S. Vas, McGill-Montreal General Hospital Research Institute, for his valuable advice in microphotography.

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Strain Sensitivity of Albino Rats to Reserpine

During work on the effects of reserpine on chromaffin tissue, it became apparent that albino rats of Sprague–Dawley and Wistar strains differed markedly in their sensitivity to reserpine. This phenomenon has been investigated by observing the loss of catechol amines by the adrenal medulla in response to intravenous injections of 1, 5, 10 and 15 mgm./kgm. of the drug.

Male rats weighing 200–250 gm. (Wistar) or 250–300 gm. (Sprague–Dawley) were used in groups of 8 or 10. 24 hr. after an injection of reserpine the animals were killed by a blow on the head. The adrenal glands of two animals were fixed after bisection in either formol–dichromate (neutral formalin 10 per cent, potassium dichromate 3 per cent) or potassium iodate followed by 10 per cent formalin[1]. Dichromate-fixed material was embedded in paraffin wax and sectioned at 6μ. Material treated with iodate was sectioned at 35μ on the freezing microtome. Some sections were examined unstained, others were counterstained with either hæmatoxylin or sudan black. The remaining adrenal glands obtained from each group of animals were pooled and weighed: pressor amines were extracted[2], purified on alumina[3], and assayed by the method of Euler and Hamberg[4].

The results are summarized in Tables 1 and 2. A positive chromaffin reaction is given by cells which contain either adrenaline or noradrenaline while a positive iodate reaction is only given by noradrenaline-containing cells[5]. In the present work the results obtained by assay correlate well with the histochemical findings. 5 mgm./kgm. of reserpine administered to Sprague–Dawley strain animals produces the same degree of depletion of medullary catechol amines (almost complete) and the same constitutional disturbances as does 15 mgm./kgm. given to Wistar rats. Doses of 10 mgm./kgm. and more given to Sprague–Dawley animals result in convulsions and death. Constitutional disturbances include drowsiness, lachrymation and diarrhoea.

The degree of catechol amine depletion is dependent upon the dose of reserpine employed. In partially depleted glands the relative proportions of adrenaline

Table 1

Rats	Reserpine (mgm./kgm.)	Chromaffin reaction	Iodate reaction
Sprague–Dawley	0	*G*+++	*P*+++
,,	1	*G*+ or *P*+	*P*+
,,	5	– or *P*+	–
,,	10	Death	
Wistar	0	*G*+++	*P*+++
,,	1	*G*++	*P*++
,,	5	*G*+ or *P*+	–
,,	10	*G*+ or *P*+	–
,,	15	– or *P*+	–

G, Generalized reaction; *P*, patchy reaction.

Table 2

Rats	Reserpine (mgm./kgm.)	Total catechol amine		Noradrenaline (per cent)	Depletion (per cent)
		μgm per gm./adrenal	μgm. per rat		
Sprague–Dawley	0	946	42·0	18	—
,,	1	321	15·0	15	64
,,	5	35	1·5	—	96
Wistar	0	872	28·0	15	—
,,	1	411	21·5	16	23
,,	5	146	8·0	—	71
,,	15	42	1·4	—	95

and noradrenaline remain normal, noradrenaline forming about 16 per cent of the total amine, and there is no evidence of a selective loss of either amine such as occurs in association with insulin hypoglycæmia. Insufficient pressor amine was extracted from glands after injections of 5 mgm./kgm. and more to allow an estimate of the individual amines.

It should be noted that glands removed 24 hr. after an injection of reserpine show an increase in weight as compared with controls. This change is due to cortical hypertrophy and is associated with an increase in the esterase content of the inner part of the zona fasciculata and the zona reticularis. As a result of this change, the adrenals show an abnormally low content of pressor amines if these are given as per gm. of adrenal weight, and it is therefore preferable to give the catechol amine content per rat (providing rats of uniform age and weight are used), or per unit body-weight.

I would like to express my thanks to Ciba Laboratories, Ltd., for supplies of reserpine ('Serpasil').

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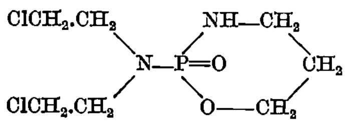
Chemotherapeutic Action of a Cyclic Nitrogen Mustard Phosphamide Ester (B 518-ASTA) in Experimental Tumours of the Rat

THE synthesis of new cytostatic drugs is governed by the attempt to find new substances which unite maximum therapeutic effectiveness with minimum toxicity. For this purpose it seems to be advantageous not to apply the substance in its active form, but by introducing suitable chemical groups to transform it into an inert transport substance which will be reconverted into the active form at the site of therapeutic action in the body. This principle has already proved of value in the treatment of prostatic carcinoma with stilbœstrol diphosphate[1].

Using the same method, Friedman and Seligman[2] combined the active *bis*-(β-chlorethyl)amino-group with phosphoric acid. The resulting compounds proved, however, to be therapeutically ineffective. In our experiments we allowed *bis*-β-chlorethyl-phosphamide-dichloride to react with alkanolamines. Thus we obtained cyclic *bis*-(β-chlorethyl)-phosphamide esters with two phosphamide bonds and one ester bond. Chemical analysis has shown that the basicity of the phosphamide nitrogen and thus also the reactivity of the chlorine atoms are considerably reduced. In comparison with *bis*-(β-chlorethyl)amine (nitrogen mustard, HN2), the rate of chlorine ion liberation in aqueous solution (at 37° C.) is considerably lowered.

The examination of the therapeutic effectiveness of numerous homologous compounds in different graft tumours of the rat has shown B 518-ASTA to be particularly effective and well tolerated. B 518 is the experimental designation of the cyclic propanol-amido-ester of *bis*-(β-chlorethyl)-phosphamide. Its trade name is 'Endoxan R', Asta-Werke A.G., Brackwede (Germany).



The minimum lethal dose of B 518 in the rat is 160 mgm./kgm., whereas for N-oxide mustard the minimum lethal dose is only 50 mgm./kgm., and for nitrogen mustard even as low as 1·5 mgm./kgm. Thus the toxicity of B 518 is remarkably low.

In therapeutic trials on fully developed tumours of the rat, for example, the solid Yoshida sarcoma (20 gm.), Walker–256-carcinoma (1 gm.) and Jensen sarcoma (5 gm.) we obtained a definite cure with a single intravenous injection of B 518. The medium effective dose (*DC*50) was found to be 3·9 mgm./kgm. for the Yoshida sarcoma, 6·0 mgm./kgm. for the Walker carcinoma and 3·6 mgm./kgm. for the Jensen sarcoma, that is, it amounts to only 2–4 per cent of the minimum lethal dose. Thus the therapeutic index of B 518 is more than twice as wide as that of N-oxide mustard and about 10 times as large as that of the ethylenimines such as TEM, TSPA and *E* 39-BAYER. In addition, B 518 proved to be the only substance which considerably inhibited the DS-carcino-sarcoma previously resistant to all other compounds[3].

In vitro tests, in which B 518 was incubated with tumour cells at 37° C., showed complete inertness of the compound up to a concentration of 10^{-3} gm./ml., the cells being then grafted on to healthy young rats and their taking capacity checked. This makes it appear probable that the cyclic propanol amide ester of *bis*-(β-chlorethyl)-phosphamide actually represents an inert transport form, from which the highly active form is liberated only within the body.

The results will be published more fully in further papers[4].

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'Compensatory Hyper-regeneration' in the Antennæ of Hemiptera

WOLSKY[1] claims that prior to his 1957 demonstration, under the above title, there was no experimental evidence to show that the antennal oligomery frequently encountered in Hemiptera Heteroptera results from the unusual course regeneration takes after larval injury. But in 1829 Heineken[2] amputated the antenna of a reduviid larva and obtained an adult exhibiting just those features which Wolsky now notes. Gäbler[3] studied antennal regeneration in three families of Heteroptera, and Balazuc[4], unaware of Gäbler's work, has given a full account of regeneration in a reduviid. In addition, the literature abounds with references to the field occurrence of both uni- and bi-lateral oligomery, more especially in Lygaeidae: in view of the work of Heineken and his successors there is no doubt that such cases are the result of larval injury. Consideration of the structure of the bug antenna, however, now suggests that analysis of the experimental results can be taken one stage further.

It has been pointed out that if amputation takes place sufficiently early in larval life then the adult antenna is shorter (and thicker) than normal because, while each 'segment' regenerates to a length greater than usual, there is always one 'segment' less than in the normal adult (except, of course, when only part of the distal 'segment' has been removed)[4]. Now consideration of the bug antenna shows it to comprise a basal scape, a pedicel (bi-annulate in Pentatomoidea) and a bi-annulate flagellum[5]. From the observations of earlier workers, including Wolsky, it is apparent that whereas a regenerated lygaeid or reduviid antenna has three 'segments', that of a pentatomoid has four: this suggests that in each case there is anarthrogenesis within the flagellum. As the articulation between flagellum and pedicel differs from other antennal articulations—the pedicel–flagellum articulation forms part of a proprioceptive organ—examination of oligomerous individuals and identification of the annuli presents no difficulties[5]: inspection of many oligomerous Lygaeidae and Pentatomoidea confirms that in every case there is but a single flagellar annulus.

It is concluded that when an antenna is amputated anywhere between the base and the intra-flagellum articulation, a bug larva will regenerate an antenna more or less shorter than normal—depending upon the time and instar at which amputation is carried out and upon its site—but always without forming an articulation within the flagellum. It follows that the factor responsible for arthrogenesis within the flagellum is dissociable from the factor controlling length of regeneration and is present only in the embryo (or is inhibited during regeneration).

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Inaccuracies of Anaphase Estimation of Radiation-induced Chromosome Exchange

Wolff and Luippold[1] have demonstrated that analysis of metaphase aberrations and of anaphase bridge frequencies gives qualitatively different radiation-dose curves, and directed attention to discrepancies between various results that some have found difficult to accommodate in classical chromosome breakage theory. There seems to me to be a factor ignored in classical theory that may explain some of these discrepancies.

In classical theory, exchanges are produced in numbers proportional to the square of the X-ray dose. Breaks are produced in numbers proportional to dose. At a given dose, D, the probability of an exchange in any one chromosome arm will be αD^2 and the probability of a chromosome break in any chromosome arm will be βD. The probability of an exchange and a break involving the same chromosome arm will be $\alpha D^2 \times 2\beta D$, the factor 2 being introduced because the exchange involves two arms. Now half these coincident breaks will be between the exchange point and one of the centromeres and may effectively prevent an anaphase bridge occurring. The expected number of anaphase bridges will be proportional to $\alpha D^2 - \alpha B D^3$. Better algebra may no doubt be devised, but the essential point will remain that the larger dose will increase the probability that an exchange may be 'undone' by the production of a suitable break.

It seems unlikely that the resulting correction will explain the discrepancy observed by Wolff and Luippold unless the effective breaks adhere in metaphase and separate in anaphase. But it would explain discrepancies between metaphase and anaphase data for chromatid exchanges, and would require some departure from the $(\text{dose})^2$ law for exchanges at high doses.

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Jan. 13.

[1] Wolff, S., and Luippold, H. E., *Nature*, **179**, 208 (1957).

Sex-linked and Sex-limited Mutation of the Fly *Muscina stabulans* (Fall.) (Muscidae)

In a series of papers, Tate[1-4] has described the inheritance and expression of a mutation, white-apricot (w), in the blowfly *Calliphora erythrocephala*. He showed that this factor is probably situated in the X-chromosome and is recessive to the dominant allele for wild-type eye colour which is located in the homologous section of the Y-chromosome in heterozygous males. No evidence was found of crossing-over between X- and Y-chromosomes in this fly. The object of the present communication is to report a similar case in the fly *Muscina stabulans*.

A few white-eyed females were noticed in a stock of *M. stabulans* which had been started with eggs of an unknown number of females from Johannesburg. The F_1 generation flies from these females were all of the wild-type, but in the F_2 generation white-eyed females again appeared. By breeding from the white-eyed females and males from the same batch, a pure line was eventually obtained in which the females are all white-eyed and the males all of the wild-type. This line has now been maintained for more than twelve generations without a single white-eyed male or red-eyed female appearing. A wild-type line was also selected for, and it has produced no white-eyed females in more than twelve generations.

When white-eyed females were crossed with wild-type males, the F_1 generation was wild-type, but the F_2 generation comprised 79 white-eyed females, 71 wild-type females and 169 wild-type males. When heterozygous wild-type males were crossed with homozygous wild-type females, the resulting F_1 and F_2 generations were both wild-type, but the F_3 generation yielded 43 white-eyed females, 239 wild-type females and 291 wild-type males. These figures support the hypothesis that, in this stock, the mutant gene (w) is situated in the X-chromosome and that there is a dominant allele (W) in the homologous section of the Y-chromosome ($\chi^2 = 1{\cdot}533$, $P > 0{\cdot}4$ and $\chi^2 = 2{\cdot}058$, $P > 0{\cdot}3$, respectively). Since the heterozygous and homozygous wild-type flies are phenotypically indistinguishable, and since there is no gradation in the expression of the mutant gene, the above explanation of the observed facts seems the most likely. The fact that no white-eyed males were found suggests that crossing-over between the centromere and (*w*) locus is at least very rare or wholly absent.

In the Calyptrata, besides the case of *Calliphora erythrocephala* reported by Tate, white-eyed mutants have been described in the blowflies *Lucilia cuprina*[5] and *Phormia regina*[6]; but in these cases the mutant genes are simple autosomal recessives to the dominant alleles determining wild-type eye colour. It would be interesting to have information on the location of eye colour genes in other members of the Calyptrata.

I am indebted to Dr. D. Nolte, of the Department of Zoology, University of the Witwatersrand, for reading this communication.

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[1] Tate, P., *Nature*, **160**, 361 (1947).
[2] Tate, P., *J. Genet.*, **48**, 176 (1947).
[3] Tate, P., *J. Genet.*, **48**, 192 (1947).
[4] Tate, P., *J. Genet.*, **48**, 338 (1948).
[5] Mackerras, M. J., *Aust. J. Exp. Biol. Med. Sci.*, **11**, 45 (1933).
[6] Dichler, H., *Amer. Nat.*, **77**, 287 (1943).

Niobium in Ascidians

IT has been known since 1911[1] that the blood of certain species of ascidians contains organically bound vanadium. Bertrand[2] has shown that most marine invertebrates contain between 0·2 and 2 parts per million of vanadium dry weight, whereas in ascidians the figure may be as high as 6,500 p.p.m. dry weight. This high level is not, however, true of all species, and in some families the level, where investigated, is not significantly above that found in other groups of marine invertebrates. *Didemnum candidum*, for example, is quoted as containing 2·6 p.p.m.

In the course of some other work I was led to the conclusion that some of these species of ascidians may possibly contain niobium in place of, or in addition to, vanadium. This has in fact proved to be correct. Preliminary analyses have kindly been made for me by the Chemical Research Laboratory of the Department of Scientific and Industrial Research, using spectrographic methods. These analyses have been supplemented by the use of chromatographic methods in the Plymouth Laboratory. By these methods the flesh of *Mytilus edulis* was shown to contain 0·22 p.p.m. of vanadium dry weight and less than 0·001 p.p.m. of niobium. *Phallusia mammillata* (a species of ascidian with known high vanadium content) had 1,260 p.p.m. of vanadium dry weight in the flesh (compared with 1,700 p.p.m. found by Webb[3]), while niobium was not detected (that is, less than 0·001 p.p.m. dry weight). In *Molgula manhattensis* both vanadium and niobium were detected. Expressed in p.p.m. dry weight, the vanadium content of the test of *Molgula* was 16, of the flesh without the test 101, and of the whole body 54 (compared with 31·8 given by Bertrand[2]); the niobium content of the test was 1·9, of the flesh without the test 56, and of the whole body 26·5. These figures were based on analyses carried out on pooled material from more than a hundred individuals. Investigations using niobium-95, however, suggested that only about one quarter of the individuals contained any niobium, the remainder lacking even the ability to ingest it. The chromatographic analysis of single individuals confirmed this: all individuals contained either vanadium or niobium, but there was no detectable niobium in animals which had significant vanadium, while only traces of vanadium could be detected in animals with detectable niobium. In the former group the vanadium content ranged from 29 to 98 p.p.m.; in the latter the vanadium content was less than 2 and the niobium content 25–75. The niobium appears to be organically bound.

If, as has been suggested, the vanadium present in petroleum deposits is derived from ascidians, it seems likely that these may also be the source of the niobium which is likewise present in these deposits.

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[2] Bertrand, D., *Bull. Soc. Chim. Biol.*, **25**, 36, 39 (1943).
[3] Webb, D. A., *Pubbl. Staz. zool. Napoli*, **28**, 273 (1956).

Rearing Newts in the Laboratory for Experimental Purposes

I HAVE always considered the methods employed in the rearing of newts in the laboratory as too time-consuming. The newts are generally maintained in finger bowls; the water is usually changed once a day, and during the summer months a cool room is required, or the water is changed several times a day.

My aquarium was designed to eliminate these difficulties. It consists of a sheet metal tank 6 in. high and divided into compartments. Small holes are cut in the partitions so that the water can flow freely. A fine mesh screen is welded on the bottom of the partition so that the newts cannot crawl from one compartment to another. One end of the aquarium rests above a sink and the water is piped in at the opposite end. An overflow pipe regulates the level of the water at 3 in., and the diameter of the overflow pipe is at least twice that of the inflow pipe. A large pipe at bottom-level is used for draining the aquarium, which need be done only two or three times a year.

A free area 1½ in. wide is provided at each end of the tank by making the partition 3 in. less than the length of the tank. This prevents the newts escaping through the overflow or inflow pipes. The tank can also be drained without removing the newts. The inflow pipe enters the tank at about 4½ in., which is 1½ in. above the water-level, making it easy to observe the amount of water flow.

The compartments are 6 in. × 8 in., and there are 15 of them in the present model. Since the water flows constantly, more newts can be placed in each compartment than in a non-flow container of equal size. The largest number that have been reared in each compartment is twelve.

Each compartment contains a liberal supply of floating water plants, such as *Elodea* (*Anacharis*), *Lemna* (duckweed), *Riccia* and several snails. Five sections of clear glass cover the aquarium so that the plants receive adequate light. Since the glass is in sections, newts can be removed with long forceps from a compartment without uncovering more than three compartments. A screen covering tends to shade the plants, preventing them from thriving.

It has not been necessary to use biological water. Newts do equally well in tap water, and I have raised them in the city water of New York City and Chicago.

Most investigators who employ newts feed each one individually by offering it meat with a pair of forceps; this occupies considerable time. I find that if small pieces of ground muscle are placed in the water once a week the newts will eat readily; only 10–15 min. a week is then required to feed a hundred or more newts.

By employing the principles of the aquarium described above, many more newts can be studied at less expense of time and money than by the methods generally used.

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Release of Phosphate from Soil Minerals by Hydrogen Sulphide

In this laboratory it was observed that some colonies of soil bacteria and fungi, grown on carrot-extract agar containing 0·1 per cent ferric phosphate in suspension, turned the particles of phosphate in their vicinity black. Blackening occurred only when hydrogen sulphide was produced by these organisms, some of which formed it anaerobically but others aerobically. Bromfield[1] showed that hydrogen sulphide was produced by several strains of *Bacillus megaterium* in apparently well-aerated soils. These results suggested that sulphides in soil may reduce ferric phosphate to black ferrous sulphide and release available phosphate.

The influence of 24-hr. treatment with hydrogen sulphide at room temperature was determined on phosphates of ferric iron (isomeric with metastrengite) of calcium (hydroxy apatite, octa phosphate and a trace of brushite) and of aluminium (amorphous by X-ray analysis), and also on ferric and calcium phytates.

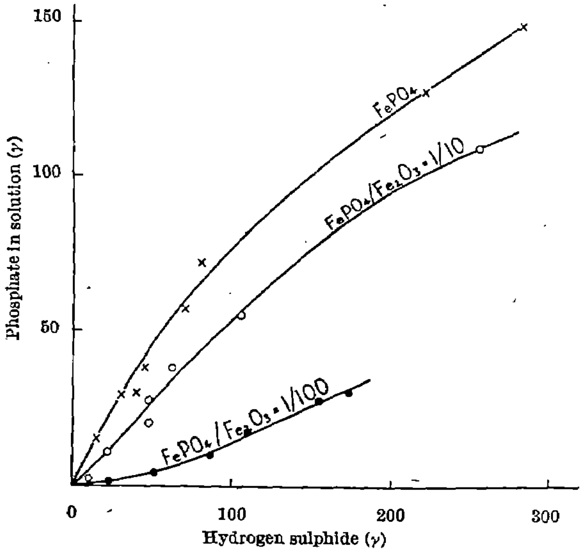

Fig. 1. Release of phosphate from ferric phosphate by hydrogen sulphide in the presence and absence of iron oxide

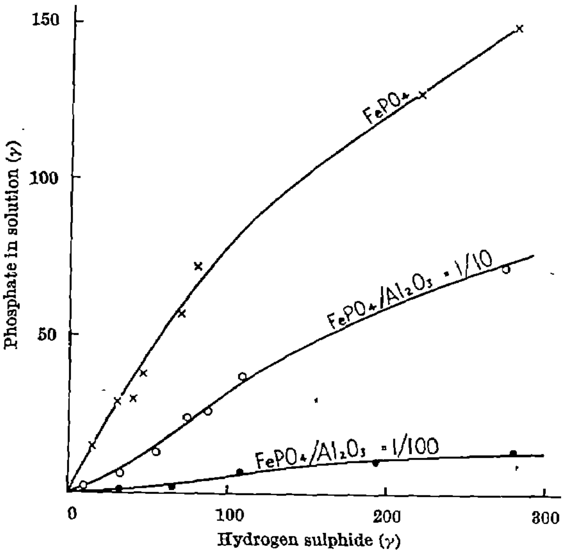

Fig. 2. Release of phosphate from ferric phosphate by hydrogen sulphide in the presence and absence of aluminium oxide

Phosphate was released from ferric phosphate by much lower concentrations of hydrogen sulphide than from tri-calcium and aluminium phosphates or from ferric and calcium phosphates. It was considered that most soils would not contain sufficient hydrogen sulphide even under anaerobic conditions to attack any phosphate other than ferric phosphate. Since most soils contain sesquioxides which might compete with ferric phosphate for any hydrogen sulphide formed, additional treatments were included to test the effect of hydrogen sulphide on ferric phosphate mixed with either iron oxide (hæmatite) or aluminium oxide (boehmite) in the ratios of 1 : 10 and 1 : 100.

Increasing amounts of sulphide increased the quantity of phosphate in solution, measured colorimetrically[2] as shown in Figs. 1 and 2.

At all sulphide-levels the amount of phosphate in solution was suppressed when sesquioxides were present, particularly by the finely crystalline aluminium oxide, but less so by the coarser iron oxide. The level of phosphate in solution reached a maximum after several hours and thereafter fell steadily, suggesting refixing of phosphate on the surface of sesquioxide particles.

Sesquioxide would greatly hinder release of phosphate, but in waterlogged siliceous soils, low in sesquioxides but high in hydrogen sulphide, release of phosphate might be of importance.

I thank Dr. R. J. Swaby for helpful suggestions during this work.

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[1] Bromfield, S. M., *J. Gen. Microbiol.*, 8, 378 (1953).

[2] Gomori, G., *J. Lab. Clin. Med.*, 27, 955 (1942).

FORTHCOMING EVENTS

Monday, March 31

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal Evening on "Future Radiocommunication Methods for Civil Aircraft". Talk by Mr. W. E. Brunt.

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. A. H. Toms: "Soil in British Railway Civil Engineering".

Society of Chemical Industry, London Section (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Prof. G. Wilkinson: "Transitional Metal–Hydrogen Complex Compounds".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. Thor Heyerdahl: "The Enigma of Easter Island".

Tuesday, April 1

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 10 a.m. and 2.45 p.m.—Dr. G. W. H. Gardner, Mr. A. D. Baxter and Mr. L. H. Bedford: "Rockets and Guided Flight" (Leonardo da Vinci Lectures).

Institute of Refrigeration (joint meeting with the Low Temperature Group of the Physical Society, at the Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1), at 5.30 p.m.—Dr. G. G. Haselden and Dr. L. Klimek: "An Experimental Study of the Use of Mixed Refrigerants for Obtaining Cooling Over a Temperature Range".

Institution of Civil Engineers (at Great George Street, London, S.W.1), at 5.30 p.m.—Sir Claude Inglis and Mr. F. J. T. Kestner: "The Long-Term Effect of Training Walls in Estuaries".

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, London, W.C.2), at 6 p.m. Discussion on "Economic Aspects of Electrical Engineering".

Tuesday, April 1—Wednesday, April 2

Institute of Biology (in the Beveridge Hall, Senate House, University of London, Malet Street, London, W.C.1), at 10 a.m. daily—Second International Symposium on "Freezing and Drying".

National Coal Board (at the Mining Research Establishment, Worton Hall, Worton Road, Isleworth, Middlesex)—Conference on "The Mechanical Properties of Non-Metallic Brittle Materials".

Wednesday, April 2

Physical Society, Colour Group (in the Physics Department, Imperial College, Imperial Institute Road, London, S.W.7), at 9.45 a.m.—Eighteenth Annual General Meeting.

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Prof. C. W. Allen: "Solar Radiation" (Symons Memorial Lecture).

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Dr. A. Klinkenberg (N.V. De Bataafsche Petroleum Mij.): "Electrostatics and Explosion Hazards in the Petroleum Industry".

Society for Analytical Chemistry (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Meeting on "Gas Chromatography".

Thursday, April 3

Institute of Metals, London Local Section (at 17 Belgrave Square, London, S.W.1), at 6.30 p.m.—Annual General Meeting, followed by Mr. W. E. Ballard: "New Protective Coatings for Metals".

Saturday, April 5

British Interplanetary Society (in the Tudor Room, Caxton Hall, Caxton Street, London, S.W.1), at 6 p.m.—Mr. F. R. F. Taylor: "Problems of Handling Large Missiles".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer (male, with sound practical and teaching experience) in Crop Husbandry—The Principal, Institute of Agriculture and Horticulture, Oaklands, St. Albans, Herts (April 4).

Assistant, Grade B (with a good honours degree and preferably teaching experience), in Chemistry, to teach general chemistry to G.C.E. Advanced Level and assist with teaching of inorganic chemistry at degree level—The Principal, Brighton Technical College, Brighton (April 5).

Lecturer in Physical Chemistry, and an Assistant Lecturer (Grade B) in Chemistry—The Registrar, College of Technology, Portsmouth (April 5).

Spectroscopist (with an honours degree and/or the A.R.I.C., and a knowledge of, and a special interest in spectroscopy) in the Public Analyst's Section of the Public Health Department—The Registrar, The University, Bristol (April 8).

Assistant Director of the Royal Botanic Gardens, Kew—Civil Service Commission, 30 Old Burlington Street, London, W.1, quoting Ref. S.4825/58 (April 10).

Lyons Fellow (graduate in medicine or science (if the latter preferably with a Ph.D. in one of the medical sciences)) for Multiple Sclerosis and Allied Nervous Diseases, to take part in a combined programme of research, under the direction of the Professor of Pathology, on the biology of myelin and the experimental pathology of the demyelinating diseases—The Registrar, The University, Leeds 2 (April 14).

Senior Lecturer in Mathematics—The Secretary, Royal College of Science and Technology, Glasgow (April 14).

University Demonstrator in Physical Chemistry—Dr. F. B. Kipping, University Chemical Laboratory, Lensfield Road, Cambridge (April 16).

Senior Lecturer (with high academic qualifications and/or professional qualifications, and some teaching experience) in Chemical Engineering at Neath Technical College—The Director of Education, County Hall, Cardiff (April 17).

Assistant Lecturer in Pharmacology—The Registrar, The University, Manchester (April 19).

Bacteriologist (with a university honours degree in science or equivalent qualifications together with some research experience and a knowledge of, and experience in, general bacteriology) in the Division of Fisheries and Oceanography, Commonwealth Scientific and Industrial Research Organization, Cronulla, near Sydney, New South Wales, Australia, to study the importance of bacteria in building up and decomposing organic matter and in metabolizing the various inorganic compounds present in the sea—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 320/137 (April 19).

Graduate (preferably with some postgraduate experience in microscopy and/or biology), for work involving applications of ultraviolet and interference microscopy, etc., in biology—The Secretary, Chester Beatty Research Institute, Fulham Road, London, S.W.3, quoting "EMFR" (April 19).

Senior Lecturer (university graduate with industrial and teaching experience, and preferably some experience in development work in a branch of electronics) in Applied Physics—The Principal, Twickenham Technical College, Egerton Road, Twickenham, Mddx (April 19).

Chair of Physics—The Registrar, University College of Wales, Aberystwyth (April 30).

Chief Laboratory Steward (preferably with university or equivalent experience) in the Department of Chemistry, University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (April 30).

Imperial Chemical Industries Research Fellows in Chemistry, Physics and allied subjects, for example, Pharmacology, Engineering or Metallurgy—The Registrar, The University, Manchester 13 (April 30).

Research Assistant or Junior Fellow in Aeronautical Engineering—The Registrar and Secretary, The University, Bristol (April 30).

Research Fellow in the Department of Nuclear Physics, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

Lecturer or Assistant (Grade B) (with teaching and research experience) in Geology (Palæontology and Stratigraphy) up to the standard of the B.Sc. (Special) degree of the University of London—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (May 3).

Assistant (with an appropriate honours degree) in Research in Agricultural Botany, for research on crop plant evolution—The Secretary, School of Agriculture, The University, Downing Street, Cambridge (May 16).

Assistant Professor (preferably with a Ph.D. in a biological subject and experience in electron microscopy) of Anatomy at Dalhousie University, Canada—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Canada, May 31).

Chair of Medicine—The Registrar, The University, Manchester 13 (May 31).

Assistant (Grade B) to teach Physics—The Principal, College of Technology, Queen Street South, Huddersfield.

Physical Chemist (with a first- or second-class honours degree in chemistry or equivalent, experience of handling radioactive isotopes, all types of counting equipment, and a knowledge of electronics) at the Chemical Research Laboratory, D.S.I.R., Teddington, to lead a small team engaged in radiometric work—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.207/8A.

Physicist or Engineer, to co-operate in the design and development of a large liquid hydrogen bubble chamber and associated plant for use in high energy nuclear physics research (Ref. No. 220(*a*)); and a Draughtsman, to work with the above (Ref. No. 220(*b*))—The Registrar, The University, Liverpool 3, stating the appropriate Ref. No.

Postdoctoral and Predoctoral Research Associates in Experimental and Theoretical Chemical Physics in the Molecular Excitation Group—Dr. R. W. Nicholls, Department of Physics, University of Western Ontario, London, Ontario, Canada.

Qualified Technician or Junior Technician (male or female) in the Pathological Laboratory—The Secretary, Wembley Hospital, Wembley, Middlesex.

Research Assistant (honours graduate in microbiology or zoology) in the Vaccine Lymph Department, for work on the development of tissue culture methods in the bulk production of virus and related viral techniques—The Secretary, The Lister Institute, Elstree, Hertfordshire.

Scientific Assistant (Abstractor) (with a degree in agriculture or natural science and a knowledge of languages)—The Director, Commonwealth Bureau of Pastures and Field Crops, Hurley, Maidenhead, Berkshire.

Scientific Assistant (with a good science degree, a reading knowledge of two European languages (preferably other than French or

German), ability to write good English and preferably a knowledge of soil science and plant physiology), for work in a scientific information service involving abstracting and indexing—The Director, Commonwealth Bureau of Soils, Rothamsted Experimental Station, Harpenden, Herts.

Scientist (preferably with a pass degree or at least H.S.C. (science) or equivalent, and an interest in a wide range of scientific subjects), to assist in the planning and operational control of overseas trials, and to collaborate with authors in the preparation and editing of reports from scientific records obtained during trials, the post involves tours of duty abroad—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1732/34.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

British Museum (Natural History). Contribution to the Ornithology of Western South Africa: Results of the British Museum (Natural History) South West Africa Expedition, 1949–50. By J. D. Macdonald. Pp. xi+174+7 plates. 35*s*. The Culicine Mosquitoes of the Indomalayan Area. Part 2: Genus *Heizmannia* Ludlow. By P. F. Mattingly. Pp. 57. 12*s*. 6*d*. Bulletin of the British Museum (Natural History). Entomology. Vol. 5, No. 9: A Study of the Chironomidae (Diptera) of Africa South of the Sahara. By Paul Freeman. Pp. 321–426+1 plate. 30*s*. Vol. 6, No. 1: New and Little-Known Species of African Trichoptera. By D. E. Kimmins. Pp. 1–37. 10*s*. Vol. 6, No. 2: New Hystrichopsyllid Siphonaptera. By F. G. A. M. Smit. Pp. 39–76. 10*s*. Vol. 6, No. 3: Neue Erotyliden aus dem Britischen Museum 21. Beitrag zur Kenntnis der erotyliden (Col.). Von Kurt Delkeskamp. Pp. 77–90. 5*s*. Vol. 6, No. 4: Lectotypes of Trichoptera from the McLachlan Collection now in the British Museum (Natural History). By D. E. Kimmins. Pp. 91–126. 9*s*. Vol. 6, No. 5: New Species of the Genus *Dicercomyzon* Demoulin (Ephemeroptera, Fam. Tricorythidae). By D. E. Kimmins. Pp. 127–136. 4*s*. Vol. 6, No. 6: Revision of the Neotropical Acanthocinini (Coleoptera: Cerambycidae). 2: The Genus *Lagocheirus*. By Lawrence S. Dillon. Pp. 137–166. 7*s*. 6*d*. Geology. Vol. 3, No. 3: The Oligocene Flora of the Bovey Tracey Lake Basin, Devonshire. By M. E. J. Chandler. Pp. 71–123+plates 11–17. 25*s*. (London: British Museum (Natural History), 1957.) [3112

Ministry of Power: Safety in Mines Research Establishment. Safety in Mines Research 1956: Thirty-fifth Annual Report. Pp. 75+4 plates. (London: H.M. Stationery Office, 1958.) 4*s*. net. [3112

General Register Office. The Registrar General's Quarterly Return for England and Wales of Births, Deaths and Marriages; Infectious Diseases; Weather; Population Estimates; quarter ended 30th September, 1957. (No. 435, 3rd Qtr. 1957.) Pp. 24. (London: H.M. Stationery Office, 1957.) 1*s*. 6*d*. net. [3112

The British Gelatine and Glue Research Association. Ninth Annual Report for the year October 1956 to September 1957. Pp. 16. (London: British Gelatine and Glue Research Association, 1957.) [3112

Grassland Research Institute. Experiments in Progress No. 9: Annual Report for 1956. Pp. viii+61. (Hurley, near Maidenhead: Grassland Research Institute, 1957.) 5*s*. [3112

Flora of Tropical East Africa. Orobanchaceae. Edited by Dr. W. B. Tyrrill and E. Milne-Redhead. Pp. 7. (London: Crown Agents for Oversea Governments and Administrations, 1957.) 1*s*. 6*d*. [3112

Dental Practitioners' Formulary 1957, for use in the National Health Service. Pp. 49. (London: British Medical Association and The Pharmaceutical Press, 1957.) 3*s*. [3112

Royal Institute of Chemistry. Lectures, Monographs and Reports, 1957, No. 3: Zone Refining. By N. L. Parr. Pp. ii+29+6 plates. (London: Royal Institute of Chemistry, 1957.) 5*s*. net. [3112

Kent Incorporated Society for Promoting Experiments in Horticulture. Abstracts and Index to the Annual Research Reports, 1913–1953, East Malling Research Station. Pp. vi+175. (East Malling: East Malling Research Station, 1957.) 20*s*. [3112

United Kingdom Atomic Energy Authority: Research Group. Report on the Conference on the Utilisation of Heat from Nuclear Reactors, held at Harwell on 18th January, 1957. Pp. 87. (A.E.R.E. CE/R 2257.) (London: H.M. Stationery Office, 1957.) 10*s*. net. [3112

Other Countries

Sveriges Geologiska Undersökning. Ser. Aa, No. 187: Beskrivning till Kartbladet, Vårvik. Av Walter Larsson och Ragnar Sandegren. Pp. 116 med en tavla. 10 kronor med karta. Ser. Aa, No. 199: Beskrivning till Kartbladet Uppsala. Av P. H. Lundegårdh och G. Lundqvist. Pp. 117+1 plate. 10 kronor med karta. (Stockholm: Kungl. Boktryckeriet P. A. Norstedt and Söner, 1956.) [3112

University of California Publications in Botany. Vol. 29, No. 2: Systematic Anatomical Studies on Myrrhidendron and Other Woody Umbellales. By Raefel Lucas Rodriguez. Pp. 145–318+plates 36–47. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1957.) 3.50 dollars. [3112

U.S. Department of Commerce: Weather Bureau. Technical Paper No. 32: Upper-Air Climatology of the United States. Part 1: Averages for Isobaric Surfaces—Height, Temperature, Humidity, and Density. By Benjamin Ratner. Pp. iv+199. (Washington, D.C.: Government Printing Office, 1957.) 1.25 dollars. [3112

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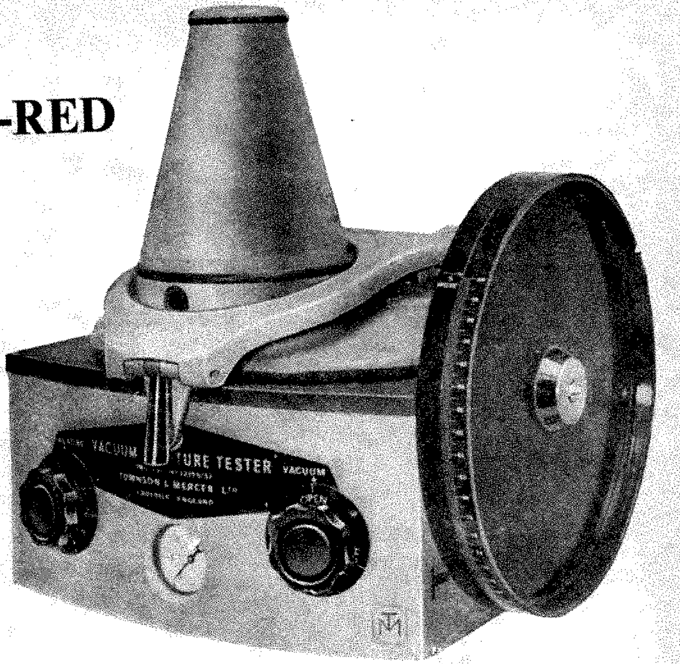

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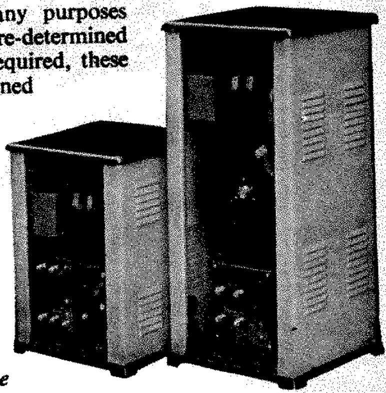

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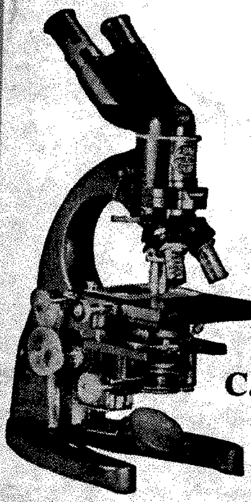

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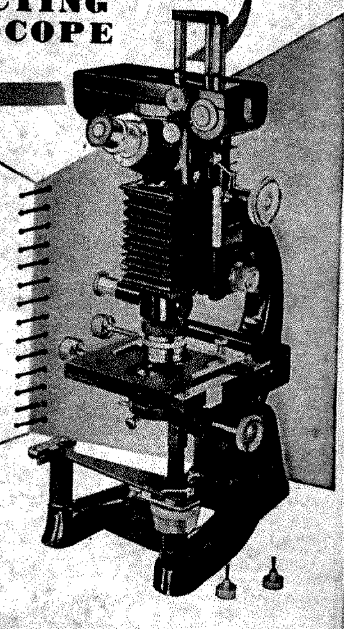

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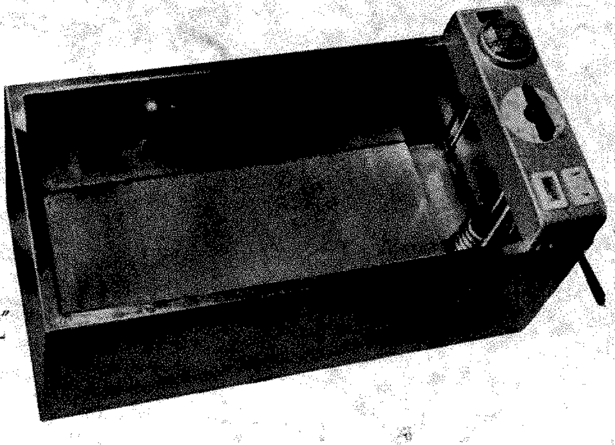

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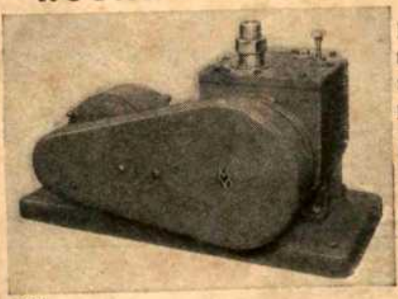

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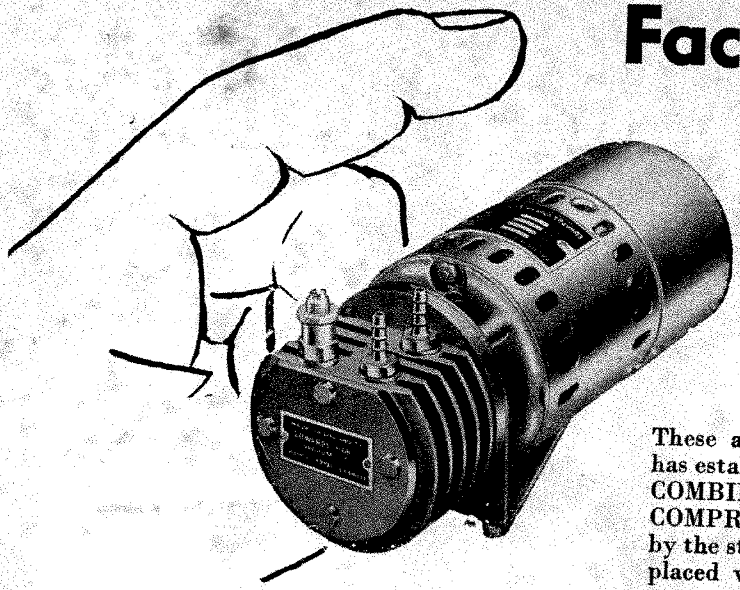

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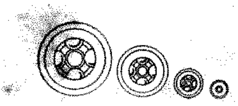

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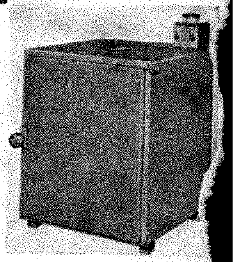

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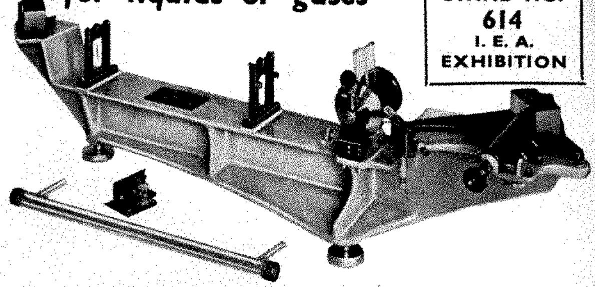

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PRESERVATION OF THE COUNTRYSIDE

A PASSAGE in the report of the Nature Conservancy for the year ended September 30, 1957, discussed the effects on the Conservancy's work of the plans announced towards the end of 1956 for the development of Milford Haven as a major port, capable of taking large oil tankers. The proposals under consideration include an oil refinery on the north side of the Haven and a depot for trans-shipping iron ore from Canada at Angle on the southern side, and there is also a plan to erect a barrage across the River Cleddau. The shores of Milford Haven at its seaward end are in the Pembrokeshire Coast National Park, and nearly three-quarters of the proposed development would be located in the Park. The Haven and the area surrounding it also contain a flora and fauna of considerable scientific interest; and the national nature reserves of Skomer, Skokholm, Grassholm and Flimston Stacks and Cliffs and the sites of special scientific interest at Crabhall Saltings, Dale Point, Sleekstone and Goulthrop Roads, Marloes Sands and Westdale Bay, and Broomhill Burrows may be affected, directly or indirectly, by the proposed developments.

The main threats are the greater disturbance and development arising from an influx of industrial population into previously remote and sparsely inhabited places, the risk of oil and other forms of pollution arising from the increased seagoing traffic and industrial development and the deterioration, or even worse, of scientific interest due to gravel winning, or the deposition of material near Dale Point and Crabhall Saltings. Other problems will inevitably arise from the increase in population and secondary industrial and commercial activities required to support the proposed development which, so far as the Conservancy's interests are concerned, come immediately from those proposed by the Esso Petroleum Co., Ltd., and the British Petroleum Co., Ltd., and by the Milford Docks Co. The companies have given firm assurances that they will do all that is reasonable and within their power to eliminate the risk of oil pollution, or minimize its effects should it occur, and the Nature Conservancy intends to press for the strict enforcement of the Oil in Navigable Waters Act, 1955, which provides the necessary statutory protection, and of the International Convention for the Prevention of Pollution of the Sea by Oil, 1954; and the Conservancy trusts that the oil companies which are authorized to develop sites in Milford Haven will, in concluding charter parties for vessels of countries which are not parties to the Convention, include a clause stipulating no discharge of oil into the sea within 500 miles of Milford Haven. The companies have also agreed to consult the Conservancy before depositing dredged material in any area likely to affect the sites of special scientific interest in the Haven.

An immediate threat has arisen in the proposal to win gravel by dredging in Dale Bay; but following consultation with the Ministry of Transport and Civil Aviation, the Haverfordwest Rural District Council and the development company, agreement has been reached on the issue to the company of a temporary lease for obtaining gravel, subject to certain conditions as to area and amount. It is hoped that fuller information will become available in the course of the development about any possible effect on the sites of special scientific interest, and that by further consultation this can be eliminated or minimized, and surveys have been undertaken to record the present coastal vegetation before any changes take place.

The eighth report of the National Parks Commission, which has since been issued (see p. 950 of this issue), also considers the proposed developments at Milford Haven at some length, though the Commission equally expresses profound misgivings as to the invasion of the Snowdonia National Park by the proposed nuclear power station at Trawsfynydd. It is indeed the scale and nature of such developments that lead the Commission to the uncompromising general conclusion to its report, namely, that such development is wholly alien to the very purpose of national parks, which is the preservation of the distinctive rural character of fine landscape for the enjoyment and recreation of both present and future generations.

The Commission holds that the siting of large-scale industry in national parks should be sanctioned only on over-riding and inescapable national necessity, and after alternative sites outside the national park areas have been zealously sought. In the absence of such proved national need, there is no justification for sacrifice of the essential character of unspoilt country, which is itself a real, if intangible, national need. A countryside once invaded by industry in this way is irretrievably altered in character, and its value for agriculture and for recreation is damaged or for ever destroyed. So important is this value of unspoilt country to a crowded and urbanized island like Britain that we must recognize before it is too late that we are trustees for future generations, and that we can only at our peril disregard that trust.

That general principle is of vital importance in considering the Milford Haven Conservancy Bill*, which was published last December, and also the Commission's approach to the main proposals affecting the Pembrokeshire Coast National Park and other particular developments. In moving the second reading of the Bill in the House of Commons on November 22, the Minister of Transport and Civil Aviation, Mr. H. Watkinson, was concerned essentially with the practical purposes of the Bill, which establishes a conservancy authority for Milford Haven to be known as the Milford Haven Conservancy Board. Reference was made to a section of the Bill which would require the Board, in considering any proposals, to have regard to the desirability of preserving natural beauty; conserving flora, fauna and geological or physiographical features of special interest; and of ensuring an easy passage at all times through the waters of the Haven for ascending salmon and sea-trout. But it was left to other speakers, notably Mr. Ness Edwards, Mr. P. Williams and Mr. D. Donnelly, to point out that the way development was handled under the Act would apply the decisive test as to whether the Government has a real concern for the national parks, and to stress the outstanding importance of the amenity issue.

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* Milford Haven Conservancy Bill. Pp. iv+38. (London: H.M. Stationery Office, 1957.) 1s. 9d. net.

Mr. A. Neave, the Joint Parliamentary Secretary to the Ministry, in replying to the debate, readily responded, pointing out that there are further safeguards in that clauses would restrain the Board from depositing dredged materials so as to prejudice establishment of the Pembrokeshire coastal path; and making the Board subject to the provisions in the Town and Country Planning Act, 1947, would provide a further safeguard for amenities. Similarly, by constituting the Board as a harbour authority under the Oil in Navigable Waters Act, the area would be safeguarded against the danger of oil pollution. Nevertheless, there is need for great vigilance. It would have been more reassuring had the Government sponsors of the Bill directed attention spontaneously to the significance of these features of the Bill. Reference might have been made to the Electricity Act, 1957, Section 37 of which empowers the Electricity Generating Board, any Area Board, the Electricity Council and the Minister to have regard to the desirability of preserving natural beauty, conserving flora, fauna and geological or physiographical features of special interest, and of protecting buildings and other objects of architectural or historical interest, and to take account of the effect of any proposals on these objects. As the Nature Conservancy points out in its annual report, such clauses have removed the danger that legal or financial action required to make desirable and fair arrangements may prove *ultra vires*. The National Parks Commission also expresses satisfaction that this and other new and more satisfactory provisions relating to the holding of public inquiries, while not resolving the problems of the ever-increasing conflict between the claims of industrial development and that less tangible national asset, an unspoilt countryside, have given statutory recognition to the importance of this aspect of planning.

Nevertheless, the National Parks Commission is seriously concerned at the effect of industrialization on the scale contemplated at Milford Haven on the national park area. Some two-thirds of a 900-acre site for the Esso Petroleum Co. jetty and oil refinery would be within the National Park. The Commission submitted at the public inquiry last July that the developers should be obliged to show beyond doubt that there is no other site available outside the National Park which would meet the material requirements.

As regards the proposals of the British Petroleum Co., while the Company has been concerned to minimize their effect on the landscape so far as it is able, the Commission is particularly concerned with the effect of the suggested form of tank. These tanks, 140 ft. in diameter and 60 ft. high, would be seen over a wide area as an incongruous element in the landscape, and although the Commission's recommendation that no tanks should be erected in a defined part of the area was not written into the proposals, the Pembrokeshire County Council, as local planning authority, was given control over the siting. Since the Bill received Royal Assent in July 1957 there have been discussions on the site on the best measures for making the tanks less obtrusive.

A third development at Milford Haven to which the National Parks Commission refers is that proposed by the Steel Company of Wales for building a jetty and establishing a stocking ground for iron ore at Chapel Bay on the south shore well within the Park. The Commission believes that this project would be totally at variance with any conception of the right use of land in a national park, and hopes that the Company will seek an alternative site elsewhere. That hope is unlikely to be fulfilled now that the Minister of Housing and Local Government has approved the oil refinery project. The other developments will almost inevitably follow, once it has been conceded that the incomparable advantages of the Haven for the very large tankers which are likely to carry much of our oil supplies in the near future constitute a national interest over-riding that of amenity even in a national park area; and it is of course such future and secondary developments, with the consequent profound changes in the whole character and appearance of the area, that are at the root of the Commission's objections.

That much conceded, whether rightly or wrongly, the utmost care should be taken to see that the destruction of amenity is kept to a minimum, and that positive action is taken to offset the inevitable loss of some natural beauty. The Milford Haven Conservancy Bill has left the House of Commons, but something could still be written into it to ensure that adequate means, such as a new town corporation, well financed and competent to handle all these developments and consequential changes, are available. It is unfair and unwise to place all the responsibility for planning and financial aspects on the local authority, even when it has proved itself as capable as the Pembrokeshire County Council of taking long views and seeking the national interest. It is already clear that the companies primarily concerned are willing and anxious to play their part, and the current annual reports of both the Nature Conservancy and the National Parks Commission testify as fully to what can be done by co-operation and with goodwill and public support as they do to Government parsimony in its refusal to provide the resources to make the National Parks Act effective. Indeed, the Dolphin Development and Management Co. has already offered to serve, without fee, as planning consultants to the Pembrokeshire County Council in collaboration with its planning officer and, through him, in liaison with the Ministry of Housing and Local Government.

This offer goes far to meet the most urgent need which follows from the Minister's approval of the project of the Esso Petroleum Co. Only something in the nature of a regional development corporation can prevent the worst effects of industrial development from repeating themselves in the area, and reconcile the conflicting demands on the use of the land which will arise from housing and social needs. Foresight as well as adequate financial resources are required, and the powers and resources of a small and sparsely populated county are hopelessly inadequate to deal with such a situation. Although it may prevent development in the wrong places, it cannot effectively induce development in the right places, even if it can tell where the right places are. Failure to place adequate resources at the disposal of the National Parks Commission has already undermined its work, and often prejudiced local authorities against it. Milford Haven provides a decisive test of the sincerity of the Government's support of the National Parks which no protestations of economy can evade; finance, in fact, is the crux of the situation.

At the public inquiry into the iron ore stocking proposal, the Pembrokeshire County Council and the National Parks Commission claimed that reasonable requirements of the Steel Company of Wales for a deep-water jetty and ore stocking ground in Milford Haven could be adequately met with less injury to the amenities of the National Park at Ferry Cwm, to the east of Bullwell. At this inquiry, however, the first under the new procedure adopted in accordance with recommendations of the Franks report, the Admiralty indicated that while it had no objections to the Chapel Bay site, it reserved the right to consider all the implications if any other site were seriously considered. The Admiralty claims were not disclosed, but the announcement may well weaken public confidence in the new system at the outset.

The position at Milford Haven, however, has implications elsewhere, and it is in the light of what has already been decided there that the proposal to place a nuclear power station at Trawsfynydd in the Snowdonia National Park should be considered. The Commission has already expressed its concern to the Minister of Power, and a public inquiry has opened since its annual report was issued. Lord Strang, in addressing the Council for the Preservation of Rural Wales, said explicitly that although there is a *prima facie* case for saying that the facilities offered by Milford Haven cannot be found in comparable degree elsewhere, it is not clear that any such argument can be advanced for the location of a nuclear energy station in the middle of the Snowdonia National Park. It does not appear, in fact, that any comprehensive survey of alternative sites has been even contemplated by the Central Electricity Authority, and although the Commission has already informed the Minister that this development appears to be incompatible with the maintenance of the area as a national park, it is already apparent that the local authorities, to which, in defiance of the National Parks Act, the Minister of Housing and Local Government has entrusted the administration of the Park, cannot be relied on to set the national before supposed local interest. The Merioneth County Council has from the start welcomed the scheme and set local employment before the national interest of amenity.

Evidence given at the inquiry on February 13 put a new and alarming face on a proposal which now looks even weaker than was supposed. Not merely is the life of the power station to be no more than twenty to forty years, but also, when the reactor reaches the limit of its effective life, it can be neither brought up to date nor demolished except at enormous expense, but must be left to cool down for perhaps half a century. The electricity plant, however, is still there and could be used or modernized, and also the network of power-lines. It would seem that the full implications of the nuclear power programme have not yet been considered.

What is to happen when the reactors are worn out? Will entirely fresh sites be sought, or will a fresh reactor be placed beside the first? It makes all the difference to the treatment of any proposal to enter an area such as a national park, if the encroachment is to be one of steady accretion. Indeed, if the life of a power station is to be only two decades or so, the argument against entering a national park area at all is almost unanswerable, while that for putting the reactor underground in any event is enormously strengthened.

What was disclosed at this inquiry has already made the very moderate and reasonable representations of the National Parks Commission quite inadequate. It is imperative, if preservation of amenity as a national interest has any meaning, that the full report of the inquiry should be published, and that the Ministers concerned, both the Minister of Power and the Minister of Housing and Local Government, should be pressed closely in Parliament to indicate clearly the views and intentions of the Central Electricity Authority in regard to the obsolescence and replacement of power stations, the implications of obsolescence and the policy they propose to adopt in regard to the protection of amenity. The cost of the whole programme for the development of nuclear energy needs to be reconsidered. If that programme is to threaten the national park areas, nature reserves and areas of exceptional natural beauty or scientific interest, it should include adequate financial provision for underground building or for the demolition of a reactor, at whatever cost, within, say, a decade of ceasing to use it. Until this is done, we are evading the real cost of nuclear power development and are betraying our trusteeship for our land and its natural beauty. The scale and pace of development have now taken us far beyond the point at which the nation can postpone paying the price demanded if anything of its natural and scenic heritage is to be preserved for this and future generations.

PASTEUR'S WORK ON FERMENTATION AND ITS SIGNIFICANCE FOR PRESENT-DAY STUDIES IN BIOCHEMISTRY

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IN 1858 Louis Pasteur turned his attention to the behaviour of yeast and made observations which were to have far-reaching consequences for the study of intermediary metabolism. Now, a hundred years later, it seems a suitable moment to attempt an assessment of the extent to which his work and his ideas are still influencing the direction of inquiries in biochemistry.

Although trained as a chemist, Pasteur laid great stress on physiological function in its relation to the chemical activity of yeast. Liebig, in 1839, had affirmed that the change of sugar to alcohol and carbon dioxide is effected by what he termed a 'ferment', a nitrogenous, unstable substance, formed in plant juices containing sugar when such liquids are exposed to air. The ferment was supposed to act by imparting its instability to the sugar. Pasteur believed alcoholic fermentation to be entirely bound up with the metabolism of the yeast cell, and his attitude in this matter was thus in striking contrast to that of contemporary workers of the Liebig school. After much controversy, Liebig's point of view became untenable when Pasteur demonstrated the ability of a strain of yeast to multiply and to set up alcoholic fermentation in a medium containing only pure sugar, ammonium tartrate and mineral salts.

Moritz Traube[1], in 1858, formulated a general theory of fermentation which he elaborated further in 1877. In his opinion, the ferments of putrefaction, fermentation and decay were substances of definite composition, allied to proteins and produced by living cells. He conceived the idea of 'reduction ferments', able to transfer the oxygen and hydrogen of water to different parts of the molecule of the fermentable substance, and so effect that apparent intramolecular oxidation and reduction first postulated by Lavoisier. Traube also pictured 'oxidation ferments' which could take up free oxygen and transfer it to oxidizable molecules, or groups of atoms, to bring about such changes as the conversion of alcohol to acetic acid or of ammonia to nitrate. He thus anticipated to a remarkable extent modern views on the enzymes effecting oxidation and reduction in vital processes.

Those reduction ferments which Traube envisaged as responsible for the evolution of free hydrogen in certain fermentations, were later to be identified with such reducing enzymes as those of the butyric acid-producing organisms, studied by Pasteur in 1861. Pasteur demonstrated their inability to grow in air and thus showed that the maintenance of life is not necessarily dependent upon the taking-up of oxygen from the external medium. These forms of life became known as 'obligate' anaerobes.

In 1872 Pasteur showed that highly aerobic organisms, such as *Penicillium glaucum*, which normally could oxidize sugar completely to carbon dioxide and water, gave rise to an alcoholic fermentation when deprived of air. Conversely, when yeast, an anaerobic organism, was grown in strongly aerated sugar media, he observed that reproduction of cells increased considerably while production of alcohol diminished. In other words, if oxidation is suppressed by lack of oxygen, fermentation is enhanced. This inter-relation became known as the 'Pasteur reaction' or the 'Pasteur effect'. Thus, Pasteur defined two kinds of life, the aerobic and the anaerobic. Later[2], in 1875, in reply to criticisms formulated by Traube, he was to make the categorical statement that: "Fermentation is the consequence of life without air, life without free oxygen. More generally, every living thing, every organ, every cell which has the power to perform chemical work without making use of free oxygen forthwith brings about phenomena of fermentation". Again[3], in the "Troisième réponse à M. Berthelot" (1879), and in other publications, Pasteur reiterated his doctrine that all fermentation phenomena are manifestations of the life of the causative organism.

What Pasteur now needed, in order fully to maintain his theory, were quantitative results to permit mathematical definition of the real relations between the presence of oxygen and the rate of fermentation, measured by weight of alcohol formed by unit weight of yeast in unit time. However, experimental techniques of that period were inadequate for this purpose and the matter was left unresolved until, some forty-five years later, Meyerhof was able to furnish the necessary figures.

In 1897, two years after the death of Pasteur, the brothers Hans and Eduard Buchner separated from yeast the cell-free preparation, zymase, which could set up alcoholic fermentation. As a consequence, the theory that fermentation was simply the manifestation of the action of an isolable enzyme held the field for some years and Pasteur's opinion received little consideration. However, after 1906, when Harden and Young had revealed the complex nature of zymase and the occurrence of phosphorylation of hexose in fermentation, the teaching of Gowland Hopkins and the work of colleagues inspired by him brought growing realization of the functional importance of the hitherto uninvestigated intracellular enzymes. As early as 1913, Hopkins[4] anticipated, with surprising accuracy, developments which were not to occur until some ten to twenty years later. In the words of Dr. Marjory Stephenson[5], he pictured the cell as: "the seat of ordered chemical events controlled in the interests of growth and function", and it is evident that in this picture the enzyme theory of fermentation is harmonized with Pasteur's[5] teaching. The details came slowly, however, for even a partial explanation of the Pasteur effect had to await the outcome of an immense amount of further original work by many gifted investigators. These researches cannot even be outlined here, but the principal findings may be stated, for now, at last, they permit understanding of some of the ways in which the Pasteur effect may be regulated.

The quantitative experimental data, which Pasteur had been unable to furnish in substantiation of his theory, came in 1925 from a series of experiments brilliantly devised and performed by Meyerhof[6]. Using the Warburg micro-respirometer, he found considerable differences in the extent to which fermentative functions of the cells of different types of yeast (wine yeast, brewers' bottom fermentation yeast, bakers' yeast and wild yeast) were diminished when aeration was increased. His results proved a striking confirmation of Pasteur's views; in particular, in the case of wild yeast (*Torula* sp.) the fermentative and oxidative powers of the cell were seen to be almost completely interchangeable; the respiratory power of these cells was so high that in presence of oxygen they were to the extent of 75 per cent an oxidizing mechanism. In anaerobic conditions they were pure fermenters.

Returning to Harden's discoveries, it could be said that these provided the basis for the highly important studies of glycolysis in animal tissues, undertaken in the first half of the present century by Embden, Meyerhof, Parnas, Warburg, Dr. and Mrs. Cori and D. M. Needham, all of whom contributed to our now extensive knowledge of the reactions proceeding anaerobically from glycogen to lactic acid in muscle. Simultaneously, further work on alcoholic fermentation by yeast and other organisms was undertaken by many distinguished workers, including Harden, Robison, Fernbach, Neuberg, Nord, Kluyver and Meyerhof. In the period 1910–13 it had been rendered probable by the work of Neubauer and of Fernbach that pyruvic acid takes a key role in fermentation. Neuberg confirmed this view and discovered in yeast the enzyme carboxylase; this decomposes pyruvic acid to carbon dioxide and the acetaldehyde which, on reduction, affords ethyl alcohol. By 1933 it had become clear that glycolysis in muscle and fermentation follow a common pathway from the stage of hexose-6-phosphate to that at which pyruvic acid is formed from glyceric acid phosphate. Muscle tissue, however, lacks carboxylase, so here the pyruvic acid does not suffer decarboxylation but is reduced to lactic acid. Experiments of Lohmann, and of Meyerhof with Lohmann and with Kiessling, showed that the intermediates are produced in phosphorylated form down to the stage of phospho-enol-pyruvic acid, and the quantitative data relating to yeast fermentation were found to fit exactly into the fermentation equation of Harden. Almost full knowledge of the enzyme systems which mediate in the twelve steps between hexose and pyruvic acid has been acquired since 1933. Most of these enzymic catalysts have been isolated and purified. All the stages from fructose-1,6-diphosphate to pyruvic acid have been found to be essentially reversible. The final stage of fermentation, namely, reduction of acetaldehyde to ethyl alcohol, catalysed by alcohol dehydrogenase, is also reversible.

Since the Pasteur effect expresses the inter-relations of the series of processes which take place during fermentation and respiration, it is now necessary to consider what evidence concerning the link or links between them has been afforded by the results of modern researches. The first suggestion that biological oxidations could be effected by coupled reactions with other enzyme systems had come in 1928 from Quastel and Wooldridge. In 1937 Szent-Györgyi[7] carried this idea a stage further by advancing the ingenious theory, backed by results derived chiefly from experiments with pigeon breast muscle, that the principal role of *l*-malate, fumarate and oxaloacetate in muscle is a catalytic one, that of carrying hydrogen between foodstuff and cytochrome. By combining Wieland's theory of hydrogen activation with Warburg's theory of activated oxygen and fitting Keilin's cytochrome into the system, Szent-Györgyi could now express the oxidation of a carbohydrate metabolite (the donator) as:

$$\underset{\text{(triose)}}{\text{Donator}} \xrightarrow{2H} \underset{\text{Activation by malic dehydrogenase}}{\text{oxaloacetate} \rightleftharpoons \text{malate}} \xrightarrow{2H}$$

$$\underset{\text{Activation by succinic dehydrogenase}}{\text{fumarate} \rightleftharpoons \text{succinate}} \xrightarrow{2H} WKS^{*}-O_2$$

* *WKS* = Warburg–Keilin system, by which hydrogen (or electrons) is donated to oxygen through the mediation of cytochrome and cytochrome oxidase.

This theory was not claimed as a complete explanation of carbohydrate oxidation in muscle, but it did constitute a notable advance in knowledge of the subject. Szent-Györgyi explained that the difference between glycolysis in muscle and oxidation lies in the fact that, anaerobically in muscle, hydrogen is transferred from triose to pyruvic acid, whereas in the presence of oxygen the hydrogen from triose is donated to oxaloacetate. Thus, to shift over from fermentation to oxidation requires nothing more than to carboxylate pyruvic acid and thus take the molecule out of the carbohydrate cycle and stabilize it as a catalyst. He suggested it was by carboxylation of pyruvic acid that Nature, in the course of phylogenetic development, changed to a process of oxidation the older and simpler process of fermentation. Szent-Györgyi[8] summed up in the statement: "According to this picture fermentation and oxidation thus represent alternate ways of metabolism. And this in part is probably the explanation of Pasteur's Effect".

While his conclusions were in course of publication there appeared the first of a most important series of papers by Krebs and colleagues in which the hypothesis of the tricarboxylic acid cycle was advanced and developed. Krebs[9] was able to show that the 4-carbon dicarboxylic acids in muscle are members of a more complicated cycle which starts from citric acid and ends in oxaloacetic acid.

After Werkman and Wood had detected the fixation of carbon dioxide by propionic acid bacteria, the synthesis of oxaloacetate from pyruvate and carbon dioxide was demonstrated by Krebs and Eggleston. This synthesis can occur in pigeon liver and in other cells from diverse sources. It is now believed that the citrate arises from union of oxaloacetate with acetyl co-enzyme A, the latter being derived from pyruvate. The Krebs cycle (tricarboxylic acid cycle) operates in living organisms of many kinds, and in animals it supplies much of the free-energy requirements of the cells.

Work by Warburg and by Keilin and Hartree twenty years ago showed that nearly the whole of the respiration of bakers' yeast is carried ultimately by cytochrome. Afterwards, claims were made that the earlier stages of respiration in yeast are those of the Krebs cycle, but there is also evidence for the view that the hexose monophosphate shunt pathway is followed.

The link between fermentation and respiration at the stage where pyruvate is carboxylated is only one of a number of inter-relations which give rise to the Pasteur effect. There is evidence that oxygen can suppress the action of several enzymes of the glycolytic pathway (for example, phosphohexokinase or triosephosphate oxidase) by oxidizing —SH groups essential for protection of these systems, and Barron[10] cites other examples of interfering influences.

Reviewing all these developments one may ask: Can this theme still inspire new pioneering inquiries? There can be no doubt about the answer when we perceive among contemporary studies Lipmann's work on energy-rich bonds and on co-enzyme A, Calvin's achievements in photosynthetic chemistry and the discoveries of Krebs and Kornberg on the role of glyoxylate in a modified tricarboxylic acid cycle, for all these researches arise from earlier work on fermentation mechanisms. Co-enzyme A comes into action, for example, in the processes by which carbohydrate is converted into fat, while the glyoxylate cycle can account for the conversion of fat to carbohydrate in, for example, *Ricinus* seedlings. Finally, it may be noted that the nucleotide co-enzymes of fermentation have lately engaged the attention of Sir Alexander Todd and co-workers, in their brilliant studies of nucleotides.

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MECHANICS OF NORMAL MUSCULAR ACTIVITY

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THE diverse aspects of the physiology of voluntary muscular activity have been recently reviewed[1]. A noticeable feature of current knowledge on muscle action is the often considerable gap that remains to be bridged between the comparatively simple properties of the artificially stimulated muscle preparation and the complex of activities which attends even the simplest muscular movement of the intact animal. Recently it has become possible to record, in greater detail than formerly, the forces and movements developed during the performance of normal, muscular tasks by the human subject. The special apparatus (force-analysis platform) used for obtaining this record has been described elsewhere[2]. In the interpretation of these records of normal muscular activity it has been found necessary to reconsider the subject of muscle mechanics, and to examine the possibility of applying the numerous results obtained with muscle preparations to an explanation of observations made on voluntary activity by the intact animal. This reconsideration has led to a conception of normal muscular activity which is, in many ways, different from that which is currently held or, at any rate, implied in modern text-books of physiology. This article is intended to indicate, as briefly as possible, the nature of this conception, the arguments on which it is based, and some of the uses to which it can be put to explain normal muscular activity. In general, what is said is concerned chiefly with the activity of skeletal 'power' musculature of the mammal.

It will be convenient to state, at the outset, the proposed hypothesis, and then to consider the arguments on which it has been based. The hypothesis states that the immediate result of the activation of a muscle via its normal nervous connexions is the production of an essentially oscillatory force. The frequency of the oscillation may vary in different muscles, but is of the order of 10 cycles per second in mammalian power muscles. The oscillatory response always has a component which does not vary, or which varies at a comparatively slow rate, in addition to the oscillatory component. The oscillatory component becomes more pronounced in stronger muscle actions. The apparent smoothness of muscle actions in the intact animal arises as a mechanical result of the application of the oscillatory force to masses—the masses being parts of the animal's body sustained against or moved in relation to external forces acting on the body parts. In the case of a man lifting or carrying a load, the mass of the load is added to that of the body parts also involved in the muscle action. The mechanical smoothing of the oscillatory driving force is never complete, so that normal muscular actions will always exhibit a small superimposed mechanical oscillation ('tremor') of the same frequency as that of the driving force. The value of this frequency is determined by an inherent property of contractile tissue (twitch-time). All the constituent fibres of a muscle are likely to participate in any sustained activity of the muscle, however slight this activity may be. Gradations of activity of the muscle are produced only partly by variations of the average rate of activation of the constituent muscle fibre. Variation of the degree of synchronization between the different muscle fibres is of comparable importance in the production of gradation of activity of the whole muscle.

It will be noted that the proposed hypothesis discards a number of views which have previously been expressed or implied with regard to the nature of muscular activity. In particular, tetanic responses of muscle are excluded as a normal feature. Tetanic responses of experimental muscle preparations have received considerable attention from muscle physiologists during the past fifty years or so, and it is still implied (for example, in text-books of physiology) that the nature of this response is of significance in the production of smooth action of muscle and in the gradation of muscular activity ('wave summation'). Lastly, the hypothesis rejects the view that muscle tremor arises as a property of sensory and neural mechanisms.

Tetanic activation of the individual muscle fibres of a muscle is precluded as a feature of normal muscular activity because direct observation of the discharge frequencies of the motor neurones which stimulate the fibres has shown that these frequencies would be inadequate to secure tetanic contraction. For tetanic contraction, artificial stimulation at frequencies greater than 50 impulses per second is required. Since Denny-Brown's[3] original observations, innumerable investigations have shown that the discharge frequency of the individual motor neurone rarely exceeds 30 impulses per second and is usually much less than this figure for normal, sub-maximal activity. For example, Bigland and Lippold[4], investigating the human gastrocnemius by electromyographic methods, observed maximum frequencies of between 25 and 35 per second during strong contractions of this muscle. These frequencies are much less than typical tetanic fusion frequencies of muscle preparations.

The basic response of the individual muscle fibre to stimulation via its normal nervous connexion is not, therefore, a tetanus but a twitch—that is, the response of the fibre to a single stimulating nervous impulse. The response is of an all-or-none character, and the force exerted (in an isometric twitch) or the shortening in length (in an isotonic twitch) follows a time-cycle which is completed, in the case of the constituent fibres of mammalian power muscles, in about 0·1 sec. (see, for example, Fulton[5]). The precise form of the force (or shortening)/time-curve during the activation-cycle of twitch has been discussed (see, for example, Sandow[6]). For purposes of computation the curve can be considered to approximate either to a harmonic or to a normal probability form. An appropriate harmonic form would be: Force (or shortening) $= A\,(1 - \cos 2\pi . t/T)$, where T is the duration of the activation cycle (about 0·1 sec.), t is any time during the activation cycle, and $2A$ is the peak force (or shortening). It will be obvious that no particular muscle fibre can complete more than $1/T$ (approximately 10) activation-cycles per second, and that for rates of activation less than 10 per second the particular fibre will exhibit discontinuous harmonic changes of force or shortening.

Completely synchronous activation of all the constituent fibres of a muscle (the number, in a human muscle, may exceed 1 million) is obviously not simply available in the intact animal. This generalization follows from two considerations: first, the conduction times between motor neurone and muscle fibre will vary; and secondly, complete synchronization of the motor neurone pool serving all the fibres of the muscle would be required. Since the motor neurone pool of a muscle may consist of several hundred motor neurones, spatially separated in the spinal cord, complete synchronization would be difficult to attain. For these reasons, the conception arises that the constituent fibres of a muscle must be activated, during voluntary contraction, in an essentially statistical manner. The muscle fibres are never, however, activated in a completely independent or random manner, because several hundred fibres (of a motor unit) are stimulated by a single motor neurone, and this will constitute a fixed synchronizing factor. Moreover, a variable physiological synchronizing factor probably exists, whereby the firing of the separate neurones of a motor neurone pool is progressively synchronized with increased afferent inflow to the spinal cord from the receptor organs of the muscle and from higher levels of the central nervous system (see, for example, Lloyd[7]).

The considerations raised in the preceding paragraphs suggest that the mechanical action exerted by a whole muscle at its origin and insertion on skeletal structures should be mathematically predictable by suitable summation of the mechanical actions exerted within the muscle by its constituent muscle fibres. Since the constituent mechanical action must vary with time, the total mechanical action must be predicted against time. The essential mathematical problem in the prediction is the summation of a large number of discontinuous harmonic changes, each of these changes being regarded as similar in all respects and the phase relations between the separate changes more or less randomly distributed. A formal mathematical treatment of this type of problem is not known to me, but a provisional solution has been attempted and has yielded the following results.

(*a*) The predicted total action of the muscle consists always of two components: a steady component which remains constant against time if the average rate of activation of the individual muscle fibre remains constant; and a continuous oscillatory component, the period of which is the activation cycle time (twitch time) of the individual muscle fibre. Thus, in mammalian power muscle, the oscillatory component will have a frequency of about 10 cycles per second.

(*b*) The magnitude of the steady component, for a muscle with a given number of constituent fibres, is directly proportional to the average rate of activation of the individual muscle fibre. The magnitude is not dependent on variation of the degree of synchronization between the fibres.

(*c*) The amplitude of the oscillatory component will be chiefly dependent on variation of the degree of synchronization between the fibres. The provisional solution suggests, for example, that the synchronization introduced by organization of a muscle into motor units of 100 muscle fibres per unit would give an amplitude 1,000 times greater than it would be if all the fibres were independent (asynchronous).

(*d*) To a lesser extent, the amplitude of the oscillatory component is also dependent on the average rate of activation of the individual muscle fibre. According to the provisional solution, the amplitude decreases with increase of rate of activation.

(*e*) It follows, from these mathematical results, that the peak force exerted by a muscle for a given average rate of muscle fibre activation would be progressively increased as the degree of synchronization between the fibres increased. The nature of gradation of muscle activity visualized by the hypothesis is summarized in Fig. 1.

The utility of these results in explaining certain aspects of normal muscular activity can be illustrated by reference to the following: (1) tremor during muscular activity; (2) muscular movement at uniform velocity; (3) the evaluation of 'static work' by muscle.

Since the original observations of Schäfer[8] there have been recurrent references to the tremor, of about 10 cycles per second, which appears to accompany muscular activity, particularly in mammals. This subject has recently been briefly reviewed[9]. Attempts have been made to account for this tremor as an oscillatory property of nerve–muscle servomechanisms. The hypothesis outlined above provides a much simpler explanation. Investigations of

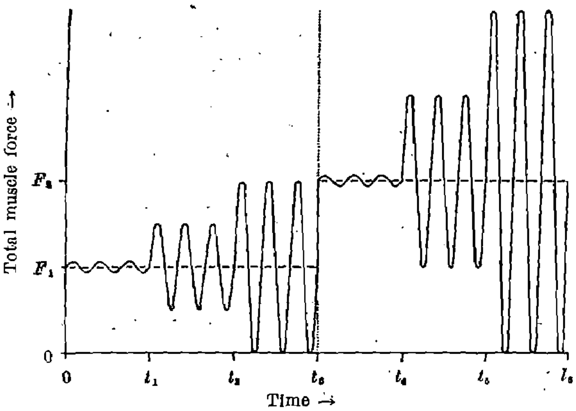

Fig. 1. Predicted effect of rate of muscle fibre activation, and of degree of synchronization between fibres, on the total muscle response due to statistical summation of responses of constituent fibres.

Two rates of muscle fibre activation, giving steady force components of F_1 and F_2, are represented. The effect on the oscillatory component and on the peak force is shown for three degrees of synchronization for each rate of activation. Time intervals t_2–t_3 and t_5–t_6 are for complete synchronization of fibres. The period of the oscillatory component remains constant throughout and equal to the twitch-time of the contractile tissue

postural tremor in man, using the force-analysis platform already referred to, indicate a progressive increase in amplitude of tremor with increased load on the musculature. This result is, of course, in agreement with the hypothesis.

The predominance of the oscillatory component in strong muscle actions, as predicted by the hypothesis, also provides a rational explanation of muscular movement at uniform velocity. It appears, from observations on man made with the force-analysis platform, that many muscular actions, such as postural readjustments and the lifting of weights, take place at almost uniform velocity. If muscle activation resulted in a steady force of the type observed in tetanized experimental preparations, accelerated movement of masses by the muscle would alone be possible. The dynamics of an oscillatory force applied to a mass shows, however, that all types of motion are possible, including uniform velocity. With the oscillatory force, a small tremor, of the same frequency as that of the applied force, is superimposed on the chief component of motion. The presence of such tremors, at frequencies of 10–12 cycles per second, has been confirmed for lifting actions carried out by man.

The oscillatory hypothesis of muscle action provides a very satisfactory conception of the nature of 'static work' by muscle. Static work is performed by a muscle when it maintains the position of a mass against an opposing external force. For example, postural muscles are required to perform static work against gravity if a certain posture is maintained and, in the case of a man holding a load against gravity, static work is performed by the muscles involved in the holding task. The evaluation of such static work in ordinary mechanical terms presents considerable difficulty if it is supposed that the task of maintaining position is performed by a steady force of the tetanic type (see, for example, Starr[10]). With a predominantly oscillatory muscle force no such difficulties arise. For example, if a mass M gm. is just sustained against gravity by an oscillatory muscle force of period T sec., then it follows from simple dynamics that the muscle performs ordinary physical work at the rate of $Mg^2T/2\pi^2$ ergs/sec. This treatment of static work may be employed to estimate the energy cost of standing upright in man, on the assumption that the whole body-mass is sustained against gravity by muscle action. If T is taken to be 0·1 sec., the estimated energy cost for a 70-kgm. man is 24 kgm.cal. per hour. This theoretical estimate is surprisingly similar to experimental values for the cost of standing obtained by indirect calorimetry, values of between 25 and 30 kgm.cal. per hour being observed by several authorities (for example, McCormick[11]).

These preliminary conceptions of the nature of normal muscular activity are being further developed, both theoretically and experimentally, and a fuller account of this work will be given elsewhere.

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THE TIDAL MODEL AT THE UNIVERSITY OF SOUTHAMPTON

By Prof. P. B. MORICE

THE tidal model of Southampton Water and the Solent at the University of Southampton was built and initially operated under a research contract from Caltex Services, Ltd., which are considering the construction of a new oil refinery off Hook in Southampton Water, just south of the mouth of the Hamble River. The refinery would be supplied from tankers lying in a specially dredged widening of the channel.

The object of the model investigation was to forecast the new tidal velocities resulting from the changed conditions due to dredging, in order to ascertain whether the bed would remain stable. This is of particular importance to the Southampton Harbour Board, since the existing channel has been made largely self-maintaining with only a relatively small amount of repeated dredging.

The position of the proposed dredged region so close to the southern end of Southampton Water precluded a model of Southampton Water only, since the tidal streams at this point are never stationary throughout the whole tidal cycle, and the flow in and out is far from rectilinear. The model was therefore limited at the next convenient boundaries—Hurst in the west and Gilkicker in the east (Fig. 1). This introduced a unique feature into

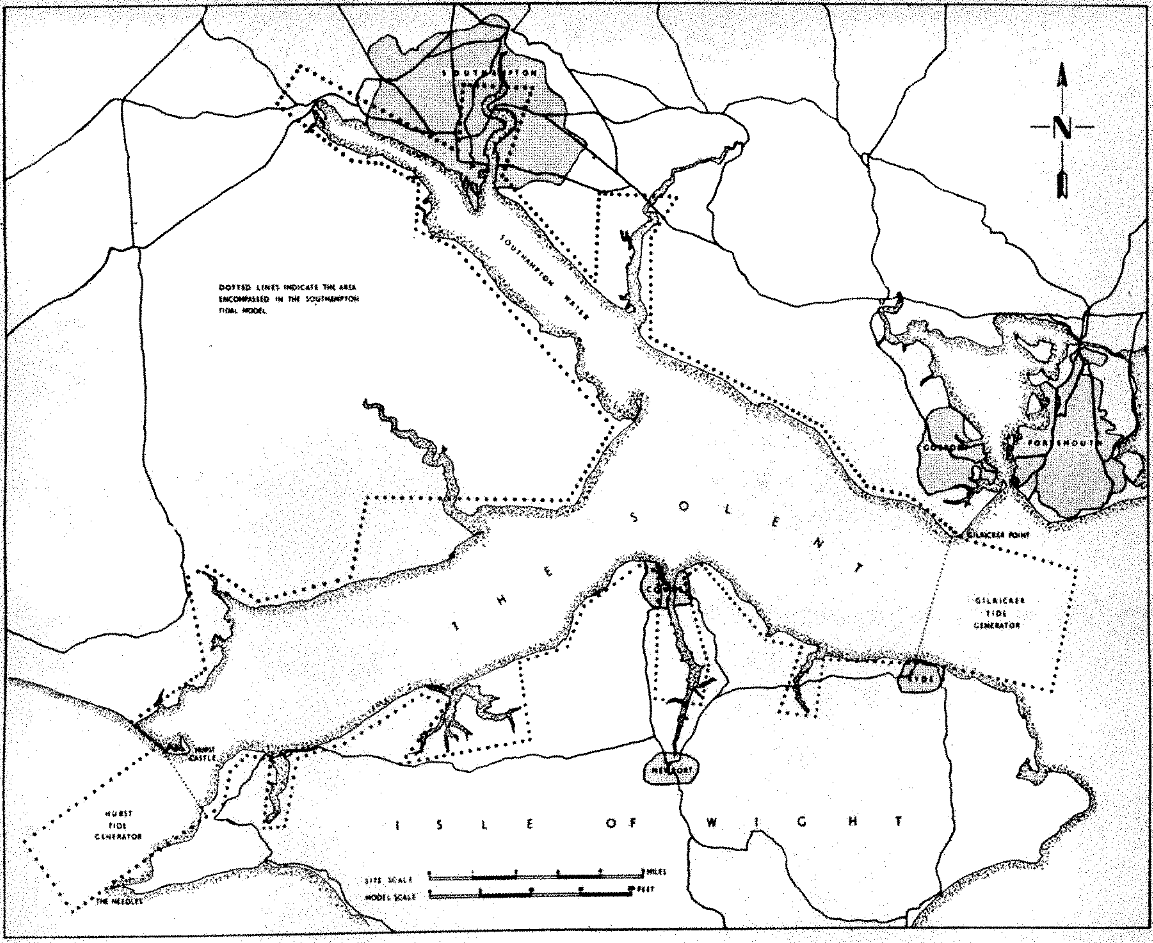

Fig. 1. Area covered by the tidal model of the University of Southampton; dotted lines indicate the boundaries of the model

the model (Fig. 2), since two tidal generators were required.

The horizontal scale of the model (1 : 1,250) was determined by the maximum dimension, that from Hurst to Gilkicker, some 20 miles in Nature, and the dimensions of the channel where the information was required. The vertical scale (1 : 100) enabled model tidal ranges of practical proportions to be used, while the exaggeration (12·5 : 1) did not cause excessive bed slopes. As a result of these choices, the velocity and times scales are fixed; namely, velocity-scale 1 : 10, time-scale 125 : 1. This latter gives a convenient tidal cycle period of 6 min. in the model

The tidal generators used in the model operate pneumatically, water being drawn into or released from tanks by changes in the tank air-pressure, which is controlled by valves allowing atmospheric leak into lines continuously extracted by high-speed pumps. The loads on these pumps are sufficiently steady to give good stability.

The tidal effects in the English Channel appear to result primarily from the excitation of a standing oscillation in the water mass extending from Land's End to Dover. The lowest frequency mode has a nodal line extending from Bournemouth to Cherbourg which, however, is distorted by the Earth's rotation to an effective nodal point inland of Bournemouth.

This system causes larger tidal ranges at the Gilkicker end of the Solent than at the Hurst end and greatly increases the range on the French coast. Superimposed upon the fundamental frequency at $12\frac{1}{2}$ hr. are many secondary effects (more than thirty components are required in a full harmonic analysis) the best known of which is the 'half-tide stand' or 'double high-water', known outside as well as inside the Solent. This gives Southampton its useful long slow flood and short fast ebb.

The main feature of the current system is a large flow back and forth in the Solent, with a relatively small quantity of water flowing in and out of Southampton Water and, so far as is known, no resultant circulation around the Isle of Wight, although this had been allowed for in the model by provision of an external connexion between the tidal generator tanks.

It is intended that the whole range from neap to spring tides should be produced by an electronic control system, but initial difficulties in the system made it necessary to obtain the information originally required by controlling the valves by motor-driven cams, prepared by a process of successive trial and error. For the present, the model operates on a maximum spring tide cycle only, which undoubtedly gives the maximum current velocities.

For the work in hand the model has been constructed with a hard bed. The bed was shaped by

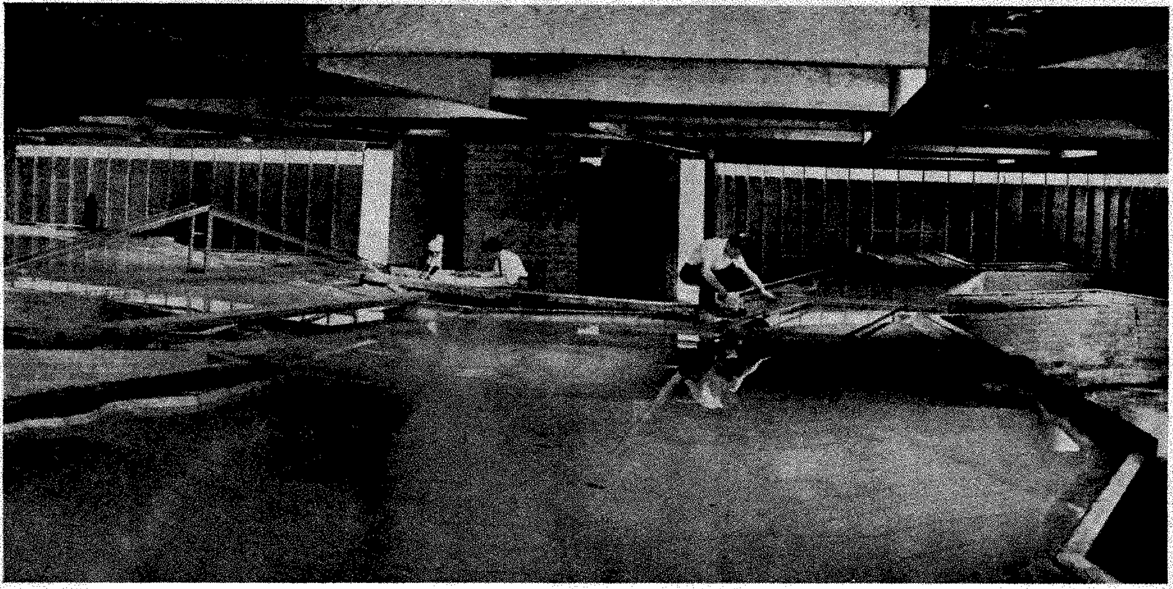

Fig. 2. View of the tidal model of the University of Southampton, looking north-west

hardboard templates made as profiles from charted information and spaced at approximately 1-ft. intervals on the model. A ½-in. mortar screed was placed between the templates and was given a brushed finish, which fortunately seems to have provided almost the correct degree of roughness to the surface. The rivers of the region are included to the extent of their tidal reaches; but it was concluded that none has a significant flow, so that this effect might conveniently be ignored, at least for the time being.

The recording equipment at present used in conjunction with the model includes capacitor-transducer level recorders and a movable integrating current-meter.

The model has already satisfied the Southampton Harbour Board that the proposed dredgings are likely to be stable; and a number of projects concerning changes to the regime have been proposed, for which the model will be used to predict full-scale effects.

The construction of the model was carried out under the direction of Dr. W. Wright (now professor of civil engineering, Trinity College, Dublin) with the assistance of Prof. A. N. Black and his colleagues and Commander D. H. Macmillan, of the Southampton Harbour Board.

NEWS and VIEWS

Pembroke College, Cambridge: Prof. W. V. D. Hodge, F.R.S.

Prof. W. V. D. Hodge, who has been pre-elected master of Pembroke College, Cambridge, will take up his duties there in August. Prof. Hodge, who has held the Lowndean chair of astronomy and geometry in the University of Cambridge since 1936, has achieved an international reputation as a geometer, mainly through his creation and development of the theory of harmonic integrals. The importance of his pioneer work in this field was recognized by the award to him, last year, of a Royal Medal by the Royal Society. He is also the joint author of the important three-volume work, "Methods of Algebraic Geometry", a careful exposition of modern algebraic investigations into the foundations of this subject. In addition to leading a vigorous school of research, he has taken an active part in University administration, having served on the Council of the Senate and on the General Board of the Faculties. Last November he succeeded Sir David Brunt as physical secretary of the Royal Society.

Engineering Structures at the Imperial College: Prof. S. R. Sparkes

Dr. Stanley Robert Sparkes, who has recently been appointed to the new chair of engineering structures in the Department of Civil Engineering in the Imperial College of Science and Technology, London, graduated in the University of Bristol in 1932; he was awarded an industrial bursary by the Royal Commissioners for the Exhibition of 1851 and gained practical experience in the design of steel structures with Messrs. Dorman, Long and Co., Ltd. In 1935 he joined the staff of the Department of Civil Engineering at the Imperial College and has been attached to it ever since. At the outbreak of the Second World War he was seconded to the Ministry of Supply for duty in connexion with air-raid precautions in building structures, and in 1942 he spent some months in India as structural precautions adviser to the Government of India. In 1944 he returned to the Imperial College, where he was appointed reader in civil engineering in 1947.

With the post-war expansion of the Imperial College and its consequent need for a considerable building programme, the then rector, the late Sir Roderic Hill, found it necessary to appoint a full-time planning officer and Dr. Sparkes was seconded from his Department to that post in 1953. In 1955 the importance of this work was recognized by making him director of building works. In that position, Dr. Sparkes has carried considerable responsibility for the new buildings already completed—the Roderic Hill Memorial Building to house the Departments of Aeronautics and Chemical Engineering, large extensions to the City and Guilds College and the Royal School of Mines, and additions to the Students' Union—as well as for much bigger work now under construction or on the drawing-board. Dr. Sparkes's research work has been in the experimental study of problems relating to building and ship structures and in the correlation of stresses as calculated in the design office with those found by measurement on actual buildings. With the large constructional programme now in progress in connexion with the expansion of the College, Prof. Sparkes will have unrivalled opportunities for continuing this work which is so necessary for a real knowledge of the behaviour of engineering structures.

Corday-Morgan Medal and Prize

THE Corday-Morgan Medal and Prize of the Chemical Society for 1956 have been awarded to Dr. K. W. Bagnall (Atomic Energy Research Establishment, Harwell) in consideration of his contributions to the knowledge of the chemistry of polonium. This award, consisting of a silver medal and a monetary prize of 200 guineas, is made annually to the chemist of either sex and of British nationality who, in the judgment of the Council of the Chemical Society, has published during the year in question the most meritorious contribution to experimental chemistry, and who has not, at the date of publication, attained the age of thirty-six years. Copies of the rules governing the award can be obtained from the General Secretary of the Society at Burlington House, London, W.1. Applications or recommendations in respect of the award for the year 1957 must be received not later than December 31, 1958, and applications for the award for 1958 are due before the end of 1959.

The Comptrollership of the Patent Office

QUESTIONED in the House of Commons on March 18 by Mr. F. T. Willey regarding the professional qualifications held by the newly appointed Comptroller-General of the Patent Office, the President of the Board of Trade, Sir David Eccles, said that the officer appointed has a first-class record as an administrator, and that he considered that to be the qualification most urgently required at the present time. When Mr. Willey asked Sir David if he realized that Britain is now the only major country in the world without a man of high professional reputation at the head of its Patent Office, thus reversing a policy thirty years old, Sir David replied that he considered the office required men of administrative ability at the top, but that he has requested the new comptroller to give scientists on the staff better administrative opportunities, with the view of reverting next time to the old method of selection. In a written reply to Mr. P. G. Williams on the same day regarding the reasons for the appointment, Sir David said that the functions of the Patent Office extend beyond the administration of the Patents Acts to questions relating to trade marks, designs and copyright, as well as to other matters such as international negotiations and agreements about industrial property. About two-thirds of the staff of 1,200 of the Patent Office, costing about £1 million a year, is non-professional, and the size of the Office and the complexity of management problems due to pressure of work and shortage of scientific staff have made the appointment of a comptroller-general of particular importance at this time. After weighing carefully the many considerations, Sir David said he decided that the primary need is for a comptroller-general with qualities of leadership and wide administrative and managerial experience. The appointment would be without prejudice to the selection of future comptrollers-general from within the Office.

The Patent Office appointment was discussed in an editorial article in *Nature* of March 15, p. 725.

Exchange Visits with the Soviet Union

MR. IAN HARVEY, Under-Secretary of State for Foreign Affairs, replying to a question in the House of Commons on January 27, said that there is a growing exchange of visits by students and teachers between Great Britain and the U.S.S.R., many of the visits being organized on the initiative and with the support of the Soviet Relations Committee of the British Council. In particular, the Committee, in partnership with British youth organizations, has invited 300 Russian students and young people to visit Britain for short periods. The Committee has also offered an annual exchange of twenty students of the Russian and English languages as well as two British Council scholarships for a full academic year and short courses for teachers, both on a reciprocal basis. Mr. Harvey also referred to the assistance given in these exchanges by universities and training colleges, and agreed that expansion of these facilities might contribute to mutual understanding between the two countries in a manner acceptable to both Governments. On March 17, Mr. Harvey said that the Committee still awaits a definite answer from the Soviet Union, although some progress has been made with the arrangements for the visit of 300 Soviet students and young people and two groups have already visited Britain. Any delay with the other proposals is entirely due to the Soviet side.

New Reactor at Harwell

HAZEL, a new zero-energy reactor, is now operating at the Atomic Energy Research Establishment at Harwell. HAZEL (homogeneous assembly—zero energy) uses enriched uranium fuel in the form of a salt of uranium (uranyl fluoride) which is dissolved in the heavy water used as a moderator. The core of the reactor is a stainless steel cylinder (7 ft. high × 2 ft. in diameter) surrounded by a graphite reflector. The fuel solution is pumped into the cylinder from two nearby storage vessels. The system is controlled by adjusting the level of the fuel solution in the reactor vessel and by moving a vertical neutron-absorbing cadmium plate into the gap between the steel cylinder and the graphite reflector. Two cadmium plates similar to the control device are used as 'shut-off' rods: two additional 'shut-off' rods can be dropped vertically into the fuel solution in the reactor vessel. The reactor will be operated at a power of less than a watt and cooling is not necessary. HAZEL will be used to obtain basic nuclear information. An earlier system at Harwell, ZETR (zero energy thermal reactor), was used to study solutions of nuclear fuel in ordinary water.

Atomic Energy

A NUMBER of questions on the peaceful uses of nuclear energy were asked by Mr. R. Mason in an adjournment debate in the House of Commons on March 20. Replying for the Government, Sir Ian Horobin, Parliamentary Secretary to the Minister of Power, said that from his inquiries at Harwell the question of the drift of leading scientists to the United States does not appear to be a very urgent problem at present. The storage and disposal of nuclear waste is a great trouble but not so far a major difficulty, and the present system of allowing the early decay to proceed and concentrate has not faced the Authority with any insuperable difficulties. The direct conversion to electricity from ZETA is a long way ahead and not at the moment a practical consideration. We now know a great deal more about the Wigner release, so that categorical assurance could be given that such an accident as that at Windscale could not recur. Moreover, the tendency is towards the use of higher temperatures and consequently, with graphite-moderated reactors, greater annealing of the moderator. The prospects of finding uranium in the United Kingdom are extremely slight. As regards secrecy restrictions, there is every evidence that Britain has been free from considerable difficulties which have arisen elsewhere, and he thought our approach has been sensible and moderate and also that we have found happier and more practical arrangements for partnership between the Authority and industry than some other countries. Considerable progress is being made in connexion with conventional stations, and it is thought that the economic difficulties of air-cooling might be sufficiently offset by savings in fuel transport when the stations are located nearer to coal. For nuclear power stations, the enormous usage of water renders the chance of economic advantage very slight. Sir Ian firmly defended the declassification and publication arrangements made in regard to ZETA and claimed that the matter had been handled well by the Authority, which was entitled to the confidence of the House and of the nation.

Human Sciences in Industry

ANOTHER stage in the development of psychology, sociology and related sciences in application to management, design and other industrial problems is marked by the decision of the Council for Scientific and Industrial Research to continue promoting research into the human problems of industry. In a written answer to a question in the House of Commons on January 21, Mr. H. Nicholls, the Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, announced that the Council has set up a Committee on Human Sciences in Industry which will keep under review the development of the human sciences in relation to industrial needs, and will advise on the allocation of grants and on other means of promoting research in this field. On the side of the Department this Committee replaces the two former committees, on Human Relations in Industry and on Individual Efficiency in Industry, set up jointly with the Medical Research Council in 1953, agreement having been reached to replace them by separate committees reflecting the different interests of the two bodies.

A substantial flow of results is now coming from the research projects sponsored by those committees, on subjects ranging from psychological information theory applied to machine design to sociological aspects of technical change in the steel and other industries; the new Committee is expected to promote further applied research as well as more basic research in this field. Research and industrial interests are represented on the Committee, which has as chairman Mr. Lewis Wright (Amalgamated Weavers' Association), who is a member of the Council for Scientific and Industrial Research. The other members are Mr. P. W. S. Andrews (Nuffield College, Oxford); Mr. H. Briggs (Unilever, Ltd.); Prof. J. Drever (Edinburgh); Mr. E. Fletcher (Trades Union Congress); Prof. M. Gluckman (Manchester); Mr. H. G. Jones (Industrial Group, U.K. Atomic Energy Authority); Mr. H. G. Nelson (English Electric Company); Prof. E. A. G. Robinson (Cambridge); Miss B. N. Seear (London School of Economics); and Dr. A. T. M. Wilson (Tavistock Institute of Human Relations). The secretary is Mr. R. G. Stansfield.

Supply of Teachers in Schools and Technical Colleges

REPLYING for the Government in an adjournment debate on science teachers and National Service on March 17, Mr. R. Carr, Parliamentary Secretary to the Ministry of Labour and National Service, agreed most strongly with what Mr. W. Stones, Mr. E. Short and Dr. H. King had urged as to the importance of a sufficient number of adequately staffed technical colleges. Nevertheless he explained that, whereas technical colleges already have substantial help in their staffing problems from the existing arrangements for deferment, the even more favoured treatment of the secondary schools is a matter of deliberate policy, largely because of their greater need. In 1957 there were about 12,250 graduate teachers of mathematics and science in the schools and at least 300 unfilled vacancies. Between 1957 and 1964 the number of children more than fifteen years of age in the schools is expected to rise from about 250,000 to nearly 500,000, and even if the present net annual increase of 500 in science and mathematics teachers is maintained, sixth-form classes in those subjects are likely to be overcrowded. This is the first reason why the Government is concerned to do nothing that might interrupt the flow of such teachers into secondary schools. The second reason is that it is considered desirable that teachers in a technical college should have had some industrial experience, and that accordingly any concession to benefit technical colleges should also be given to jobs requiring similar qualifications in industry. This was recognized by the Willis Jackson Committee; the Government has moved a considerable way towards the more general and broader extension of deferment recommended by that Committee, but believes it is important to maintain a preference in favour of the schools. A third reason lies in the needs of the Services, which rely upon National Service to supply skilled scientific man-power until scientists can be recruited on a long-term basis. As regards the current position in the technical colleges, there was a net increase in full-time teachers of about 900 in 1956; for 1957 this was expected to be more than 1,000; and for 1958, about 1,400.

Technical Teacher Training

FOR the past ten years or so the technical teacher training colleges in Bolton, Huddersfield and London have had only some 350 places available in all. This number is now being increased by more than 60 per cent, and substantially higher grants are to be paid to students, in order to attract the right quality and quantity of candidates from those already settled in industry and commerce. Candidates are accepted as either 'private' or 'recognized' students for a course of one academic year. The latter pay no tuition fees, are offered free board and lodging in the college hostels and are eligible for maintenance allowances. To be accepted a candidate should normally have reached his twenty-fifth birthday, should possess a degree, Higher National Certificate or equivalent qualification and should have some commercial or industrial experience. Further information can be obtained from the Director, Huddersfield Training College, Queen Street South, Huddersfield.

Royal Society Expedition to Southern Chile

The Royal Society has announced that plans are being made, in co-operation with the Royal Society of New Zealand, to send a small expedition to southern Chile in September. Dr. Martin Holdgate, Zoology Department, University of Durham, has been appointed organizer, and Mr. G. A. Knox, Canterbury University College, New Zealand, and Dr. E. J. Godley, director of the Botany Division of the New Zealand Department of Scientific and Industrial Research, will also take part. The University of Chile has expressed its interest and also hopes to send representatives. It is intended that this expedition should be exploratory and preliminary to a proposed Commonwealth expedition to the South Pacific area.

Many genera and species of animals and plants occur both in South America and in New Zealand and Tasmania. The precise extent of this relationship remains uncertain, however, although its elucidation is clearly important for an understanding of biological evolution and of the past history of the Earth's surface. The fauna and flora of the world are now changing so rapidly through man's activity that it is likely that within another generation precise information about the natural distribution of animals and plants will be unobtainable, so that further research is needed urgently. A great deal of work has been done on the biology of New Zealand and its neighbouring islands, but by comparison southern Chile has been little studied. The present expedition's first visit will therefore be to the western hills of the island of Chiloe, where there are extensive tracts of dense evergreen rain-forest, and it will then proceed southward towards the Straits of Magellan. Ecological and geological studies will be made in the three areas it is proposed to visit, and peat samples will be collected from mountain bogs and lowland lakes in connexion with pollen analyses, from which it is hoped to learn something about past climatic and vegetational changes in the region.

Bardsey Observatory

The report of Bardsey Bird and Field Observatory for 1956 (Eglwysfach, near Machynlleth, Mont.: W. M. Condry, Hon. Secretary, 1957) contains details of many successful observations and developments. In a year of unusually heavy migration twice as many birds were ringed as in any previous season; more than a thousand birds were ringed at the lighthouse at night. Among the more unusual birds recorded were the melodious warbler, *Hippolais polyglotta*, and the greenish warbler, *Phylloscopus trochiloides*. During the year a visit was paid by botanists from the University College of North Wales, who surveyed the island's flora and prepared a species list, which is included in the report. The Observatory is open to visitors, particularly during the months of May, June and July. Further information can be obtained from W. M. Condry, Eglwysfach, Near Machynlleth, Montgomeryshire.

University News: London

The following appointments have been made: Dr. C. P. Whittingham, assistant director of research in botany in the University of Cambridge, to the University chair of botany tenable at Queen Mary College; and Dr. A. R. Flint, consulting civil engineer, to the University readership in structural steelwork tenable at the Imperial College of Science and Technology.

Announcements

Dr. G. A. H. Elton, at present reader in applied physical chemistry at Battersea College of Technology, has been appointed director of research of the British Baking Industries Research Association, Chorleywood. Dr. Elton's research has been mainly in the field of colloid chemistry. He was awarded the degrees of Ph.D. and D.Sc. of the University of London for work on this subject and for a number of papers which he has published in the field of rheology.

The Sixth Conference of the British Agricultural History Society will be held on April 10 and 11 at the Yorkshire (W.R.) Institute of Agriculture, Askham Bryan, York. Further information can be obtained from the Secretary of the Society at the Department of Agriculture, Parks Road, Oxford.

The Scottish Group of the Nutrition Society is holding a symposium on "Nutrition and Climatic Stress" at the Hannah Dairy Research Institute, Kirkhill, Ayr, on April 26, when papers will be read on both human and animal nutrition. Further particulars may be obtained from Dr. J. Davidson, The Rowett Research Institute, Bucksburn, Aberdeenshire.

The Scottish Branch of the Science Masters' Association is to hold its annual general meeting during April 10–12, in the University Chemistry Department, King's College, Aberdeen. The programme includes lectures, exhibitions and visits to places of scientific interest. Further information can be obtained from D. W. Menzies, Aberdeen Academy.

The Ergonomics Research Society is holding a conference on "Problems of Training" at the University of Bristol during April 13–16. Further information can be obtained from Dr. O. G. Edholm, Department of Human Physiology, M.R.C. Laboratories, Holly Hill, Hampstead, London, N.W.3.

The Operational Research Society is to hold an open conference at the Old Swan Hotel, Harrogate, during May 21–22. The conference will afford to representatives of commerce and industry an opportunity to discuss current applications of operational research. The main theme of the conference is "Aids to Decision Making". Further information can be obtained from the Honorary Secretary of the Operational Research Society, 3rd Floor, 20 Albert Embankment, London, S.E.11.

NATIONAL PARKS IN BRITAIN

THE eighth annual report of the National Parks Commission*, which includes confirmation of the Designation Order for the Brecon Beacons National Park, brought the number of National Parks established to ten, covering an area of 5,250 square miles. With the confirmation of the Commission's orders designating areas in the Gower Peninsula and in Lleyn and the Quantock Hills the first areas of outstanding natural beauty designated under Section 87 of the Act have been established, but the Minister's decision on the Surrey Hills area is awaited. Formal proposals for the designation of other areas on the Dorset coast and its hinterland, in Cornwall and Cannock Chase and on the Northumberland coast have been made to the local authorities concerned. The Commission also reports that though there has been no general relaxation of the restriction on capital expenditure, the Minister has enabled Park planning authorities to proceed with some tree planting and construction on car parks. Some quiet progress is reported in other matters also, such as the provision of cheap holiday accommodation for visitors with young families, anti-litter campaigns and caravan sites; but it is clear that, although in some areas progress has been made in the removal of misunderstandings and unreasonable criticism of the handling by the Park committees of applications for the supply of electricity, the Commission is still not entirely happy about the administrative arrangements resulting from the Minister's failure to insist on the provisions of the Act. There is also still room in all Park areas for the publicity activities which the Park Planning Board have been extending.

New rights of way were dedicated along some ten miles of the Pennine Way, leaving some 5½ miles outstanding, but progress in making footpath agreements for the approved Cornwall North and South Coast Paths remains slow. With the acquisition of some nine new miles along the Pembrokeshire Coast Path, 25 miles remain to be completed, and some 44 miles of new rights of way are still required for the Offa's Dyke route. Increasing attention is being given to publicity by the Commission itself, both for the Country Code and in attempts to make the National Parks more widely known and create public awareness of what is being done under the National Parks Act. Evidence was given to the Royal Commission on Common Land in which the National Parks Commission recommended that any body or person empowered to sanction change of use of commons, or to extinguish common rights, or to draw up schemes of management for commons, should, before any action were decided, receive representations from the local planning authority and, where National Parks or areas of outstanding natural beauty were concerned, from the National Parks Commission. The hope was expressed that common land would be given over to rotational cropping only where it was clearly in the national interest to do so, and that in forestry schemes landscape values would be protected so far as possible by the consultations already indicated. Management schemes designed to enhance the beauty of the landscape and preserve to the public the recreational use of the land were favoured, and the National Parks Commission stated that it would strongly oppose, save in cases of the most exceptional national importance, the use of common land for mineral extraction. An approach was again made, but without success, to the Chancellor of the Exchequer for provision in the Finance Bill, or in a separate Bill, for the reimbursement from the National Land Fund of expenditure on National Parks.

The outstanding feature of the Commission's report this year is once again that of development, and especially those represented by the proposals for a nuclear power station at Trawsfynydd. The Tryweryn Valley Water Scheme (in which the Liverpool Corporation withdrew entirely the Conway part of its scheme against which statutory and amenity bodies had petitioned) and developments at Milford Haven are going ahead, but the Commission affirms the view that large-scale industry should only be sited in National Parks in cases of over-riding and inescapable national necessity and in the absence of alternative sites elsewhere.

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* Eighth Report of the National Parks Commission for the Year ending 30th September, 1957. Pp. iv+66+8 plates. (London: H.M. Stationery Office, 1958.) 5s. 6d. net.

RECRUITMENT OF TEACHERS

SIR EDWARD BOYLE, Parliamentary Secretary to the Ministry of Education, replying for the Government in a debate on February 14, on the recruitment and training of teachers, said that he did not think that unemployment among teachers in the nineteen-sixties was to be feared. The cornerstone of the Government's educational policy was that the first priority should be a reduction in the size of classes, and although Sir Edward did not discuss other objectives such as compulsory part-time day release and raising the school-leaving age to sixteen still required for full implementation of the 1944 Act, he pointed out that decision on the timing of these objectives would be governed by, *inter alia*, the supply of teachers. The debate was a little too early for him to give the full picture, but over the seven years that ended in 1956 the increase in the number of teachers in maintained schools was about 6,500, but this now seemed to have dropped to just over 5,000. About 900 more training teachers should be going into the schools in 1958 than in 1957 and a further 700 in 1959. Recruits to teaching without professional training remained fairly steady at 700 a year, but there was a marked increase in graduates taking up first appointments in schools —from about 1,800 in the year ended March 31, 1956, to about 2,600 the following year. There had, however, been marked decline in the number of married women returning to teaching, from 2,300 in 1951–55, to just over 1,000 in 1956. Nearly 600 more teachers retired in 1957 than in 1956 and it seemed also that more women teachers resigned than in previous years. On this net annual increase of 5,000, if the present ratio of 21·5 pupils per full-time teacher was maintained in senior classes, the average size of junior classes could only fall to a little more than 31 by 1962. Major changes in policy, however, must await adequate information and consultation.

Sir Edward Boyle affirmed that the Government was absolutely committed to the three-year training course announced last summer, and much planning was proceeding to secure the best results from this advance. He entirely agreed that the training colleges must be up to date in curriculum and discipline, and he thought that conditions were improving. The standard of many libraries was excellent and the regime much more flexible. On the technical side, after referring to the Willis Jackson report, Sir Edward said that recent figures for recruitment of technical teachers were encouraging: an increase of 1,000 appeared probable in 1956–57 and for 1957–58 a total increase of 1,400 was anticipated. After stressing the need for close co-operation with industry, Sir Edward said that in principle the Willis Jackson Committee's recommendations regarding pre-service courses in the three technical training colleges had been accepted and that Dr. Willis Jackson had accepted the chairmanship of a new standing committee on the supply and training of technical teachers which had just been established.

After dealing in some detail with the assessment training grants for former members of the Regular Armed Services, Sir Edward referred to the question of specialist teachers, particularly of mathematics and science. Although the 12,250 graduate teachers of mathematics and science in the schools was an increase of 1,750 over the past five years, this was insufficient to maintain the staffing standard in these subjects. The demand for such teachers was expected to increase by 40 per cent between now and 1962, but the actual increase was estimated at only 27 per cent. In the long term, the best hope of avoiding overcrowded classes in mathematics and science in sixth forms during the coming years lay in a large increase in mathematics and science graduates from the universities and in an increased attractiveness of teaching as a career. Sir Edward hoped that industrialists would remember that it was in their own interest that science and mathematics should be well taught in the schools. The training colleges could help in some measure and had been asked to bear in mind the importance of mathematics and science in planning their courses and selecting students for training, and in the past five years the number of training college students taking main courses in mathematics had doubled; in science the number had risen by 75 per cent.

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THE LEVERHULME TRUST

THE first report of the Leverhulme Trust on the Leverhulme Research Awards (pp. 72. London: The Leverhulme Trust, 1957) gives a record of the research awards, 1933–47, covering 273 made under the general scheme at a total cost of £130,299. Up to and including 1957, 612 were made at a total cost of £276,548, of which 580 costing £255,787 belong to the general scheme. The record is arranged in three sections: arts and humanities; natural sciences (including mathematics and medicine); and social science. In each section awards are listed chronologically by year and alphabetically for each year, giving the subject of research and relevant publications. There is an index of names and list of abbreviations for periodicals. The record is preceded by a historical note by Sir Hector Hetherington describing the circumstances which led to the establishment of the scheme, reviewing briefly its working and development and noting some of the problems encountered. The scheme was conceived mainly to help senior academic workers to complete their research projects, but it has never been restricted to the universities: many awards have been made to members of the staffs of national museums and galleries for study at home and abroad, and the primary purpose of the scheme continues to be to offer opportunities for periods of study and research which are not provided or inadequately provided by the official systems.

In general, the method used is to make good to the recipient any loss of income incurred by taking a period of study-leave and to meet such special expenses of the programme as could not be covered by other resources. Normally, the award, which has from the beginning been of no fixed amount, consists of two parts: a personal grant to replace earnings foregone, and a grant towards the special expenses of the programme.

The primary test of eligibility for a personal grant is that some loss of earnings should be incurred in undertaking the programme, and in general the Trust requires that the awards should be made for a significant period of time—at least three months, with an upper limit of two years. It is not at all concerned to pay the expenses of delegates to conferences or to other national or international gatherings. Recently the Trustees, however, have approved four further smaller schemes. In 1953 two 'European' awards were offered to young postgraduate scholars to meet the cost of a year of study in one or more centres of learning in Continental Europe. Two further schemes were developed for two or three years postgraduate study in a British university for candidates nominated by universities and university colleges in Africa and the West Indies. Four awards a year are also offered to graduates of British universities who wish to work for one or two years in the West Indies or in Africa, while finally three awards are offered each year to enable young graduates of certain major art schools to have a year of continuous study abroad, one of these awards being in the field of industrial design.

These recent policies are still regarded as experimental, and while awards have been made in almost every field of study, the Advisory Committee's working rule that no one project could be supported to the extent of more than 15 per cent of the resources available in any year has excluded a few very expensive schemes. The main area of concentration has been in age-group 40–60, but the spread extends from 27 to 80, and Sir Hector refers to the notable advantage of the private trust that it may more readily employ some of its resources as venture-capital to support a promising but more than ordinarily hazardous programme. It is intended to issue further reports at five-yearly intervals.

THE EUROPEAN NUCLEAR ENERGY AGENCY

THE European Nuclear Energy Agency was established to further the development of the production and uses of nuclear energy for peaceful purposes through co-operation among the participating countries, which include the United Kingdom and all the member countries of the Organization for European Economic Co-operation. It came into being on February 1, and the text of the Statute and related instruments was published as a White Paper on February 4*. The Agency will operate through a Steering Committee for Nuclear Energy and such other commissions and working parties as may be required, and the Governments of Canada and the United States are invited to associate themselves with the work of the Agency. Where appropriate, the Agency will promote the formation of joint undertakings for the production and application of nuclear energy for peaceful purposes, endeavouring to secure the participation of as many countries as possible, and it will do all in its power to ensure that joint undertakings as well as participating countries are regularly supplied with the necessary raw materials.

The Agency is instructed to examine jointly with the Steering Board for Trade measures to achieve the maximum freedom of international trade in products of interest for the production and application of nuclear energy and will encourage the development of research, promoting, where appropriate, agreements for the joint use of research installations, and the creation of joint research establishments, and also the exchange of scientific and technical information between participating and associated countries. It is also to promote the development of training in matters relating to nuclear energy so as to assist in meeting the demand for scientific and technical personnel in this field, both by encouraging co-operation to secure the full use and development of existing training facilities in competent national institutions and by encouraging legislation to secure the protection of public health and prevention of accidents in nuclear industry, the most efficient use of patented inventions and to provide for third-party liability and insurance against nuclear risks. The Agency is required to establish a security control to ensure that the operation of joint undertakings and the materials, services and equipment provided by the Agency or under its supervision do not further any military purpose, and the organization of this control is detailed in a special Convention, the text of which is included in the White Paper. The Convention provides for a central bureau assisted by a director and administrator and technical officers, in particular a group of international inspectors, as well as for a tribunal of seven independent judges appointed for five years.

The Statute also provides for close collaboration with the European Atomic Energy Community (Euratom), with which an agreement is to be made defining the arrangements under which the control established by the new Convention is to be carried out in Euratom territory. Agreement may also be made with the International Atomic Energy Agency for the same purpose.

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* Atomic Energy. Miscellaneous No. 2 (1958): Decision of the Council of the Organization for European Economic Co-operation establishing a European Nuclear Agency and Convention on the Establishment of a Security Control in the Field of Nuclear Energy, Paris, December 20, 1957. Pp. 19. (Cmnd. 357.) (London: H.M. Stationery Office, 1958.) 1*s.* net.

STANDARD FREQUENCY TRANSMISSIONS FROM THE UNITED KINGDOM

A LIMITED programme of transmissions of standard radio frequencies was started in 1950 from the Post Office station at Rugby under the call sign *MSF*. This was extended in 1953 to the provision of a continuous service on the three frequencies of 2·5, 5 and 10 Mc./s. with periods of modulation by a 1,000 c./s. tone and by 1 c./s. pulses (see *Nature*, 172, 529; 1953). From the start these transmissions have been monitored at the National Physical Laboratory, which has just published a new edition of a pamphlet entitled "*MSF*—Standard Frequency Transmissions from the United Kingdom". This gives full technical details of the current programme, including reference to the additional transmission which is made for one hour each day on a frequency of 60 kc./s., and which provides a ground-ray service over a wide area inside the skip-distance of reception on the higher frequencies. This transmission has proved so valuable that the carrier wave of the 16 kc./s. *GBR* telegraph transmitter is now also controlled from the *MSF* standard although it is not yet regarded as part of the regular service.

The new pamphlet (obtainable free on application to the Director, National Physical Laboratory, Teddington, Middlesex) also announces that the *MSF* frequencies are now based on the resonant frequency of the caesium atom. Provisionally, the value of 9, 192, 631, 830 cycles per second has been adopted for this. This frequency is a fundamental physical constant, free from the small corrections and uncertainties associated with astronomical time. The precise value of the frequency is based on the value of astronomical time for 1955. Some years must pass before the astronomical and atomic units can be compared to the full accuracy attained by the atomic clock because astronomical time must be averaged over a long period to eliminate small errors and uncertainties of measurement. If any corrections prove necessary in years to come, they can readily be made and, therefore, will not restrict the accuracy already available.

The *MSF* frequencies and modulations are maintained to ± 5 parts in 10^9 but are monitored to ± 1 part in 10^{10}. Continuous measurements on the transmissions are made at the National Physical Laboratory, 120 km. distant from Rugby. The results, which are published monthly in *Electronic and Radio Engineer*, are given only to ± 1 part in 10^9 to allow for slight transmission and propagation errors, but even more precise average values can be used when steps are taken to eliminate these errors.

WATER RESOURCES OF BRITAIN

A BROADSHEET, "Policy for Water" (No. 418; January 27, 1958), issued by Political and Economic Planning, attempts to give the background to the problem of water resources and supply by sketching the history and development of the water industry and other organizations concerned with the exploitation, disposal and conservation of water. Current economic and technical problems of supply and demand and pricing are then reviewed, including the need for more information, and the Broadsheet next discusses the two main administrative problems: first, the urgent need for a comprehensive rationalization of local water undertakings; and secondly, the need for greater co-ordination in all matters concerning water supply, fisheries, drainage, etc.

Pending the publication of the reports of the sub-committees appointed by the Central Advisory Water Committee, Political and Economic Planning concludes provisionally that the water resources of Britain are likely to be adequate to meet foreseeable demands, but that much new capital must be expended if water is always to be available in adequate quantity or appropriate quality wherever it is needed. The Broadsheet points out that while water of high quality is essential for drinking purposes, low-grade water will often serve industrial needs, and it is desirable that increasing attention should be given to this aspect and that we should not continue to draw on our relatively scarce resources of pure water for purposes for which water of inferior quality would do equally well.

There are far too many authorities. A radical rationalization of the water-supply industries is long overdue and is essential for substantial progress, although the basic technical economic problems of water supply can only be served if adequate capital is provided. Procedures laid down in the current Water Acts are long and intricate, and further measures may be required to overcome the natural unwillingness of many authorities to acquiesce in their own extinction within a reasonable time.

DIATOMS FROM EQUATORIAL INDIAN OCEAN CORES

THE appearance of the ninth volume of the reports of the Swedish Deep-Sea Expedition 1947–1948* completes Dr. R. W. Kolbe's trilogy on the diatoms from the equatorial zones of the most traversed oceans. The material here reported consisted of twenty-three cores selected from those obtained from the Indian ocean by M/S *Albatross* under the leadership of Prof. Hans Pettersson.

The cores were taken with a Kullenberg sampler and some of them from a depth exceeding 5,000 m. were more than 11 m. in length. As the complete examination of so large a mass of material would be impracticable, three samples were usually taken from each, namely, one from the deepest layer, one from the uppermost layer, and one midway between. The cores chosen for this study had been shown by preliminary survey to contain diatoms, and after submitting the material to the usual acid-cleaning technique it was mounted for microscopical examination.

The cores selected were obtained from seven geographical regions: (1) Java, (2) East Indian Ocean, (3) Ceylon, (4) Maldives, (5) West Indian Ocean, (6) Seychelles, (7) African coast.

In this way samples were examined from inshore positions (68 m. depth) to positions of great oceanic depth of more than 5,000 m.

By his use of the term 'diatom assemblage' Kolbe has rendered a great service in stressing the relation, or lack of it, between the silica unicells of the sediments and the diatom flora living in the column of water immediately above them. This abyssal assemblage differs from the planktonic and benthonic populations from which it is derived not only in a reduced number of species, but by their differing numerical frequencies. This assemblage is therefore not a natural facies of living organisms but belongs to a thanatocœnosis. Further, the physico-chemical selection which is brought to bear upon dead and dying diatoms during their slow journey through great oceanic depths to the sea floor is largely responsible for the marked uniformity observed in the diatoms over wide regions of the ocean floor. Dr. Kolbe's researches have also led him to observe a marked similarity between the diatom assemblages of the Atlantic[1], Pacific[2] and Indian oceans, and that the most frequent species are not confined to any one area, and that they differ only by their relative frequencies in the different areas. For example, *Coscinodiscus nodulifer*, *Ethmodiscus* (fragments) and *Nitzschia marina* are the commonest and most frequent species in all three equatorial oceans. Five others, *Hemidiscus cuneiformis*, *Thalassionema* sp., *Coscinodiscus excentricus*, *Coscinodiscus lineatus* and *Coscinodiscus africanus*, are common to the sediments of the three areas, but differ in their relative frequencies in the different oceans. These eight species constitute what Kolbe describes as the dominant abyssal assemblage.

One of the most interesting problems in diatom occurrence in oceanic cores is that concerning *Ethmodiscus rex* (Wall.) Hendey. This diatom, the largest known, lives or has lived in the three equatorial oceans and enormous deposits of it have been recorded from various parts. It is one of the most common diatoms in the equatorial sediments of the three oceans. For example, an area of oceanic ooze some three thousand miles long by twenty wide, consisting almost entirely of *Ethmodiscus*, has been reported between Guam and Luzon. Kolbe also has found evidence of considerable deposits of this species in the Indian and Atlantic Oceans—yet records of living specimens in the plankton have been rare.

Kolbe seeks to explain the discrepancy between the scarcity of *Ethmodiscus rex* in the plankton and its abundance and frequency in oceanic sediments, by combining three possible hypotheses: (1) dysphotic habit, explaining the rarity of the species in plankton samples taken by usual techniques (Karsten's hypothesis); (2) periodicity of short duration of mass reproduction (Hendey's hypothesis); (3) resistance to corrosion (Kolbe's hypothesis). Kolbe is of the opinion that the great accumulation of *Ethmodiscus* fragments in certain limited areas of the sea floor may be explained by the complicated relations between currents, sea-floor topography, size and form of sediment particles, all of which might result in a constant deposition of particles of certain properties in certain circumscribed areas.

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* Göteborgs Kungl. Vetenskaps- och Vitterhets-Samhälle. Reports of the Swedish Deep-Sea Expedition 1947–1948. Vol. 9: Sediment Cores from the Indian Ocean. No. 1: Diatoms from Equatorial Indian Ocean. By R. W. Kolbe. Pp. 50+4 plates. (Göteborg: Elanders Boktryckeri Aktiebolag, 1957.) 15 Sw. kr.

Thus *Ethmodiscus* fragments within a certain size range might be constantly deposited at a given place, and so form *Ethmodiscus* beds, while other particles less dependent on slow currents might be distributed in a very different way.

Those who have tried to understand something of the relation between oceanic deposits, and the distribution of the living plankton populations that contribute to their formation, will find Dr. Kolbe's stressing of the differences between thanatocœnesis and biocœnesis of the greatest interest.

It seems that these differences must be influenced by the following factors (among others):

(1) Chemical erosion, as stressed here by Dr. Kolbe.

(2) Rate of fall. Here the wide range in sinking rate of fragments derived from the one species *Ethmodiscus rex*, determined experimentally by Dr. Kullenberg, seems especially significant.

(3) Speed and direction of sub-surface currents. Recent physical observations, albeit in a very different part of the world, show that their speed may be much greater than Dr. Kolbe felt entitled to assume (cf. ref. 3).

(4) Extreme periodicity in local swarming of certain species of plankton diatoms, as postulated by Hendey[4]. Probably most plankton workers of long experience can recall odd instances supporting this view, but not, unfortunately, with regard to *Ethmodiscus* itself. The relative lack of samples from its apparent habitat is probably quite sufficient to account for this.

These four factors are very well presented in Dr. Kolbe's paper, but it is felt that yet another may be important:

(5) What might be termed the biological part in the breakdown and decay of plankton diatom frustules. The ingestion of frustules or fragments by mesoplankton animals may be repeated several times before they reach bottom, with the further probability of considerable bacterial action both before and after ingestion (cf. ref. 5). This may well be of great importance in determining which members of the biocœnosis remain recognizable in the thanatocœnosis.

One minor correction to Dr. Kolbe's paper is necessary. The record of dense swarms of *Ethmodiscus* in the Bay of Bengal does not occur in Collingwood's paper of 1868, in *Transactions of the Royal Microscopical Society*, the reference quoted, but in the discussion following the reading of the paper (*Quart. J. Micr. Sci.*, 115; 1868), as Hendey has explained. The paper has now become a rarity, and some of the surviving separates do not include the discussion. The actual observations concerning *Ethmodiscus* in the Bay of Bengal seem to have been made by Dr. Wallich in 1851 and 1857.

The number of benthonic diatoms (112 taxa) observed in the material was 56 per cent of the total and was far greater than in the sediments of the Atlantic and Pacific Oceans. This is accounted for by the number of cores taken close to land. The high number of benthonic forms taken from the vicinity of the Seychelles archipelago, however, presents several interesting problems, as the cores were taken at great depth and far from the African mainland. It is suggested that their presence indicates that the whole district may have formerly belonged to a shallow sea and that its floor might have sunk to its present considerable depth at a not very remote period. The benthonic diatoms are, with very few exceptions, provided from thirteen of the twenty-three cores examined. The cores from the Ceylon, Maldives, and East Indies areas provided but six species. The paucity of *Triceratium* species, particularly those belonging to the *T. favus* group, and of *Mastogloia* and *Amphora* in the Java cores is surprising, as these genera are well represented in the area. The occurrence of species of *Stictodiscus*, usually considered to be extinct, at widely separated areas is significant. Mann[6] showed in his work on the diatoms of the Philippine Islands that the genus is well represented there and it may be that isolated pockets of these species have persisted since the Tertiary. Those in the African cores were found at depths varying from 4 cm. to 10 m.

Dr. Kolbe is to be congratulated upon completing this very considerable task without yielding to the temptation of making a host of new species out of the wide range of variants that the abyssal assemblage offered.

N. INGRAM HENDEY

[1] Kolbe, R. W., Rep. Swed. Deep-Sea Exped., **7**, 149–184 (1955).
[2] Kolbe, R. W., Rep. Swed. Deep-Sea Exped., **6**, 1–49 (1954).
[3] Swallow, J. C., and Worthington, L. V., *Nature*, **179**, 1183 (1957).
[4] Hendey, N. Ingram, in Wiseman and Hendey, "Deep Sea Research", **1**, 47–49 (1953).
[5] Hart, T. J., *Discovery* Reports, **8**, 11, 186 (1934); **21**, 327 (1942).
[6] Mann, A., U.S. National Museum Bull. 100, **6**, 1 (1925).

SOLAR ACTIVITY AND RADIO COMMUNICATION

By R. NAISMITH

Radio Research Station (Department of Scientific and Industrial Research), Slough

SEVERAL years ago the period 1957–58 was selected as the International Geophysical Year in the expectation that it would coincide with a period of high solar activity. This long-term prediction has proved quite successful, since it is actually coinciding with the highest period of solar activity which has occurred within the past two hundred years. The success of this long-term prediction, however, must be considered in relation to a comparatively large number of failures which make anyone who is aware of the difficulties involved reluctant to make long-period predictions until more is known of the causes of the variations.

There are, however, particular parts of the sunspot cycle which can be more accurately predicted than others for intermediate periods up to twelve months.

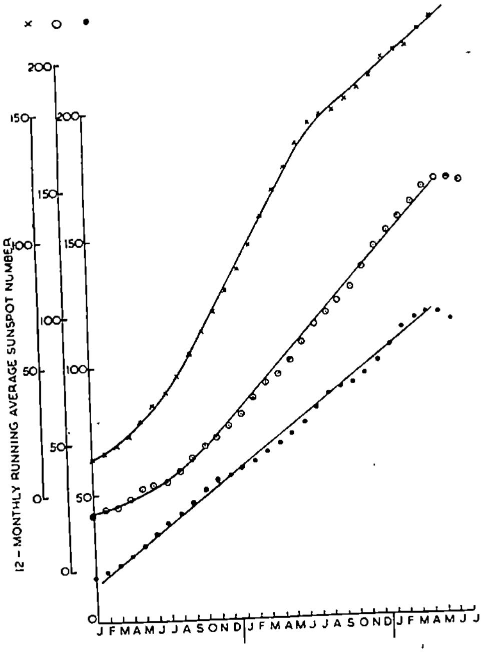

Fig. 1. ●, 1935–37 ; ⊙ , 1945–47 ; ×, 1955–57

These predictions are very useful in relation to radio communication, etc. This occurs, for example, during the rising period of each cycle, particularly when the maximum tends to be high. The last three cycles, which are good examples of this, are shown in Fig. 1. The prediction is associated with the linear rise, which may persist for periods of eighteen months or more. The end of this part of the current cycle is near, but there are features which may be associated with the present and future period of the current cycle to which attention should be directed.

In Fig. 2 the data plotted in Fig. 1 have been extended to cover a period of about two and a half years after the maximum of the cycle, and it will be noted that there is a general correspondence which may be used by a forecaster to estimate values for some time ahead. This is by no means a universal happening; but if the higher level of the present cycle should be maintained, the sunspot numbers during the next six months will be higher than those at present forecast by any organization making regular forecasts.

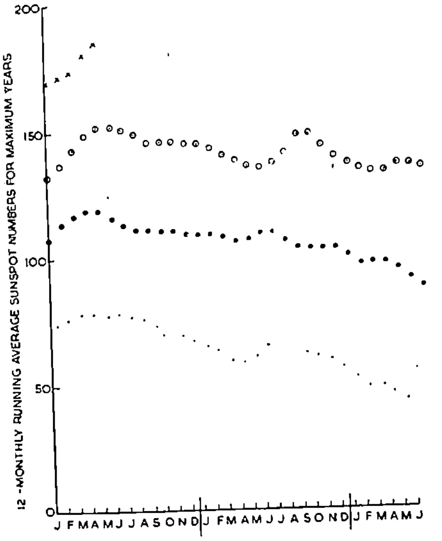

Fig. 2. ●, 1928–30 ; ●, 1937–39 ; ⊙, 1947–49 ; ×, 1957–

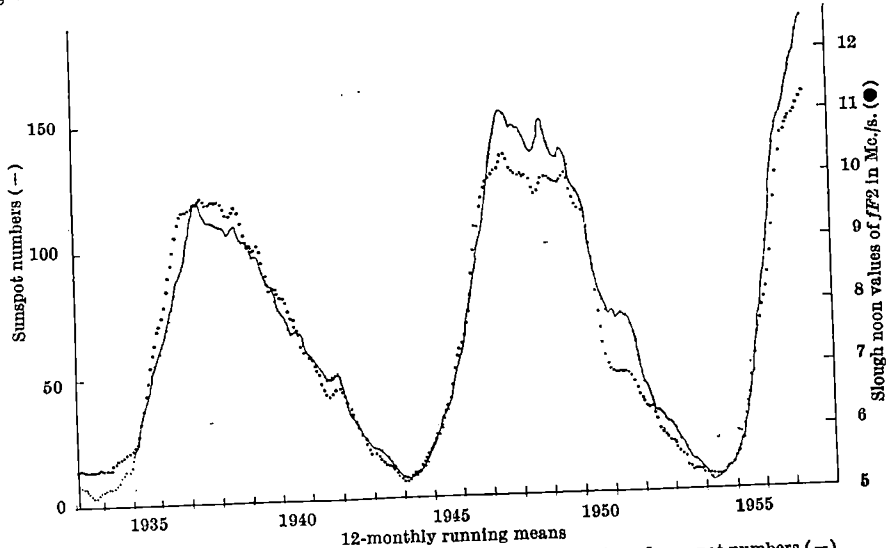

Fig. 3. Comparison of noon critical frequencies of *F*-region (●), and sunspot numbers (—)

In consequence of this, it is probable that higher radio-frequencies may be used for communication during the first half of 1958 than those forecast. The association of radio-communication conditions by way of the *F*-region of the ionosphere, as denoted by the variations in the noon critical frequencies (*fF*2) of that region as measured at Slough, and the solar activity as denoted by sunspot numbers, is shown in Fig. 3. This covers two and a half sunspot cycles, and this is the whole period for which the ionospheric measurements are available. Although neither the solar nor ionospheric index is perfect, they are both convenient for this purpose of comparison, and the agreement, even in some detail, reflects the close association of these two quantities when average values are considered.

This leads naturally to some useful data for radio-communication purposes. It is important, for example, to be able to distinguish between those radio-frequencies which may be used for long-distance radio communication by way of the *F*-region and those frequencies which, apart from a residual amount of scattering, will penetrate the ionosphere and will not reach great distances. For this purpose, use can be made of the sunspot data extending back over the years indicated in the first paragraph.

When interpreting the radio data, account must be taken of a well-known seasonal variation in the noon values of *fF*2 as recorded at Slough. This shows a very definite maximum during the winter months. It happens that the sunspot number for December 1957 was 244 and therefore greater than the twelve-monthly average for the maximum period of the present cycle. The monthly median value of *fF*2 at noon at Slough in December was 15·2 Mc./s., the highest December average value recorded at Slough since measurements were begun twenty-six years ago. This leads to the conclusion that the maximum frequency available for the longest-distance radio communication at the latitude of Slough would be close to 50 Mc./s. at noon for half the days in the month. This 'demarcation' frequency has some useful practical applications in planning radio communication in temperate latitudes.

The work described above was carried out as part of the programme of the Radio Research Board, and this communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

CHLORAMPHENICOL-RESISTANT INCORPORATION OF AMINO-ACIDS INTO *STAPHYLOCOCCI* AND CELL-WALL SYNTHESIS

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THE incorporation of radioactive amino-acids into the protein of bacteria, whole tissue cells and various sub-cellular fractions has been widely used as a method of studying the biosynthesis of proteins. In this context, 'protein' is usually defined, in practice, as the residue remaining after extraction with hot trichloroacetic acid and organic solvents. The appearance of radioactive amino-acids in this residue has often been accepted as a measure of protein synthesis. However, Gale and Folkes[1] examined the situation in which a single radioactive amino-acid was supplied to *Staphylococcus aureus* and found that, although there was no net increase in protein, the label was incorporated steadily for at least 2 hr. Furthermore, the incorporation of single amino-acids was much more resistant to chloramphenicol than protein synthesis. The authors therefore concluded that incorporation of a labelled amino-acid was not necessarily an indication of protein synthesis and suggested the possibility of an exchange reaction between the labelled molecules and the corresponding residues within the protein.

This type of reaction does not appear to be general, for other work has shown that, in *Escherichia coli*, the incorporation of glycine and leucine is almost totally suppressed by growth-inhibitory concentrations of chloramphenicol[2], and the same is true for incorporation of methionine and leucine in *Bacillus cereus* (Urbá, personal communication).

It is noteworthy that amino-acid incorporation in *Staphylococci* is particularly resistant to chloramphenicol in the case of those amino-acids now known to be associated with the cell wall. It therefore seemed possible to us that, when the organisms are incubated with a single amino-acid such as glycine or glutamate, the incorporation observed might be the result of synthesis of cell wall which, in *Staphylococci*, contains five amino-acids (glycine, alanine, glutamic acid, lysine and serine) and two amino-sugars[3]. Accordingly, experiments of the following type were carried out.

Staphylococcus aureus, Strain 524 55/*SC*[4] was grown in a casein hydrolysate medium supplemented with thiamine, nicotinic acid and 0·5 per cent glucose[5]. When the culture had reached a density of 1 mgm. dry weight of cells/ml., the bacteria were harvested and washed twice with 0·05 *M* phosphate buffer, *p*H 7·0, and suspended at a density of about 1 mgm. dry weight of cells/ml. in the same buffer solution containing 0·5 per cent glucose, 400 μgm./ml. of labelled amino-acid and 70 μgm./ml. of chloramphenicol. The suspension (150 ml.) was shaken at 35° C. for 60 min. in a one-litre conical flask. A portion of the cells (obtained from 15 ml. of the suspension) was treated with hot trichloroacetic acid and organic solvents and then dried[2]. This will be referred to as 'protein' and contains both the cell wall and the true cell proteins. The rest of the bacteria were washed, suspended in water at a density of 10 mgm./ml. and disrupted by shaking with glass beads for 15 min. Cell wall was separated, washed with water, treated with ribonuclease and trypsin followed by digestion with pepsin[3]. The cell-wall material was then washed several times with water and then with acetone and ether and finally dried. The supernatant from the disrupted cells after removal of cell wall, together with the water washings, was treated with an equal volume of 10 per cent trichloroacetic acid and left at 2° for 30 min. The precipitate was extracted with hot trichloroacetic acid and organic solvents and dried. This will be referred to as the 'true protein' fraction. Radioactivity of samples was measured at infinite thickness in a thin end-window Geiger–Müller counter. In some of the experiments involving glycine, samples of cell wall and 'true protein' were hydrolysed, the glycine isolated by paper chromatography and its specific activity determined[2]. In addition, samples of 'protein' and cell wall were hydrolysed for 4 hr. with 4 *N* hydrochloric acid at

Table 1. DISTRIBUTION OF RADIOACTIVITY INCORPORATED INTO PROTEIN AND CELL WALL BY *Staphylococci* IN THE PRESENCE OF GROWTH-INHIBITORY CONCENTRATIONS OF CHLORAMPHENICOL

	Specific activity of cell fraction (counts/min.)			Increase in cell wall (per cent)
Amino-acid	(1) Cell wall + protein	(2) Protein	(3) Cell wall	
Glycine	145	3	662	85
DL-Glutamic	17	3	65	33
L-Lysine	16	2	61	30

Washed cells were incubated for 1 hr. in phosphate buffer containing glucose (0·5 per cent), chloramphenicol (70 μgm./ml.) and 300 μgm./ml. of a labelled amino-acid, namely, glycine-1-^{14}C, or DL-glutamic acid-1-^{14}C or L-lysine (uniformly labelled). The specific activities of the amino-acids in the incubation medium were, respectively, 350, 665 and 1,350 counts/min./μ*M*. The cell fractions isolated were: (1) 'protein' (containing cell wall and 'true' cell proteins); (2) 'true protein'; and (3) cell wall. Specific activities of these fractions are given as counts/min. measured at infinite thickness

100° and hexosamines determined after treatment with a cation exchange resin ('Dowex 50') according to Boas[6].

Table 1 shows the type of results obtained when glycine, DL-glutamate and L-lysine labelled with carbon-14 have been present singly in the incubation medium. The greatest amount of cell-wall synthesis took place with glycine. It will be noted that, irrespective of the amount synthesized, virtually all the radioactivity was associated with the cell-wall fraction; the 'true protein' fraction contained only a trace of radioactivity. Omission of chloramphenicol from the incubation mixture did not substantially affect the results except that the radioactivity of the 'true protein' fraction was slightly increased.

The question now arises whether the incorporation of an amino-acid into the cell wall is the result of exchange between the amino-acid in solution and the corresponding residues in the wall, or whether it is due to an increase in the mass of the cell wall. In a typical experiment the specific activity of the glycine isolated from the cell wall indicated that an increase of 66 per cent should have occurred in the total amount of cell wall. This is in quite good agreement with the increase found in cell-wall mass (60 per cent). Using the hexosamine content of the 'protein' as a measure of the amount of cell wall indicated an increase of 52 per cent.

It thus seems certain that, in intact *Staphylococci*, cell-wall synthesis occurs in the presence of growth-inhibitory concentrations of chloramphenicol and that this is sufficient to account for the incorporation of glycine, glutamate and lysine into the 'protein' fraction. The incorporation of amino-acids into the 'protein' fraction of disrupted *Staphylococci* described by Gale and Folkes[7] has not been examined by us in this way, and it is, of course, possible that some process of exchange occurs in such preparations which does not occur in the intact cell.

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'INTERCALATED' INTERNODES IN NERVE FIBRES

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In surveying teased nerve fibres from peripheral nerves of laboratory animals one sometimes encounters internodes which are much shorter and thinner than others on the same fibre. Such internodes were first observed by Rénaut[1] in peripheral nerves of horses and asses. Rénaut considered their existence as a proof that the nerve fibres grow not only from the central end but also by intussusception of new internodes and called them 'short intercalated segments'.

The short internodes probably represent a phase of restitution after a local inflammatory process described by Gombault[2] in lead poisoning and in many disorders of various origins. The process attacks individual internodes, or even portions of internodes, leading to granular destruction of myelin, and proliferation of Schwann cells in the affected region. The continuity of axoplasm is, however, usually preserved and the fibres do not degenerate. The denuded axoplasmic cylinder eventually becomes re-myelinated and recovers; the only permanent trace left is the shortness of newly formed internodes. Gombault calls this condition 'névrite segmentaire periaxile'.

The short internodes, vestiges of a local neuritis which struck some fibres at an earlier period, offer thus an uncommon opportunity to study the reorganization of a stretch of adult fibre after selective destruction of myelin. A short description of 'intercalated segments', based on an analysis of some forty peripheral fibres from fifteen cats, is therefore presented here.

The 'intercalated' segment always starts at a node and terminates at a node (Fig. 1). Sometimes a single short internode is present, more often the intercalated segment is formed by a succession of several short internodes. Various degrees of maturation are

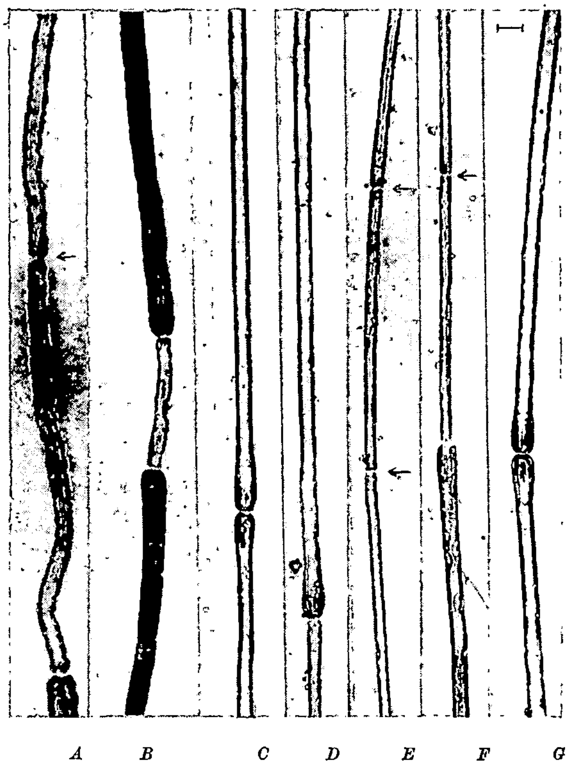

Fig. 1. 'Intercalated segments'. Proximal ends uppermost. Arrows indicate nodes between short internodes. Scale, 20μ. *A* and *B*, fibres fixed in osmium tetroxide; *A*, portion of an intercalated segment and junction with the distal normal internode; *B*, single short internode; *C* and *G*, normal portions of a fresh fibre containing four short internodes; *D*, *E* and *F*, consecutive portions of the intercalated segment

Table 1. NORMAL AND SHORT INTERNODES IN FIBRES OF CATS. SUCCESSIVE INTERNODES OF EACH FIBRE IN PROXIMO-DISTAL ORDER. ALL DIMENSIONS IN MICRONS

Fibre from	Internode	Total diameter	Axon diameter	Thickness of myelin	Location of the nucleus at	Length of the internode
Peroneal	I normal	19·8	11·7	4·0	880	1,750
	II short	13·1	8·7	2·2	170	320
	III short	13·3	8·7	2·3	230	455
	IV short	13·1	9·0	2·1	175	345
	V short	14·1	9·5	2·3	—	510
	VI short	14·6	10·3	2·2	—	230
	VII normal	19·5	11·5	4·0	910	1,850
	VIII normal	19·8	11·7	4·0	860	1,700
Ventral root	I normal	20·8	11·7	4·5	—	1,150
	II short	17·5	11·7	2·9	210	400
	III short	17·7	11·7	3·0	210	400
	IV short	17·3	11·2	3·0	200	380
	V normal	20·7	11·7	4·5	—	—
Median	I normal	18·7	11·7	3·5	—	—
	II short	13·3	7·7	2·8	140	300
	III short	13·7	7·7	3·0	230	480
	IV short	13·3	7·3	3·0	140	305
	V short	13·7	8·0	2·9	160	320
	VI normal	19·0	11·5	3·7	—	1,300
Peroneal	I normal	18·0	11·7	3·1	—	1,310
	II short	10·0	7·0	1·5	40	85
	III normal	18·0	11·5	3·2	—	—
Peroneal	I normal	12·0	6·0	3·0	—	
	II normal	12·0	6·0	3·0	—	1,200
	III short	6·0	4·0	1·0	—	50
	IV normal	12·0	6·0	3·0	—	—

encountered. In some internodes the myelin is very thin and the amount of cytoplasm of the Schwann cell is increased. In others the myelin is much thicker and the excess of Schwann cell cytoplasm has already disappeared. The diameter of the axon is less than that of the normal internodes, both up and down the fibre, until the maturation of the short internode is fairly advanced.

When there are several short internodes in succession, the total length of the intercalated segment is similar to that of normal internodes of the same fibre, suggesting that a whole internode had been affected. The length of individual short internodes varies usually between 300 and 500μ. When a single short internode is 'intercalated' in the fibre, it is much shorter, rarely exceeding 50–150μ. Its length indicates that only a fraction of an internode had been involved in the neuritic process. At the junction with the short internode, the neighbouring normal ones end by bulbs of normal dimensions and shape characteristic of their proximal or distal location[3]. At least one of these bulbs is newly formed, showing that the end of the normal portion of the fibre has been reorganized.

The dimensions of normal and short internodes in several fibres are shown in Table 1.

The nucleus of the Schwann cell is always located in the middle of the short internode. This seems to indicate that the metabolic activity connected with the deposition of myelin extends in the Schwann cell symmetrically over a length of some 150–250μ on each side of the nucleus. If the denuded portion of axoplasm is longer, several Schwann cells adhere to it and the process of myelination starts in each cell, presumably by the mechanism elucidated by Geren[4] in developing fibres. Eventually several internodes are formed on a stretch occupied previously by one internode only. The length of new internodes is similar to that found by Vizoso and Young[5] in adult fibres regenerating after Wallerian degeneration and in fibres of very young animals.

In the early stages of restitution the nodes between successive short internodes are adumbrated simply by the interruption of myelin. The axon remains cylindrical throughout. It is only in the course of further maturation that the constriction of the axon at the node appears and the juxta-nodal bulbs develop.

The similarity in the behaviour of Schwann cells after a selective destruction of myelin and after Wallerian degeneration suggests that during the latter process it is also the breakdown of myelin, and not that of axoplasm, that determines the initial proliferation of Schwann cells. During the recovery the presence of the naked axon in the neurilemmal tube leads to a similar course of re-myelination and to similar morphological outcome in both conditions.

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KINETICS OF HEAT INACTIVATION OF RIBONUCLEIC ACID OF TOBACCO MOSAIC VIRUS

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IN marked contrast to the case of deoxyribonucleic acid, which is inactivated with a high-temperature coefficient[1] reminiscent of that of heat denaturation of proteins, it is found that loss of biological activity of the infectious ribonucleic acid of tobacco mosaic virus occurs with a moderate heat and a negative entropy of activation at neutral *p*H. The results are interpreted to mean that inactivation is a consequence of a single hydrolytic break in the phosphodiester backbone of the polynucleotide chain. The present findings, considered in the light of the known properties of this ribonucleic acid, indicate support for a single-stranded molecule.

Tobacco mosaic virus ribonucleic acid was obtained[2] by the method of Fraenkel-Conrat and Williams[3] from the common strain, *U*-1. Series of 0·1-ml. aliquots of a solution containing 1–2 mgm. of nucleic acid per ml. in 0·1 *M* phosphate buffer, *p*H 7·15, are heated for various periods at temperatures between 37° and 65° in a thermostatted water-bath. Heated samples and unheated controls are diluted to 10–30 μgm. per ml. in 0·067 *M* phosphate buffer, *p*H 7·0, and assayed on *Nicotiana glutinosa*, employing 20 half-leaves or more for any given sample. Under our conditions of assay, the lesion count response is linear with concentration of ribonucleic acid up to 30 μgm. per ml.

Results of a typical single experiment in which aliquots from the same nucleic acid preparation were heated at two different temperatures are shown in Fig. 1. It is seen that the plots of the logarithm of the surviving fractions versus time of heating are linear. While the error involved is inherently great in assays of this type, the results of numerous experiments indicate no systematic deviation from first-order kinetics. Heat inactivation of viruses in general follows a course of first-order kinetics ; numerous examples, including that of tobacco mosaic virus, are cited and discussed by Pollard[4]. The plot of the logarithm of the first-order rate constants versus the reciprocal of the absolute temperature is linear over the temperature-range 37°–65° (Fig. 2). The heats of activation ($\Delta H\ddagger$) and entropy of activation ($\Delta S\ddagger$) calculated from these data for the heat treatment leading to the loss in infectivity is about 19 kcal. per mol. and – 19·5 entropy units, respectively. Bacher and Kauzmann[5] obtained values which are very close to these from their experiments on the kinetics of hydrolysis of yeast ribonucleic acid. They followed the course of hydrolysis by titration.

From the moderate value of $\Delta H\ddagger$, it would appear that inactivation of tobacco mosaic virus ribonucleic acid does not involve disordering of secondary structure maintained by a large number of weak bonds, such as H-bonds. The negative entropy of activation observed is interpreted here to reflect the formation of a cyclic phosphate triester intermediate in the activated state of the molecule. It indicates that the activated molecule has less degrees of freedom because of the added bond between the phosphorus atom and the 2-OH of the ribose. A cyclic intermediate of this kind has been postulated by Fonó[6] and Brown and Todd[7] to explain the ease of hydrolysis of ribosephosphate as compared with that of deoxyribosephosphate. Bacher and Kauzmann[5] interpreted in this manner the kinetic data they obtained for the hydrolysis of yeast ribonucleic acid.

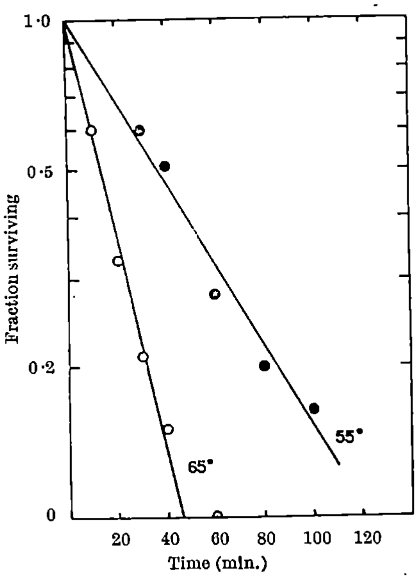

Fig. 1. Survival curves of tobacco mosaic virus ribonucleic acid heated at *p*H 7·15 in 0·1 *M* phosphate buffer

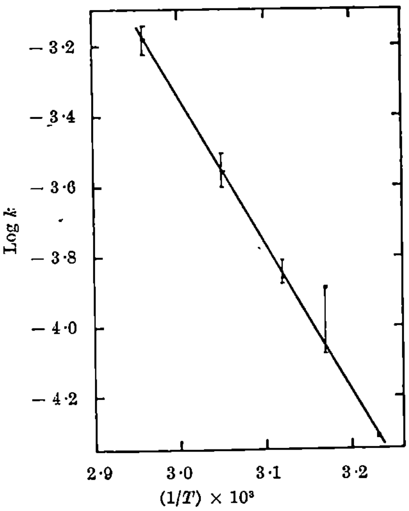

Fig. 2. Temperature dependence of the rate of inactivation of tobacco mosaic virus ribonucleic acid by heat at *p*H 7·15 in 0·1 *M* phosphate buffer. The rates at 37°, 42° and 47° were estimated from single point inactivation curves

The first-order kinetics observed in the heat inactivation of tobacco mosaic virus ribonucleic acid most likely means that a hydrolytic cleavage of only one phosphodiester bond is sufficient to inactivate the molecule. In this connexion, Gierer finds that the decrease in the mean molecular weight of tobacco mosaic virus ribonucleic acid is a simple exponential function of time of treatment with ribonuclease, suggesting that this molecule is single stranded[2,7]. Since hydrolysis of ribosephosphate bonds is involved in both cases, it follows that a single break in the polynucleotide chain by heat must also cause an exponential decrease in the mean molecular weight.

On the other hand, Thomas[8] finds that an enzymatic (deoxyribonuclease) breakdown of deoxyribonucleic acid is characterized by a lag, the molecular weight decrease being contingent on coincident rupture of two phosphodiester bonds, one on each of two chains and occurring within the distance of two nucleotides. Breaks occurring at greater distances from each other are not believed to result in scission of the deoxyribonucleic acid molecule because the intervening H-bonds are sufficiently strong to prevent separation of the two strands. Biological inactivation of bacteriophage labelled with phosphorus-32 has been studied by Stent and Fuerst[9]. In this case also the loss in biological activity is a consequence of breaks in phosphodiester bonds. A first-order kinetics is observed in this case as in that of tobacco mosaic virus ribonucleic acid, but their results are explicable only in terms of coincident scission of *both* strands of the deoxyribonucleic acid molecule. They conclude that where only a single break is incurred, the molecule is still capable of functioning. From these parallel observations, we are led to favour the view that tobacco mosaic virus ribonucleic acid is a single-stranded molecule. The comparative ease of hydrolysis of ribosephosphate bonds by heat, together with its single-stranded structure, could well account for the widely observed tendency of tobacco mosaic virus ribonucleic acid and ribonucleic acid from other sources to depolymerize rather readily[10-13].

The values of $\Delta H^\ddagger$ and $\Delta S^\ddagger$ derived from the present kinetic studies indicate that there is also a marked dissimilarity between tobacco mosaic virus ribonucleic acid and the deoxyribonucleic acid transforming principle of *Hemophilis influenzae* with respect to response to heat[14]. With deoxyribonucleic acid, the rates of biological inactivation and loss of viscosity due to heat are not measurable until a critical temperature of about 80° C. is reached ; but the rates for both changes become great above this temperature. In confirmation of the work of Zamenhof *et al.*, Doty has obtained values of 93 kcal. per mol. and 220 e.u. for the energy of activation and entropy of activation, respectively, for the heat denaturation of deoxyribonucleic acid as measured by change in viscosity[1]. This change is not accompanied by change in molecular weight. These high values are interpreted in terms of the breaking of about fifteen successive pairs of H-bonds in the Watson–Crick structure in the activated state which precedes the irreversible collapse of the molecule. The same high order of $\Delta H^\ddagger$ and $\Delta S^\ddagger$ can be estimated from the kinetics of the loss both in the transforming activity and in the viscosity of *H. influenzae* deoxyribonucleic acid from the data of Zamenhof *et al.* Both changes are found to commence at the same temperature[14]. Thus, the kinetic studies suggest that heat inactivates deoxyribonucleic acid by a process akin to protein denaturation, whereas it inactivates tobacco mosaic virus ribonucleic acid by a breakage of a covalent bond with a direct loss in molecular weight.

The following properties of tobacco mosaic virus ribonucleic acid further point to its difference from the Watson–Crick structure : (1) the purine-to-pyrimidine ratio deviates from unity ; Knight's data show the ratio[15] is 1·2 ; (2) the sign of birefringence is positive in the case both of the free nucleic acid[16] and of the intact virus[17], indicating that the bases are aligned parallel to the long axis of the molecule, while the sign is negative in the case of deoxyribonucleic acid[18] ; (3) tobacco mosaic virus ribonucleic acid reacts readily with formaldehyde[19] and is adsorbed by active carbon[20]. Both of these reagents do not affect deoxyribonucleic acid because the bases with which they presumably interact are inside the coaxial helix. The bases of the ribonucleic acid molecule must be in some situation easily accessible to these reagents. Thus, the two important requirements—base composition and conformation—upon which the specific hydrogen-bonding of the two-stranded helix of deoxyribonucleic acid depends are shown not to be satisfied by tobacco mosaic virus ribonucleic acid.

The present comparative studies of the kinetics of degradation by heat and enzymes and of other physical and chemical properties indicate that tobacco mosaic virus ribonucleic acid is quite unlike that of the Watson–Crick double helix. These studies are of particular interest because tobacco mosaic virus ribonucleic acid and deoxyribonucleic acid molecules both share a common biological function, namely, that of self-replication. This interest is reflected in the current investigations dealing with the question of whether synthetic polyribosenucleotides can form copolymers truly resembling the structure of deoxyribonucleic acid[21,22]. There appears to be no evidence, however, to suggest that any of the naturally occurring ribonucleic acids, including that of tobacco mosaic virus, is double stranded.

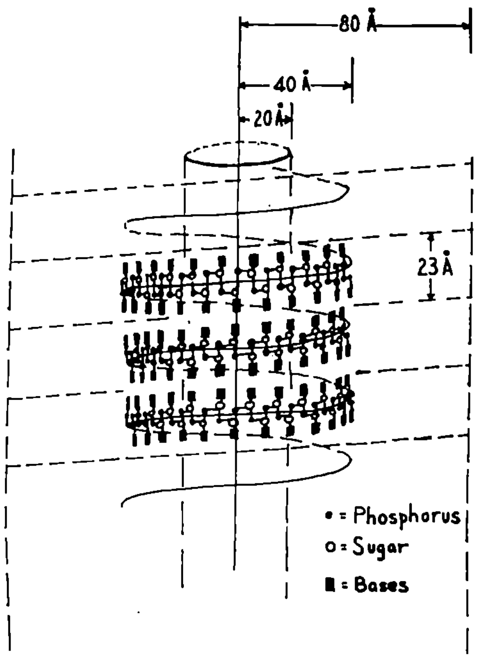

Fig. 3. Schematic representation of a single-strand nucleic acid helix of 40-A. radius (ref. 29) in position within the tobacco mosaic virus rod. The spacings of the purine and pyrimidine bases, ribose rings and phosphorus atoms with respect to the helix are made approximately to scale. There are about 50 bases per turn of the helix, aligned parallel to the longitudinal axis of the virus particle. A central hole of 20-A. radius extends the length of the particle. A protein matrix of 60-A. radius or thickness (80-A. radius of the virus less 20-A. radius of the hole) is composed of a few thousand equivalent sub-units set in a helical array about the axis of the rod (ref. 23)

Franklin *et al.* suggest that one possible model of tobacco mosaic virus ribonucleic acid involves a single strand coiled the length of the virus rod in structural conformity to the protein helix[23]. A diagram of the nucleic acid can be drawn (Fig. 3) embodying this suggestion as well as the dimensions obtained from the X-ray studies by Franklin[24] and by Casper[25] on the intact virus and its substructures. That the strand is a single molecule with a weight of about 2 million is indicated by the work of Hopkins and Sinsheimer[26], Ginoza and Norman[13] and Gierer[27]. The orientations of the ribose, phosphate and bases are arbitrarily patterned after Furberg's deoxyribonucleic acid model II[28]. The diagram depicts the ribose rings and the phosphorus atoms to be in one plane as a ribbon-like structure wound with a pitch of 23 A. (pitch of the protein helix[24]) to form a cylinder of 40-A. radius[29] by 3000-A. length[30]. The length of a helix calculated from these dimensions is about 33,000 A. For a nucleic acid chain of molecular weight 2 million to conform with this length, the spacings between phosphorus atoms along the helix would have to be about 5 A.—a reasonable value[31]. The radii of the central hole and of the virus are 20 A. and 80 A., respectively[25]. The planes of the bases are aligned, as required by the positive sign of birefringence[16,17], parallel to the long axis of the helix. A structure coiled in the manner depicted can account for the sign, which is the opposite of that reported for other ribonucleic acids[32] and deoxyribonucleic acid[18]. The 'open' arrangement of these bases is consistent with their known reactivity with formaldehyde[19] and adsorbability on active carbon[20]. The fact that this nucleic acid in cold solution will retain its positive birefringence[16] as well as its biological activity for some days following its isolation from the virus suggests that there is some kind of force stabilizing the helix. Under the present scheme, a single-chain polymer free in solution may be stabilized, as Gierer also suggests, by hydrogen bonds between turns of the helix. Such bonding would require or lead to some contraction of the coiled molecule, because the 23-A. spacings between turns would be too wide for the bridging. This type of interaction, however, is not expected to be comparable in magnitude or specificity with that involved in the internucleotide hydrogen-bonding of the deoxyribonucleic acid molecule. In the intact virus particle it appears unnecessary to invoke hydrogen-bonding to stabilize the helix because the protein matrix would be expected to perform this function.

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DEPENDENCE OF THE OBSERVED OXYGEN EFFECT ON THE POST-IRRADIATION TREATMENT OF MICRO-ORGANISMS

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TWO commercially available complete media, 'Oxoid Blood Agar Base' (10 gm. 'Lab Lemco', 10 gm. 'Oxoid' peptone, 5 gm. sodium chloride, 15 gm. agar/l.) and 'Difco Bacto Nutrient Agar' (3 gm. 'Bacto' beef extract, 5 gm. 'Bacto' peptone, 15 gm. 'Bacto' agar/l.), have been used in investigations concerning the sensitivity of *Escherichia coli, B* to ionizing and ultra-violet radiation. Survival after irradiation was estimated by plating samples, after each dose, on both 'Difco' and 'Oxoid' plates, and counting colonies after 15–24 hr. incubation. Survival curves plotted from the plate counts were always of different slope, being steeper for counts made on the 'Oxoid'. The ratios of the slopes varied from about two to more than six, depending on the type of radiation and the handling of the bacteria before irradiation (Figs. 1 and 2). After treatment by exposure to heat (51° C.) or to 0·6 per cent phenol, however, surviving fractions were the same on the two media.

Since fewer organisms formed colonies on 'Oxoid' than on 'Difco' agar, after a given dose of radiation, two possibilities were envisaged: first, that the 'Difco' medium might contain a higher concentration of growth factors for which the radiation had induced a special requirement, or secondly, that the 'Oxoid' medium contained factors which inhibited colony formation by the irradiated bacteria. The second alternative was found to be the correct one. Dialysable substances were found to be present in the 'Oxoid' nutrients which, when added to 'Difco' agar, caused the viable counts to be reduced to those observed on 'Oxoid' plates. One of these substances has been identified as chloride ion; the other, not yet identified, is associated with peptone which is present in higher concentration in the reconstituted 'Oxoid' medium. The evidence for these conclusions will be dealt with in detail elsewhere.

The results indicate that a particular type of radiation damage becomes apparent only when the bacteria are plated on a medium containing these dialysable substances, so that on other media the bacteria 'recover' from part of the total radiation effect. Our results resemble those of Roberts and Aldous[1], who plated *E. coli, B* after irradiation on synthetic and on nutrient agar, and found much the same relationship between viable counts on these two media, after ultra-violet irradiation, as we have found with 'Difco' and 'Oxoid' agar. They concluded that the nutrient medium contained a factor responsible for bringing to light a part of the damage which did not appear when a synthetic medium was used. Roberts and Aldous, however, found no effect of medium on *E. coli, B* after X-irradiation.

The presence of oxygen increases the lethal effects of ionizing radiations on bacteria[2], but does not modify the effect of ultra-violet light (Alper, unpublished results). However, that part of the damage to *E. coli, B* which is medium-sensitive appears to be much less affected by the presence of oxygen than the part of the damage which is not medium-sensitive. Thus the medium effect on a washed suspension of stationary-stage *E. coli, B* was greatest with ultra-violet light, less with X-rays in anoxic conditions, and least with X-rays under oxygen. On the other hand, the enhancement by oxygen of the sensitivities to ionizing radiations (X-rays and neutrons) was considerably greater when the bacteria were plated on 'Difco' than when they were plated on 'Oxoid'.

Radiosensitivity (S) may be defined as the inverse of the dose (D) necessary to reduce the population of colony-forming bacteria to a given fraction of the controls. If it is correct to regard the medium-sensitive and the oxygen-sensitive parts of the damage as separable, then in the general case

$$S = m\Sigma\lambda m + \Sigma\lambda n$$

where λm represents components which in the presence of oxygen are increased by a factor m, while λn represents components not modifiable by oxygen. It will be assumed that with *E. coli, B* plated on 'Difco' agar the observed radiosensitivity itself contains components which are not modifiable by oxygen, so that

$$S_{Difco} = m\,\lambda_1 + \lambda_2$$

The extra sensitivity apparent from the action of the dialysable substances from 'Oxoid' medium will be denoted by λ_{ox}.

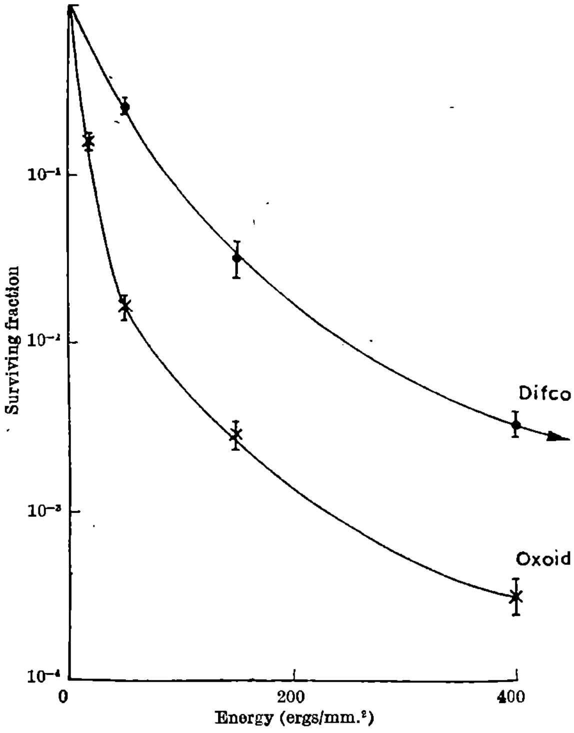

Fig. 1. Survival of *E. coli, B* in the stationary phase, after exposure to ultra-violet light

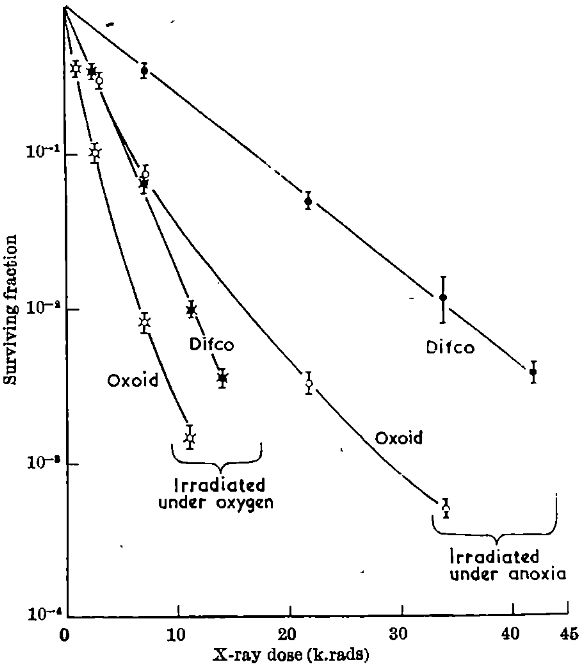

Fig. 2. Survival of *E. coli, B* in the stationary phase, after exposure to X-rays under oxygenation and anoxia

There are then four cases:

$$\text{With anoxic irradiations}\left\{\begin{array}{l} S_{Difco} = \lambda_1 + \lambda_2(\propto 1/D_1) \\ S_{Oxoid} = \lambda_1 + \lambda_2 + \lambda_{ox}(\propto 1/D_2) \end{array}\right.$$

$$\text{Irradiations with oxygen present}\left\{\begin{array}{l} S_{Difco} = m\lambda_1 + \lambda_2(\propto 1/D_3) \\ S_{Oxoid} = m\lambda_1 + \lambda_2 + \lambda_{ox}(\propto 1/D_4) \end{array}\right.$$

It would follow that

$$\frac{1}{D_1} + \frac{1}{D_4} = \frac{1}{D_2} + \frac{1}{D_3}$$

The doses found necessary to reduce the survivors of a suspension of *E. coli, B* to 10 per cent of the controls, with both X-rays and neutrons, are given in Table 1.

Table 1

Plating medium	Irradiated suspension	Symbol for dose to give 10 per cent survival	X-ray dose (k.rads)	Neutron dose (88 per cent neutrons, 12 per cent X-rays) (k.rads)
'Difco'	anoxic	D_1	16·8	8·8
'Oxoid'	,,	D_2	6·0	3·8
'Difco'	oxygenated	D_3	5·8	5·2
'Oxoid'	,,	D_4	2·9	2·6

For X-rays,

$$\frac{1}{D_1} + \frac{1}{D_4} = 0{\cdot}40$$

$$\frac{1}{D_2} + \frac{1}{D_3} = 0{\cdot}34$$

For neutrons,

$$\frac{1}{D_1} + \frac{1}{D_4} = 0{\cdot}49$$

$$\frac{1}{D_2} + \frac{1}{D_3} = 0{\cdot}47$$

For both types of radiation the agreement is within the limits of the errors involved in the determination of the doses required to give 10 per cent survival.

The relative radiosensitivities of test materials irradiated in the presence and in the absence of oxygen are of great theoretical importance. It is worth emphasizing, therefore, that the observed magnitude of this ratio for *E. coli, B* is dependent on the plating medium chosen. With 'Difco', the ratio of radiosensitivities to X-rays was observed to be $16{\cdot}8/5{\cdot}8 = 2{\cdot}9$ (given by $(m\lambda_1 + \lambda_2)/(\lambda_1 + \lambda_2)$, in the symbols defined above), whereas with 'Oxoid' as the plating medium the ratio was observed to be

$$\frac{6{\cdot}0}{2{\cdot}9} = 2{\cdot}1, \text{ given by } \left(\frac{m\lambda_1 + \lambda_2 + \lambda_{ox}}{\lambda_1 + \lambda_2 + \lambda_{ox}}\right)$$

It can be predicted that if a medium is used which will reduce λ_2 to less than its value with 'Difco', a still greater ratio of 'oxygenated' to 'anoxic' radiosensitivities will be observed.

The following bacteria have also been tested for survival after irradiation on 'Difco' and 'Oxoid' plates: *E. coli, B/R*; *E. coli, K*12; *E. coli*, 86; *Shigella flexneri, Y6R*; and *Salmonella typhimurium*. Only the last-mentioned showed an effect similar to that shown by *E. coli, B*, and this to a much smaller extent. However, post-irradiation modification of damage to various micro-organisms by different methods have been reported[3], and there are indications that effects may be found with other species which are analogous to those which occur with *E. coli, B*. It seems likely, therefore, that the extent of the oxygen effect observed with strains other than *E. coli, B* might be modified by the post-irradiation treatment. Such phenomena may be in part responsible for different oxygen enhancement ratios observed with closely related strains of micro-organisms[4], or for different ratios observed with the same strains in different laboratories.

We are greatly indebted to Mr. D. Moore for carrying out the neutron irradiations and dosimetry.

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INFRA-RED SPECTRA OF FREE RADICALS

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FLASH photolysis has been extensively used to produce momentarily a sufficiently high concentration of a number of free radicals to enable their absorption spectra to be observed in the photographic regions[1-4]. The availability of photoconductive detectors with time constants of the order of 10 μsec. or less makes it possible to examine fast reactions in the infra-red, and several rapid-scanning infra-red spectrometers have been designed and constructed for this purpose[5,6]. We have constructed such an instrument with a lead telluride detector and have used it to search for the N–H stretching frequencies of the NH_2 molecule.

The instrument is equipped with a calcium fluoride prism and uses a continuously rotating Littrow mirror. The mirror is aluminized on both sides and sweeps a spectrum across the exit slit twice in each rotation. An 'optical vernier' system supplies a set of fiduciary marks which enable the angular displacement of the mirror to be measured with a precision somewhat better than ½′. The spectrum and the markers are presented on the two traces of a DuMont Type 322*A* double-beam oscilloscope. The first marker in the set synchronizes the oscilloscope sweep and the high-intensity photolysis flash.

The flash is produced in the usual manner[3] in a quartz tube 1 m. long and 1 in. in diameter inside a cylindrical reflector adjacent to a quartz absorption cell 1 m. long and 2 in. in diameter. The spectrum source is a tungsten filament or Nernst glower forming an image on the entrance slit.

When hydrazine is photolysed at a pressure of about 1·2 cm. and with a flash energy less than 3,000 joules, the 3-μ doublet becomes rather ragged on the long wave-length side, but is otherwise unchanged. At flash energies of 3,000 joules and more, the explosive thermal decomposition of hydrazine is triggered[8]. The doublet disappears and is replaced by a broad region of absorption between slightly less than 3·00μ and about 3·24μ. The spectrum taken several seconds after the flash shows only the *Q*-branch of the NH_3 produced, with a shoulder on the long wave-length side due to undecomposed hydrazine.

Fig. 1 shows tracings of a typical sequence of records for a photolysis experiment. *A* is the comparison spectrum of hydrazine recorded several seconds before the flash is triggered; *B* is the flash record itself. The oscilloscope sweep, initiated simultaneously with the flash, was started at the point marked *X* and was carried off the face of the oscilloscope by the scattered light and the accompanying electric and electromagnetic noise pulse. Recovery was complete in 0·5–0·6 msec. *C* is the spectrum of ammonia and residual hydrazine, products of the reaction, taken several seconds after the flash. *D* is the set of fiduciary marks recorded with *C*. The markers recorded with the other traces have been omitted. *E* is a set of time markers recorded immediately after *C* by substituting in the spectrum channel the output from a 'Tektronix' Type 180 time-mark generator. The oscilloscope sweep has been expanded about three-fold and becomes somewhat non-linear at the edges, but this does not interfere with either the measurement of wave-length or time interval. The markers shown are at 0·1- and 1·0-msec intervals.

A number of such sets of records have been obtained, and, in general, the successive traces in a set can be reasonably well superimposed except in the regions

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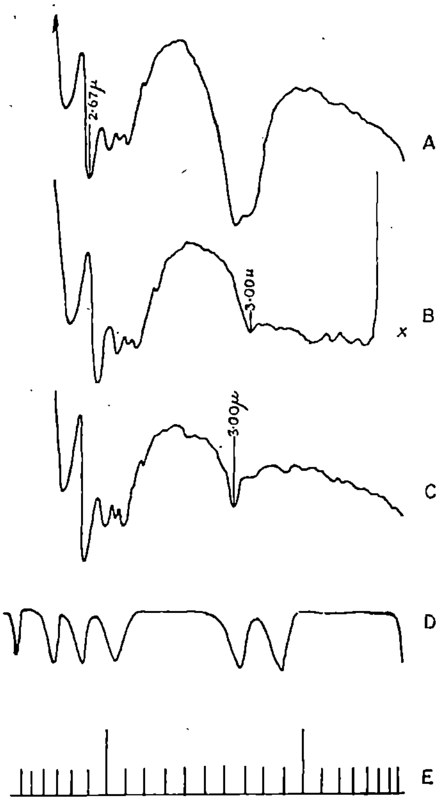

Fig. 1. Tracings of a typical record sequence. (*A*) Initial spectrum of parent compound (hydrazine). (*B*) Flash spectrum showing free-radical absorption. The spectrum is swept from right to left. (*C*) Product spectrum taken several seconds after the flash showing ammonia and residual hydrazine bands. (*D*) Fiduciary marks recorded simultaneously with *C*. (*E*) 1·0 and 0·1 msec. time marks recorded several seconds after *C*

of differing absorption and at the extreme ends. Using the final NH_3 spectrum as a background except in the 3-μ NH_3 band itself where the background was interpolated from the band edges, several records have been reduced to per cent transmission plots which are shown in Fig. 2. (In each case the abscissa is that of the original record and has not been reduced to a common linear wave-length scale; however, the measured wave-lengths are given.) It is noted that in every case a definite band appears at 3·125 ± 0·01μ. The 'fine structure' observed on one trace is probably a noise artefact. The time marks make it possible to determine the interval between the initiation of the flash and the appearance of the 3·125-μ band at the exit slit. These time intervals are given in Fig. 2. It is evident that the 3·125-μ band becomes progressively weaker and the 3·00-μ NH_3 band becomes stronger as the time between the flash and the passage of the band across the exit slit increases. It appears then that the absorption at 3·125μ is due to a transient molecule with a half-life somewhat less than 1 msec., but which can still be observed several milliseconds after the initiation of the flash. This corresponds with the kinetic behaviour of the α-bands ascribed by Herzberg and Ramsay to the NH_2 molecule[7,8].

There are two N–H stretching frequencies for this molecule in the 3-μ region, and if the force constants are not too different from those of NH_3, the symmetric stretching frequency, ν_1, will be at about 3·1μ and the unsymmetric frequency, ν_3, rather close to 3·0μ (ref. 7). It is impossible from the present records to distinguish unambiguously this latter band from that of NH_3. Nevertheless, it is evident that there is strong absorption between 3·0 and 3·1μ. Part of this absorption remains on the spectrum taken several seconds after the flash, and is evidently due to hydrazine. This might be expected as arising from the recombination of NH_2 radicals. However, the absorption intensity in this region is strong relative to the NH_3 band at 3·0μ immediately after the explosion, and the intensity decreases in much the same way as that of the 3·125-μ band. From an average of several estimates of the maximum absorption in this region immediately after the flash, the ν_3 band of NH_2 has been assigned the wave-length 3·049μ (3,280 cm.$^{-1}$). Using the assignments of ν_1 = 3,200 cm.$^{-1}$ (3·125μ), ν_3 = 3,280 cm.$^{-1}$ (3·049μ), and 103° as the valence angle[9], we have calculated the valence force constants[10] as k_l = 5·74 × 10^5 dynes per cm. and k_δ/l^2 = 0·31 × 10^5 dynes per cm. These values fall into the general pattern of force constants observed for other XY_2 molecules and for NH_3. The bending frequency ν_2 calculated from the simple valence force treatment has the value ν_2 = 1,060 cm.$^{-1}$ (9·4μ).

In addition to the NH_2 spectrum, Ramsay[8] observed NH bands. The absorption in the 3-μ region of the exploding gas is quite general, and absorption from NH molecules can certainly be accommodated in the observed spectrum. However, the band of the NH molecule at the high temperatures would be expected to be rather wide and relatively weak at the centre, whereas the two NH_2 bands, and particularly the ν_3 band, are expected to be more compact.

The possibility suggests itself that the absorption might be due to 'hot' molecules, either N_2H_4 or NH_3, and it is true that absorption from such species would be expected in this region. The rotational temperature observed by Ramsay[8] for NH radicals in the explosive decomposition of hydrazine is 1,400° K. Hydrazine decomposes thermally at a temperature of 250°–300° C. (ref. 11), and explodes at a much lower temperature when sparked. It seems unlikely that at 1,400° K. the molecule would last as long as a few microseconds, about 10^7 vibrational cycles, without decomposing. However, the principal argu-

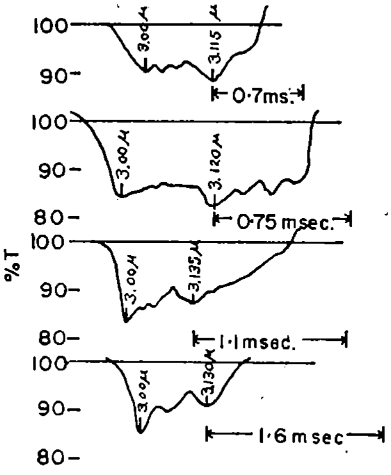

Fig. 2. Four flash spectra plotted as per cent transmission showing measured wave-lengths and delay times

ment against the assignment of these bands to either 'hot' N_2H_4 or NH_3 is the kinetic one. The maximum absorption of the transient band is about 0·75 msec. after the initiation of the flash, or about 0·6 msec. after the peak of the flash intensity. As the transient absorption decays, the 3-μ ammonia band grows at about the same rate. There is no period either before the appearance of the transient band or between it and the appearance of the NH_3 band which would accommodate an intermediate compound with a half-life anything like 1 msec. But Ramsay and Herzberg have convincingly demonstrated the presence of NH_2 radicals with a half-life of about 1 msec. in this system. The 'hot' molecule hypothesis then necessarily implies that: (1) the principal quantity of hydrazine is converted directly to ammonia without the formation of an intermediate compound with a half-life greater than a fraction of a millisecond other than the 'hot' molecule itself; and (2) that the NH_2 absorption coefficients are exceptionally small in the infra-red or exceptionally large in the violet. Neither of these implications is inherently plausible, nor is the first in accord with the postulated mechanisms of the reaction[11].

Ramsay and Herzberg[7] observed the NH_2 spectrum in the flash photolysis of 1 mm. of NH_3 ". . . with approximately the same intensity . . ."[8] as observed in the explosive decomposition of hydrazine. A considerable effort has been made to observe the 3·125-μ band in the photolysis of ammonia and in the non-explosive (using sub-critical flash energy) photolysis of hydrazine. The results have been uniformly negative. In the case of NH_3, this is not too surprising, since the decomposition of NH_3 requires light with a wave-length shorter than about 2100A., and a relatively small proportion of the flash energy will be in this region. Hydrazine photolyses on irradiation at somewhat longer wave-lengths. Fig. 2 shows that the maximum optical density in the transient absorption is about 0·08. A reduction in partial pressure by a factor of ten would take the signal into the noise-level. When the α-bands are observed with photographic plates, however, the more or less linear relationship between the photographic density and the logarithm of the incident intensity would make the method much less sensitive to changes in optical density at very weak absorption-levels. In fact, if the plates were developed so that the zero absorption background still lay on the 'toe' of the characteristic curve, the increasing gamma for larger transmitted intensity (weaker absorption) would tend to suppress to the eye the effects of decreased radical concentration. Infra-red absorption coefficients are considerably smaller than those for electronic-vibration bands, so it appears to be evident that the flash alone simply does not supply enough effective photons to create an observable concentration of these radicals in the infra-red.

Norrish *et al.*[2,4] have photographed the ultra-violet spectra of a number of diatomic free radicals produced in explosions initiated homogeneously throughout the absorption cell by free radicals resulting from the flash photolysis of nitrogen dioxide or a similar sensitizing compound. Plots of the measured concentrations against the time from the initiation of the flash show a characteristic sharp rise in 0·1–0·6 msec., followed by a slower decay. Fig. 3 shows a similar situation for the present 3·125-μ absorption. The open rectangles give the measured absorption intensity relative to the original N_2H_4 intensity vs. the time in milliseconds after the initiation of the flash. The areas of the rectangles indicate the probable error limits of the measurements. The crossed square is the result of an experiment in which the 3·125-μ band was obscured by the flash, but no, or at most very little, absorption could be observed at 3·00μ 0·6 msec. after the flash. Electronic recovery was essentially complete at this wave-length at about 0·5 msec. Since little or no absorption was observed which could be ascribed to ammonia, the reaction product, or to the 3·05-μ (or vicinity) NH_2 band, it has been assumed that the absorption at 3·125μ is zero or almost zero. Another experiment, in which the 3·125-μ band was obscured by the flash but the 3-μ region was not, showed a small but definite absorption at 3·00μ at about 0·7 msec. The solid line curve is a logarithmic decay curve obtained by fitting by eye a straight line to the points on a semilog plot. The half-life is 0·7 msec. A record in which the 3·125-μ band was scanned at 4 msec. showed no detectable absorption. The NH_3 bands at 3μ were somewhat broadened, but otherwise the same as those scanned several seconds after the flash.

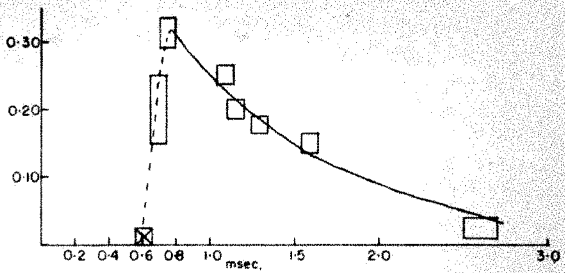

Fig. 3. Relative absorption intensity versus time after initiation of photolysis flash. Solid curve is logarithmic with a half-life of 0·7 msec.

While not completely unambiguous, until high resolution can be applied to these bands, the best interpretation appears to be that they are principally due to NH_2 radicals with possible contributions from NH, N_2H_3, and 'hot' N_2H_4 and NH_3.

It has been shown that with the use of fast photoconductive detectors, infra-red spectroscopy can be applied to the study of free radicals and other short-lived molecules with conditions of resolution approaching those of conventional instruments using thermal detectors. Furthermore, by direct photometric techniques, kinetic studies can be made easily and relatively accurately.

Work on the spectra of other free radicals and a more complete description of the apparatus will be published elsewhere.

This investigation has been conducted under the sponsorship of the United States Air Force, Office of Scientific Research.

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LETTERS TO THE EDITORS

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Early Stages of Infection with the *Tipula* Iridescent Virus

In previous studies on this interesting virus, empty membranes of the same size and shape as the virus particle were frequently seen. The possibility was envisaged[1] that these empty membranes might be incomplete virus particles analogous with the nucleic-acid-free 'top component' of the turnip yellow mosaic virus[2].

Further work, however, with ultra-thin sections of fat-body from infected larvæ of *Tipula paludosa* suggests an alternative explanation. Examination of material in the early stages of infection reveals the presence of these empty membranes in very large numbers; they are often more numerous than the normal virus particles (Fig. 1). Furthermore, they do not seem to occur in the advanced stages of the disease in which the virus particles are lining up to form microcrystals in the fat-body; in such a case all the virus particles are fully formed.

In addition to the completely empty membranes, others occur with a small dark central spot, varying in size in different membranes. It is, in fact, easy to pick out all the stages in which the size of the central spot varies, from the first beginnings to the completely filled membrane of the mature virus particle (Fig. 2).

It seems, therefore, a reasonable assumption that these empty and partly empty membranes may be stages in the development of the *Tipula* iridescent virus. This is further supported by the fact that they do not apparently occur in the late stages of the disease. Because these empty forms are the same size as the fully formed virus particle, the possibility is ruled out that the appearance is due to an oblique

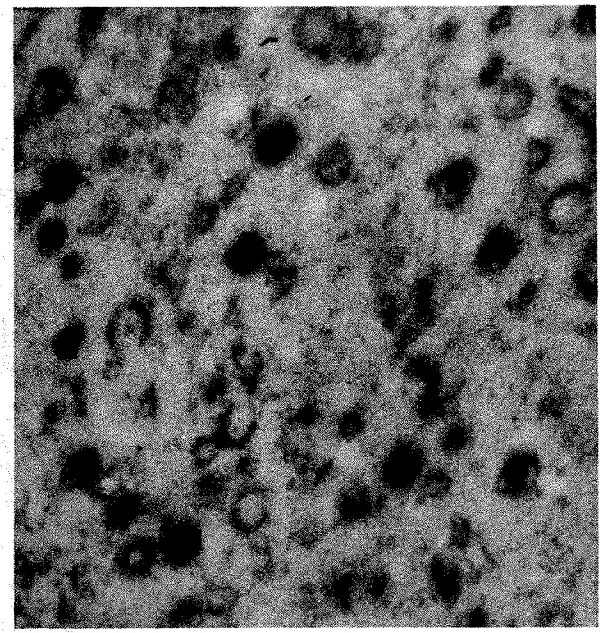
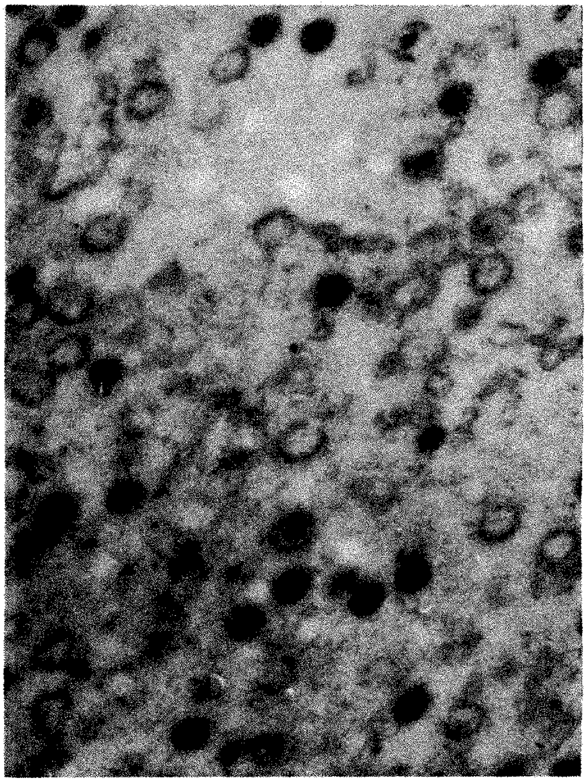


Fig. 1. Ultra-thin section of *Tipula* fat-body showing numerous empty membranes; virus particles appear dark. (× 40,000)



[Fig. 2. Similar to Fig. 1, but showing several membranes with a developing centre. (× 40,000)

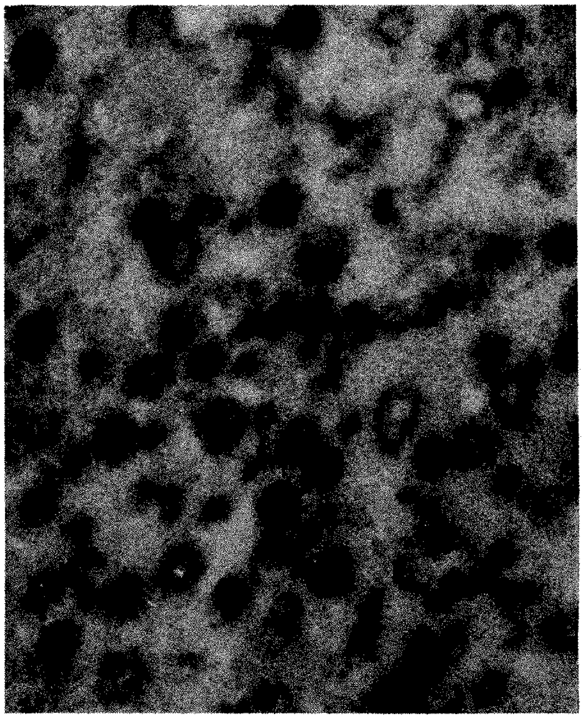


Fig. 3. Similar to Fig. 1, but showing the resemblance between the virus membranes and the endoplasmic reticulum. (× 40,000)

section passing through part of the particle only. On this assumption, the process seems to be that the membrane forms in the cytoplasm first, and then the deoxyribonucleic acid and protein begin to appear as a small darkly staining spot in the centre gradually increasing in size until the membrane is filled.

Another rather striking fact, which may of course be coincidental, must be pointed out. This is the truly remarkable resemblance between the empty virus membrane and the endoplasmic reticulum[3]. The diameter and appearance of the limiting membranes appear identical and here again all grades exist between the long forms and the oval-shaped membranes of the endoplasmic reticulum; these latter cannot be differentiated on the electron microscope from the empty virus membranes (Fig. 3).

I am indebted to Mr. G. J. Hills for taking the electron micrographs.

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Influence of Cocarboxylase on Tolerance to Morphine in the Rat

THE basic physiological mechanism affected by morphine may be that of the enzymatic processes involved in glucose metabolism: it is known, indeed, that morphine inhibits glucose and pyruvic acid utilization by minced brain[1], and the decarboxylation by rabbit's liver and brain homogenates of pyruvic acid[2]. Further, morphine is known to reduce the level of carbon-14 in brains of rats fed with labelled glucose[3]. Cocarboxylase activity is unaffected in chronically morphinized rats, but responses to pyruvate and cocarboxylase of *in vitro* muscle from animals deficient in thiamine and from chronically morphinized ones are similar, suggesting a metabolic defect in common to both conditions[4]; thiamine has no effect on morphine withdrawal symptoms in man[5], though it decreases their intensity in rats[6]. Lastly, glycids and their metabolites change the analgesic effect of morphine.

We therefore investigated the influence of thiamine and of cocarboxylase on the analgesic effect of morphine and on the appearance of tolerance to this effect.

Ninety rats were used in three sets of experiments. The animals, after a control analgesimetric test for a standard dose of morphine, were treated daily with thiamine or cocarboxylase followed 30 min. later by morphine. Controls received daily morphine only. In the course of treatment analgesimetric tests were carried out about every ten days. The analgesic effect of morphine was determined by the D'Amour and Smith technique and the analgesic efficacy was estimated in minutes and seconds of analgesia[7]. Table 1 shows the scheme of treatment in each set of experiments, and Fig. 1 shows the results.

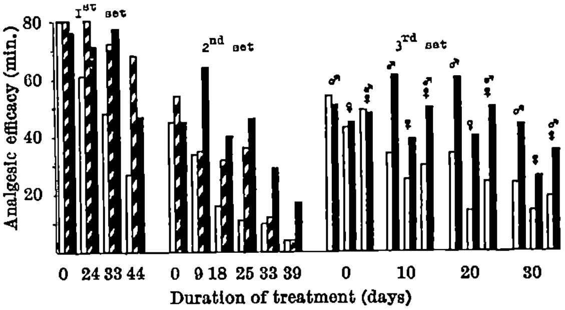

Fig. 1. Analgesic efficacy of a standard dose of morphine in successive tests in control animals and in animals pretreated with thiamine or cocarboxylase during chronic treatment with morphine. Open columns, controls; diagonally shaded columns, pretreated with thiamine; black columns, pretreated with cocarboxylase

In our experimental conditions, daily treatment with thiamine or cocarboxylase at first prevented and afterwards delayed—in comparison with the controls—the progressive appearance of tolerance to the analgesic effect of morphine. In these conditions we were not able to detect any analgesic effect due to thiamine or cocarboxylase, or any potentiating effect, in a merely pharmacological sense, of the analgesic effect of morphine. The main observations were as follow:

(*a*) With the progressive appearance of tolerance to the analgesic effect of morphine, the behaviour of the control animals changes; they become hyper-excitable, hyper-reactive and aggressive. This does not happen with the animals pre-treated daily with thiamine or cocarboxylase until the analgesic response remains unchanged or moderately decreased. Tolerance and change in behaviour may, therefore, be connected.

(*b*) The abrupt interruption of the daily morphine treatment in the controls—once tolerance to the analgesic effect has appeared—induces on the following day a moderate state of depression. This does not happen with animals pre-treated with thiamine or cocarboxylase.

(*c*) Instituting treatment with cocarboxylase in controls which have become tolerant to the analgesic effect seemed to accelerate the rate of recovery of the analgesic response to morphine.

Table 1. SCHEME OF TREATMENT

		No.	Weight (gm.)	Sex	Test morphine (mgm./kgm. subcutaneous)	Treatment (10 mgm./kgm. intraperitoneally)	Morphine		Time (days)
							Route	mgm./kgm./day	
1	Controls Pretreated Pretreated	10 10 10	130–200	♂ and ♀ (random)	10	Sodium chloride 9°/₀₀ Thiamine Thiamine + cocarboxylase	Subcutaneously	10th until the 25th day 15th until the 34th day 25th until the 42nd day	42
2	Controls Pretreated Pretreated	10 10 10	120–160	♂ and ♀ (random)	5	Sodium choride 9°/₀₀ Thiamine Cocarboxylase	Subcutaneously	15	40
	Controls Pretreated	20 10	90–100	♂ and ♀ 1 : 1	7·5	Sodium chloride 9°/₀₀ Cocarboxylase	Intraperitoneally	15	30

Our experiments confirm, as shown in Fig. 1, a difference between the sexes in susceptibility to the analgesic effect of morphine, female rats being less sensitive at the same body-weight—and consequently for the same total dose—than males.

Di Mattei's hypothesis[8] on the relations between the functions of certain vitamins and the pharmacological effects of some drugs suggests that morphine may affect in some way biological processes in which thiamine is involved.

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Effect of Hypothermia on Death by Starvation

It is known that during the winter months some animals adjust themselves to unfavourable living conditions, particularly food shortage, by hibernation. This leads to a considerable lowering of the total metabolism and a drop in body temperature which enable the animals to survive the winter with a minimum consumption of nutrient.

Recently some very interesting substances have been prepared, for example, chlorpromazine, which produce an effect in some respects resembling hibernation. Hence the term 'artificial hibernation'. Chlorpromazine has been used with good results in psychiatry, surgery, pædiatrics and clinical states with a general hyper-reactivity of the patients.

We attempted to solve the problem, whether the effect of this substance can in some manner protect the animal from death from starvation, as this is, no doubt, the main purpose of hibernation in Nature.

The experiments were carried out on rats. We used 10 rats which had been fed on a standard diet (Larsen). They were then deprived of food while they had free access to water. Half the animals received chlorpromazine (Largactil Specia), 5 mgm./kgm. body-weight daily. The second group was used as control. Chlorpromazine, which lowered the body temperature of the experimental group by 3° C., caused a general apathy with a lowering of voluntary movements, but did not exert any influence on the time of survival (control group $6{\cdot}0 \pm 1{\cdot}4$, experimental group $6{\cdot}5 \pm 1{\cdot}73$ days; $P = 0{\cdot}7$) or on the loss of weight. The weight curves were the same in both groups. Nor was the excretion of nitrogenous substances much affected (control group 120 ± 27, experimental group 100 ± 12 mgm. nitrogen/24 hr./100 gm. weight; $P = 0{\cdot}2$) and ketone bodies (expressed as acetone) in the urine (control group $0{\cdot}18 \pm 0{\cdot}05$, experimental group $0{\cdot}19 \pm 0{\cdot}07$ mgm. ketone bodies/24 hr./100 gm. weight; $P = 0{\cdot}8$).

Apparently the drop of body-temperature under the influence of chlorpromazine was too small to protect the animals from death by starvation. We did not want to use larger doses of chlorpromazine for fear of pharmacological side-effects. Therefore in subsequent experiments we chose young rats (10 days old) because, as is well known from the literature[1-4], their body-temperature can easily be lowered to the environmental temperature. We used suckling rats from the same litter of which half (5 animals) were kept at an optimal temperature of 30° C., the second group at 20° C. Both groups of animals were taken from their mothers at the same time. The body-temperature of the animals kept at 20° C. dropped considerably within 15 min. and the rate of respiration decreased by as much as 40 per cent. In spite of this the group which survived in the colder environment was not protected against death by starvation. The time of survival at a temperature of 30° C. was $98 \pm 13{\cdot}6$ hr., at 20° C. $85 \pm 9{\cdot}9$ hr. ($P = 0{\cdot}2$). The total weight-loss as compared with the control group was, however, less than half (12·5 per cent loss of body-weight in animals kept at 20° C.; 34·3 per cent in animals kept at 30° C.; $P < 0{\cdot}01$). It is interesting that the relative composition of the carcase was, in both groups, practically the same. The animals kept at 30° C. had at the end of the starvation period a carcase composition of 80 per cent water, 20 per cent dry matter, 2·4 per cent nitrogen; the animals kept at 20° C. 82 per cent water, 18 per cent dry matter, 2·1 per cent nitrogen. During starvation, however, the control group kept at 30° C. lost 2·1 gm. more water (that is, 175 per cent more).

The animals kept at a temperature of 20° C. were pale, apathetic, with voluntary movements reduced, and a slow rate of respiration. The opposite was true of animals starving at 30° C.; they also had very strong sucking reflexes. It is interesting that as compared with the first group we noted a marked growth of fur in these animals during the starvation period.

The most probable explanation of our findings is that the hypothermia caused by chlorpromazine bears no relation to the reduction of the total energy metabolism. This is in agreement with the work of Ankermann and Jung[5], who showed that oxygen consumption in such animals is not reduced but actually has a tendency to rise. Chlorpromazine could cause a lowering of oxygen consumption and a reduction in metabolic rate if at the same time the body was cooled physically, thus lowering the temperature twice as much as in our experiments.

However, even experiments on young rats, where the reduction of body-temperature was as much as 10° C., did not protect the animals from death by starvation. This fact (independently confirmed at another laboratory: Faltová, E., and Konečná, V., personal communication) is very interesting from the point of view of the mechanism of death by starvation, since hypothermia protects animals, particularly young animals, from short-term stresses, such as anoxia, pain and poisons.

From our experiments, and those of other workers using 'artificial hibernation', it appears that the term 'hibernation' is not suitable.

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THE INDIVIDUAL: UNIQUE BUT IMPERFECT

The Uniqueness of the Individual
By Professor P. B. Medawar. Pp. 191. (London: Methuen and Co., Ltd., 1957.) 18*s*. net.

ARTICLES and lectures published by Prof. Medawar over the past twelve years are here collected together and presided over by an essay on the wider implications of skin grafting specially written for the volume. That Prof. Medawar should exhibit an easy command over his material is to be expected; his equal command over the English language will give great pleasure to his readers, whose close attention he constantly rewards by a turn of phrase or a felicity of expression which enlightens as it entertains.

The eight essays range widely, but Prof. Medawar threads them together upon the topical theme of evolution. To this end he devotes his introduction to a defence of natural selection, which prepares the way for the first two essays. These start by formulating the evasive phenomena collectively recognized as 'growing old'; and then develop Medawar's idea that ageing is a consequence of the declining impact of natural selection upon those members of a population who have lived longest and who, owing to the mere hazards of time, contribute least to succeeding generations. That adaptation may proceed faster during the earlier phases of an animal's life-history than later on has important consequences for the comparative zoologist as well as for the actuary.

It is perhaps particularly in "A Commentary on Lamarckism" that Prof. Medawar's interest and skill in the careful definition of terms and the orderly unfolding of an argument are made apparent. Lamarckism takes a 'weak' and a 'strong' form: the weak form asserts that some types of inheritance could be interpreted in a Lamarckian fashion; the strong form asserts that these are correctly so interpreted—an assertion which Medawar finds unproved among the Metazoa and meaningless among the microbes.

Helmholtz's somewhat insensitive strictures upon the human eye were provoked by the perfectionist school of evolution, which may not be vocal to-day. But adaptation is still too often regarded as a condition rather than as a process, an arrival rather than an optimistic journey, and it is against this error that the essay on "The Imperfections of Man" is directed. As a newly evolved organism, man may perhaps be unusually imperfect, but this is hard to assess since he has kicked over the scales, shaping rather than being shaped by the environment, doctoring his ailments and supplementing genetic inheritance by tradition. This is the subject of a short essay on "Tradition: The Evidence of Biology", in which the reader is spared the too obvious and humiliating undertones of a theme which earlier generations of Darwinists would have developed with robust confidence.

"The Uniqueness of the Individual"—the title of the last and longest of these essays—lies at the heart of evolution theory. It is not, however, with the evolutionary aspects of uniqueness that Prof. Medawar is here primarily concerned, but with a new manifestation of uniqueness and the light which this throws on the organization of the individual. The preliminary facts are provided by modern surgery: skin can be transplanted from one part of an individual to another, but not from one individual to another. But there are significant exceptions to this rule: transference is possible between identical twins, members of very pure strains, embryos, or individuals whose blood-streams have been naturally or artificially confluent during embryonic life. Prof. Medawar gives an account of the reasoning and the series of critical experiments by which he and his colleagues, among others, have explored these phenomena.

There are two questions. First, what is the unique substance or group of substances apparently produced by all the tissues of an individual? Secondly when a tissue is transplanted into another member of the same species, what is the mechanism activated by this substance causing the host to treat the graft as a foreign body and destroy it? To these two questions it is to be expected that Prof. Medawar, as a zoologist, should add and discuss the answer to a third: What are the normal functions of these processes which have been almost accidentally brought to light through surgical practice and experiment? He suggests, only to reject, the idea that the tissue exudate is a sort of queen-substance which regulates the growth of the body. But is not the alternative suggestion—that, having passed from the nucleus to perform its function in the cytoplasm, it emerges from the cell as a mere excretion—too great an anticlimax? Excretion is a favourite disguise for elusive physiological processes. Many of these investigations have been reported in specialized medical journals, but they are of great consequence for biology in its widest sense, and biologists of many sorts will be most indebted to Prof. Medawar for publishing this masterly survey of a challenging field of research.

D. A. Parry

THE FACE-CULT

The Eye Goddess
By Dr. O. G. S. Crawford. Pp. 168+48 plates. (London: Phoenix House, Ltd., 1957.) 50*s*. net.

THOSE acquainted with the services which Dr. O. G. S. Crawford rendered to prehistoric archæology will read this interesting, speculative book with mingled feelings of gratitude and regret, since its publication was followed immediately by the author's lamented death (*Nature*, January 18, p. 156). If his chief contribution to the science has been in the domain of air photography and as the founder and editor of *Antiquity*, in this volume (written, incidentally, in the first instance for readers of *Antiquity*) he has shown remarkable powers of detection in the elucidation of obscure symbols on rock-carvings, cult-objects, megalithic monuments and other tombs and temples. These enigmatic figures have long been a matter of discussion and speculation, and in recent years it has become increasingly clear that they were very intimately connected with the cult of the goddess in its various forms and phases.

The axes and daggers which Mr. R. J. C. Atkinson found carved on the sarsens of Stonehenge in 1953 started Dr. Crawford on his quest and eventually led him to a temple at Brak in the Khabur valley in eastern Syria, belonging to the Jemdet Nasr period about 3000 B.C. In this sanctuary, dedicated to the Mesopotamian goddess Inanna-Ishtar, Prof. Mallowan discovered in 1937–38 a quantity of female figurines with very prominent eyes, sometimes associated with similar male figures, representing in all probability cult-images of the mother-goddess and her consort son. Statuettes of this nature, so prevalent from the eastern Mediterranean and the Fertile Crescent to the Indus valley, suggest the wide-spread distribution of a fertility ritual in the ancient Near East connected with the renewal of vegetation at the annual festival in the spring.

On this hypothesis, for which there is reasonably strong presumptive evidence, Dr. Crawford proceeds to trace the diffusion of the "Face-cult" westwards in successive waves overland through, or (as he thinks more likely) by sea around, Anatolia to the Troad, the Aegean, Crete and Greece, and thence to the Danube basin; along the Mediterranean to southern Italy, Sicily, Malta and Spain, with possible extensions to north Africa and the Canary Islands. Northwards, following the Atlantic littoral, it made its way along the coastal megalithic route to Brittany, Ireland, Britain and north-west Europe. Thus, at Los Millares in Almeria, where contacts with the Aegean, Crete, Anatolia and the eastern Mediterranean have been recognized for some time, 'owl-eyes' were painted on cist plaques, bovine phalanges, and stone and ivory cylinders found in megalithic tombs. In the northward extension of the cult the links become increasingly less apparent and problematical; nevertheless, Dr. Crawford has been able to make a fairly convincing case for an unbroken chain connecting its probable appearance in Brittany and Ireland in the second millennium B.C. with that in Anatolia, and ultimately, in the previous millennium, at Brak in Syria. Its arrival in northern Britain, very likely from Ireland with the passage graves, raises a number of problems regarding dating and technique that await final solution. This also applies to the Danish 'owl-faced pots' and their possible connexions with similar sherds from Los Millares, and the other indications of Danish–Iberian relations.

If there are some weak and missing links in the evidence at present available, this provocative volume, with its excellent photographs, drawings and maps, focuses attention on a complex of widely dispersed cult-symbols which hitherto have not received the serious consideration their importance and significance merit. It is indeed regrettable that the author could not complete the inquiry he had begun with such ingenuity and promising results.

E. O. JAMES

DARWIN AND THE HISTORY OF SCIENCE

The Darwin Reader

Edited by Prof. Marston Bates and Dr. Philip S. Humphrey. Pp. ix+481. (London: Macmillan and Co., Ltd., 1957.) 30*s*. net.

WE are here given a reprint of Darwin's "Autobiography" and extracts from several of his books. Some of the extracts are long—more than a third of "The Origin of Species" is included, and about one-sixth of "The Descent of Man". There are also shorter extracts from "The Expression of the Emotions", "Climbing Plants", "Insectivorous Plants" and "The Formation of Vegetable Mould by Earthworms". It is a pity that these last extracts could not have been longer, for Darwin's minor works are some of the most fascinating books in zoological literature, giving as they do a very clear insight into his methods of work as an investigator.

In their introduction the editors state that their object was to provide a book for a course aimed at giving students who will not be scientists, and who will presumably not have much general knowledge of biology, some appreciation of scientific thought. When they read Irvine's biographies of Darwin and Huxley in "Apes, Angels and Victorians", it seemed to them that there was a book that could be used "to build up an illuminating case-history in the development of science", but that if students were to read about Darwin they should also read some of his works. They could scarcely be asked to give the time needed for reading the whole books.

The compilation has been well done, and the book gives a sound view of Darwin's broad outlook as a naturalist and the fairness of his argumentation. But it is less clear that the book is suited to the object for which it was designed. In reading Darwin's work, anyone acquainted with modern biology continually meets passages which would certainly be written differently to-day. At several points Darwin's views have definitely been discarded, as, for example, his belief that the species is nothing more than a stage in the process of differentiation, his attribution of sexual selection to æsthetic appreciation by the opposite sex, and, for most modern biologists, his frequent recourse to Lamarckian inheritance as a real, if not a primary, cause of evolution. It is to be expected that not all his beliefs should be accepted after a lapse of a century, and it is the best test of the soundness of his work that it has stood the test of time with so little modification. But if a student who has not a good background of modern biology reads Darwin, and him alone, he will certainly get an out-of-date view of evolution and its theory.

The book might well be useful in a course on the history of science at a later stage of biological education, though in such a course the books themselves should perhaps be read; no one better than Darwin can easily be found as an exemplar of scientific argument. For the purpose for which the book was designed it would seem that some more recent work would be more appropriate. It is true that a few recent books on evolution are cited in an appendix as suggestions for further reading, but it seems that the student should know the modern theory *before* he takes up the reading of Darwin.

Whatever doubts one may have concerning the use to which the book is to be put, any work that may encourage biologists to take an interest in evolution and the history of its theory is welcome, and this book should certainly do that. It is especially valuable that the "Autobiography" should be reprinted; this has not been done, to my knowledge, since Darwin's "Life and Letters" were published by his son in 1887. G. S. CARTER

THE MECHANISM OF INSECT FLIGHT

Insect Flight

By Dr. J. W. S. Pringle. (Cambridge Monographs in Experimental Biology, No. 9.) Pp. viii+133. (Cambridge: At the University Press, 1957.) 15*s.* net.

THE problem of how insects fly has interested biologists for a very long time. This interest has been intensively revived, partly as the result of the development of new techniques, since the War. Half the references on which "Insect Flight" is based are from the past ten years, showing new productivity which would be sufficient reason in itself for a monograph. But the immediate reasons for its appearance are twofold. One is the realization (by Boettiger and Pringle, independently) that in insect flight muscle, particularly that of the higher orders of insects, there are peculiar physiological mechanisms of considerable interest. The interpretation of these may throw new light on problems of the functioning of muscle tissue in general. The other is the recent publication of several papers which describe a very thorough investigation of the flight of locusts made by T. Weis-Fogh, a brilliant pupil of the late August Krogh. This work made the minimum of assumptions, utilized exact methods and rigorous analysis and thereby greatly illuminated the whole problem. These matters are dealt with in the monograph. At every stage in the presentation new lines of development are made apparent. In particular, the elucidation of the special physiological problems of the flight muscles offers a rewarding challenge, and the aerodynamic problems which have been overcome by extremely small flying insects require clarification.

The monograph illustrates well the newer approach to problems of experimental biology, in which the artificial barriers between collateral disciplines are broken down in the interest of solving a single functional problem. The anatomy, fine-structure, cytology, biochemistry, sensory and motor physiology and flight dynamics of the relevant parts are all given careful treatment. Critics of this approach will have to look hard for traces of superficiality. It is noteworthy in this connexion that most of the recent advances reported have come from zoologists who, like Weis-Fogh, have mastered other disciplines with no other end in view than bringing their techniques and principles to bear on the insect problem. Insect flight has in the past attracted a lot of attention of the arm-chair variety, with the result that it suffers from a number of unwarranted simplifications. Now it has advanced far beyond the string-and-sealing-wax stage and is being placed on a firm foundation of observation and theory.

The text is extremely well illustrated with 52 text-figures including several original drawings. All pay tribute to Dr. Pringle's superb draughtsmanship and unique sense of emphasis. The book suffers from only one fault—that of being difficult to read; but this only reflects the complexity of the mechanisms of insect flight and the inevitable consequences of the distillation of information.

It is a pity that the important work of Rodendorf (1951) on dipteran flight was not covered. Also the observations of Larssen on the thoracic muscles of gyrinid beetles, some of which fly although completely lacking dorsal longitudinal muscles. Pringle notes that the dorsal longitudinal muscles of some beetles are reduced in size. Their function is taken over by the basalar and subalar muscles. (I am indebted to Mr. R. A. Crowson for directing my attention to these papers.)

"Insect Flight" is a book in which many physiologists, biochemists and biophysicists as well as zoologists should find much to interest them. It has the advantage shared with other books in the series of being at a price which one can afford and of a length which permits reading from cover to cover.

GRAHAM HOYLE

FISH PHYSIOLOGY

The Physiology of Fishes

Edited by Margaret E. Brown. Vol. 1: Metabolism. Pp. xiii+447. 12 dollars. Vol. 2: Behavior. Pp. xi+526. 14 dollars. (New York: Academic Press, Inc., 1957.)

The Physiology of the Pituitary Gland of Fishes

By Grace E. Pickford and James W. Atz. Pp. xxiii+613. (New York: New York Zoological Society, 1957.) 6 dollars.

DR. MARGARET BROWN does not tell us how she came to have the idea of asking a number of authors to write upon different aspects of the physiology of fishes. It was a very good idea, and the result has been two volumes that will be of value and delight to many general zoologists as well as to those interested especially in fishes and fisheries research, to whom she says they are specially directed. Although there are no close links between the various sections, there is evidence that Dr. Brown has unobtrusively played a considerable part in editing the whole. In particular, she has herself set for each author the extent of his contribution—an excellent plan, which has ensured special emphasis on fields often neglected or of special interest because of recent work. Dr. Brown's own article on "Experimental Studies on Growth" is a good example. She has succeeded in collecting many fascinating facts about the determination of the age and growth of fishes and relating these to general biological problems.

Inevitably, any book that deals with the physiology of an arbitrarily chosen group of vertebrates will seem in some respects disjointed. One regrets particularly that neither amphioxus nor ascidians have been considered to be 'fishes'. Without them the discussions of the evolution of, for example, digestion and the endocrines inevitably lose some of their interest—though both remain fascinating enough.

The depth of the treatment and extent of literature quoted vary somewhat. There are more than 125 references on the swim bladder, but only eight on colour changes. Generally speaking, the work will serve to give an introduction to the special features of the physiology of the various organ systems of fishes, and in some cases, but not all, will provide a critical discussion of the current problems.

The monograph by Drs. Pickford and Atz on the pituitary of fishes goes much deeper. Every aspect of the subject is treated in the greatest detail, and the result would be fascinating were it not for the severe difficulty of reading imposed by the hideous type, with lines much too long and unaligned. The effect of this extensive review is to emphasize that a very large body of detailed fact is available and yet is little used by biologists. Co-ordination of ideas only becomes possible when a full and scholarly treatment such as the present one becomes available.

An interesting feature is the discussion of the use of injection of pituitary extracts in pisciculture in Brazil and the U.S.S.R. The authors have gone to great trouble to obtain translations from the original papers published in those countries. They are able to present a full survey of the techniques, and the results claimed for them. It is especially interesting to have an account of the sequence of enthusiasm for the method by the schools of Skadovskii and Gerbils'kii and the criticisms by Derzhavin. The work has involved very thorough study of the breeding habits of the various races of sturgeon and other fishes and comparison of the results of natural and artificial spawning methods. That the former should be the more efficient is not surprising, but the latter is becoming increasingly necessary as the sturgeons are cut off from their up-stream spawning grounds by dams.

The book is dedicated to Prof. Petrunkevitch on his eightieth birthday, and he has himself performed much of the translation from the Russian.

These two works together emphasize that comparative physiology is growing up into an extensive discipline contributing greatly both to theoretical and practical biology. J. Z. YOUNG

HISTOLOGY

A Student's Histology

By H. S. D. Garven. Pp. xii+650. (Edinburgh and London: E. and S. Livingstone, Ltd., 1957.) 55*s*. net.

OF the various text-books of histology of the traditional type, designed to meet the needs of the medical student, this is one of the best I have seen. It is an excellent work which despite minor blemishes deserves great praise. Dr. Garven has succeeded admirably in steering a course between what he terms "the Scylla of elaborate detail . . . and the Charybdis of over-simplification". The essential facts are presented clearly and concisely yet the student is always encouraged to keep an open mind and be prepared, when necessary, to consider more than one point of view. The diagrams are in general simple but effective, clearly emphasizing the points to which attention is being directed—for example, the scheme of the splenic circulation on p. 251, or the figure of the renal corpuscle on p. 438. The only doubts which assail one in reviewing such a book concern the extent to which the teaching of histology should incorporate some of the revolutionary changes which are now taking place.

It was in 1850 that Kölliker produced one of the earliest classical texts in histology, and it is interesting to note that this pioneer in his subject, who was professor of anatomy and physiology at Würzburg, gave his book the title of "Mikroskopische Anatomie". The great anatomist Jacob Henle had already, in 1841, extended the scope of anatomy from macroscopic down to molecular detail. In the introduction to a shorter "Handbuch der Gewebelehre", published in 1852, Kölliker wrote: "If it be possible that the molecules which constitute cell-membranes, muscular fibrils, axile fibres of nerves, and so forth, should be discovered, and the laws of their apposition, and of the alterations which they undergo in the course of the origin, the growth, and the activity of the present so-called elementary parts, should be made out, then a new era will commence for histology. . . ."

In the light of the vast body of new facts which in our own day are so rapidly accumulating through the use of the electron microscope and other agencies, Kölliker's prophecy of 105 years ago is well on the way to fulfilment. The new era in histology which he foretold has indeed commenced. From now on text-books of histology must incorporate to an increasing extent the newer concepts, which will bring histology ever closer to the molecular level, and demonstrate with yet greater precision the integration of structure and function, as the newly explored territory of the cell is mapped out afresh. J. M. YOFFEY

NORTH AND CENTRAL EUROPEAN FLORA

Flora von Nord- und Mitteleuropa

Von Friedrich Hermann. Pp. xii+1154. (Stuttgart: Gustav Fischer Verlag, 1956.) 98 D.M.

THIS is a remarkable book. It is the work of an amateur botanist living in a small town about 85 miles south-west of Berlin and therefore without ready access to the vast amount of literature concerning European plants which has accumulated during the past two centuries. Nevertheless, it contains a great deal of information, both descriptive and distributional, in a single volume of convenient size but unreasonable price. The brief preface gives all too little information about the area covered, the sources used (there is no bibliography), and the general plan and purpose of the book. One is left longing to know more, particularly of the author's obviously extensive journeys and of his views on species and subspecies.

So far as can be discovered from the preface and from the species included in and excluded from the body of the work, the area covered may be outlined roughly as follows: Iceland, Spitsbergen, Fennoscandia, Poland, Carpathians, Bulgaria, Alps (south to the Alpes Maritimes), the line of the Rhône and Seine and the British Isles. The author has, he says, no personal knowledge of the western Alps, the British Isles, Iceland and Spitsbergen, but appears otherwise to have sampled the area with such thoroughness that he claims to have seen the majority of the species growing wild and to have cultivated many of them in his garden.

The descriptive part of the flora occupies rather more than 1,000 pages and deals with approximately 4,500 species, which is a little more than a quarter of the estimated total number of species in Europe. The exclusion of the Iberian peninsula, most of the Balkan peninsula, a considerable part of east Europe and of all the Mediterranean plants, except for the few which ascend sheltered valleys in the southern Alps, accounts for the remaining three-quarters of the European flora.

The well-known Engler and Prantl system of classification is followed, perhaps a slight disadvantage to some British users of the book. The descriptive information is contained in extended keys which are clearly set out and easy to use, though in places rather fuller descriptions would have been helpful. These keys often contain information derived from personal observations, which greatly enhance the value of the work. Flower colours are described in general terms and then often made more precise by reference to Ostwald's colour scale: a useful innovation.

Not infrequently two or more taxa are keyed out together and then indicated in such a way as to leave one in complete doubt about whether the author regards them as species or subspecies or even varieties. For example, in the key to *Cytisus* (p. 592) he has:

"4. . . . Hülse ganz kahl (*leiocarpus* Kerner 1863) bis angedrücht seidenhaarig. . . . *ratisbonensis* Schäffer 1760.

4* . . . a) Krone weiss bis blassgelb, Kelch zottig, bis 12 mm. lang. *albus* Hacquet 1790. a* Krone sattgelb. *austriacus* L. 1763. . . . *austriacus* L. 1763.

One might guess from this that *leiocarpus* is to be regarded as a variety of *C. ratisbonensis* and that *C. austriacus* has two subspecies, but when one looks at the distributions one finds all three taxa are given binomials, as though they were species.

Other, though less important, peculiarities are the fairly abundant invention of new sectional names (indicated by asterisks), without a word of definition, and certain liberties with nomenclature. Herr Hermann believes in consistency more than in the international code. He says, "Ich schreibe daher stets chloa nicht bald chloa, bald chloë", etc., and prefers *Heleocharis* to *Eleocharis*.

T. G. TUTIN

CHROMOSOME SCIENCE

Cytology and Genetics

By Prof. Carl P. Swanson. Pp. x+596. (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1957.) 13.35 dollars.

THIS is an ambitious book. It sets out to cover every aspect of nuclear cytology, the function and structure of the chromosomes, their movements and their crossing-over, their variation and their evolution, their chemistry and their organization into genes; and, very properly, it seeks throughout to integrate the information from cytological examination with the results of the breeding experiment. Twenty-five years ago this was already a big task to essay. To-day it is tremendous and the author is to be congratulated not only on his courage in tackling it, but also on the success he has achieved. In surveying, and be it noted surveying at the research level, so large a field, Dr. Swanson inevitably finds himself dealing with much that is away from his own direct interests. Equally inevitably, this is reflected in the quality of the treatment. There is a confidence, for example, in the handling of induced aberrations of the chromosomes, which is lacking from the treatment of nuclear behaviour in differentiation. Again, a topic is sometimes taken up more than once in different parts of the book, with conclusions that are not always fully co-ordinated; but this is scarcely to be avoided in so extensive a survey.

It is a measure of the book's achievement that "Cytology and Cytogenetics" invites comparison with Darlington's "Recent Advances in Cytology", first published twenty-five years ago and revised in 1937. In aim and scope the two books are very similar. Much new material has, of course, accrued since the earlier book was written, and the light of observation and experiment can now be thrown on questions which were then only beginning to loom ahead. Yet it is remarkable how often this later development is in some sense foreshadowed in the earlier work, and the two books are clearly talking about basically the same matters in essentially the same language. The real contrast between them lies rather in the author's approach. "Recent Advances in Cytology" sought to assemble the facts of chromosome behaviour and its genetical implications in terms of the comprehensive theoretical structure which Darlington has done so much to give to this science and which has provided the basis for its continuing development. Swanson, on the other hand, is content to ask questions and to give such information as is available about them, without pressing far into what he would doubtless regard as the speculatively theoretical in reaching answers. In consequence, to quote from his preface, "The reader will observe that few definitive answers can be given". Many will, no doubt, applaud this approach as permitting a fairer appraisal by letting the facts speak for themselves. To others it will be less obvious that this advantage can be counted on to follow, for left to themselves facts seldom fall into a complete or tidy pattern. Difficulty in reaching an answer can result from failure to confront the facts squarely with one another and reduce each to its true significance in relation to the rest. As Charles Darwin pointed out, theory supplies a guide to observation, and, even more to the present point, it can also stimulate the re-examination and reassessment of the 'facts' themselves. Obviously, no theory can be pressed in the face of recalcitrant but incontrovertible fact. But are all so-called facts of observation to be taken on their face value? Where everything fits except for some apparently stubborn observation, should the theory promptly be sacrificed? Or should not the observation first be re-examined in respect both of its validity and the significance attached to it? It is a rare observation which does not have some element of interpretation about it, and while to dismiss the observation out of hand simply because it is awkward is to miss the lead to truer understanding, to accept it unquestioningly on its face value is to invite frustration and confusion.

This problem of acceptance is well illustrated by Swanson's treatment of chromosome structure in relation to meiotic pairing. He dismisses a chemical theory of pairing proposed by Delbrück (p. 213) and also Darlington's precocity theory of meiosis (p. 212) on the ground that they are inconsistent with what he variously describes as the cytological fact and the idea that chromosomes are already divided and double at leptotene. The evidence from chromosome morphology suggests that each chromosome or chromatid may, in fact, be multipartite in structure, but what does this mean for chromosome function? We learn (p. 121) that the chromosome behaves to X-rays as though it were single during interphase but double at mitotic prophase. Further, the evidence from deoxyribonucleic acid content (pp. 415–416) indicates that this doubles during interphase prior to mitosis, but that synthesis is not completed until zygonema (zygotene) or pachynema (pachytene) at meiosis. Now all that, for example, the precocity theory requires to provide its elegant account of behaviour at meiosis is the assumption that a division or doubling in the chromosomes, functionally effective in respect of their behaviour in pairing, takes place during interphase before mitosis but is not effected until pachytene at meiosis. The evidence of behaviour in respect of X-rays and deoxyribonucleic acid synthesis agrees with this; yet Swanson rules it out, without proposing any alternative, on the basis of static observations of chromosome morphology. Can such fully coherent evidence of behaviour be ruled out solely on that of structure, however valid the observations of morphology may be? Or should we not rather see the question as that of why a functional unit is structurally multiple and of how the structural entities are tied together into a single functional unit? Indeed, Swanson himself asks virtually this very question when he is considering structure in relation to X-ray effects. Further, he is prepared to accept the functional singleness of the chromatid when he is favouring Belling's hypothesis of how crossing-over comes about (a hypothesis, we may note in passing, with a serious intrinsic weakness in that, without subsidiary postulates, it fails to give an account of that most important feature of crossing-over, the occurrence of interference). It is thus not easy to share his rather surprising confidence that structural complexity puts at least singleness in respect of pairing properties completely out of court. The task is surely one of seeking to reconcile the evidence from behaviour and structure, of interpreting the physiological and the anatomical each in terms of the other, rather than of setting them in opposition as alternatives so that one or other must be abandoned.

The same problem of how function is related to structure is at the root of the lively discussions in progress to-day about the nature and organization of the gene. This has been repeatedly emphasized by Goldschmidt and others, and indeed it emerges, albeit somewhat sideways, from Swanson's account of chromosomes and genes. Yet one still feels that if he had been readier to grasp the theoretical nettle the reader would have emerged with a clearer idea of what is at issue, of where we stand and where we are heading, and with less of a sense of conflict than this chapter manages to convey.

Such comments could be extended to other parts of the book, and one might perhaps wonder whether the inclusion of a little more genetics, as, for example, when discussing the role of chromosome inversions in wild populations, would not have made clearer the significance of the cytological findings. These are, however, all comments on treatment, interpretation and opinion. The value of "Cytology and Cytogenetics" as a factual record is not in dispute. Misprints and misusages are few, and at least one reader quarrelled only occasionally with the author on the grounds of misleading statement or omission. This book will be widely used, and deservedly so, especially by postgraduate students of cytology and genetics; and if at times it provides them with the material for exercising their own judgment in questioning the author's conclusions, that is scarcely to be regarded as a defect. K. MATHER

RECENT RESEARCH ON PHOTOSYNTHESIS

Research in Photosynthesis

Edited by H. Gaffron, A. H. Brown, C. S. French, R. Livingston, E. I. Rabinowitch, B. L. Strehler, and N. E. Tolbert. (Papers and Discussions presented at the Gatlinburg Conference, October 25–29, 1955.) Pp. xiv+524. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 12 dollars.

MANY scientists at present actively engaged in research in photosynthesis met at Gatlinburg, United States, in 1955 to discuss their work and current problems. This book contains summaries of the papers presented, and in addition allows the reader to share some of the animation of the conference by printing much of the discussion which followed them. The editors are to be congratulated on producing a well-prepared, readable book from what must have been a confused transcript.

The book will be of the greatest value to the specialist. Largely due to the brilliant exploitation of carbon tracer in the study of photosynthesis the mechanism of the process can be now stated in broad biochemical terms. The remaining outstanding problem is the mechanism whereby light energy is converted to chemical-bond energy in the form of reducing power. This subject dominated the proceedings of the conference and was dealt with under five headings. First, the photochemistry of chlorophyll *in vitro* was discussed; a consideration of the primary photochemical process *in vivo* followed, largely centred on the analysis of spectral changes induced in photosynthetic cells during illumination and on studies of chemiluminescence of photosynthetic cells. The observed spectral changes could not be interpreted in terms of a change in the photosynthetic pigments alone; the changes in the yellow portion of the spectrum indicated the probable functioning of a cytochrome system. The possible role of cytochromes constituted the third topic and was extensively considered with reference to the photosynthetic bacteria, including the obligate anaerobe *Chromatium*. Another discussion was concerned with the reactions of chloroplasts after isolation from the green plant. The formation and condition of chlorophyll in the living cell were also considered. In addition, a section describing various physiological phenomena was included; much of this concerned the anomalous gas exchange which occurs immediately after the initiation of photosynthesis in the induction phase. It is a great convenience to have all these facets of photosynthetic research assembled in a single book.

Besides the large number of papers describing original work, three of the sections commence with a general review paper, and some others are scattered throughout the book. These are written with the object of introducing one specialist to the work of another, which is nowadays necessary even within a single field of research. Livingston's article on the photochemistry of chlorophyll *in vitro* is a valuable survey for the biologist; so also is Franck's paper on the possible role of an excited triplet state. The discussion following this latter paper emphasizes the difference of opinion between the physical chemist, who is greatly concerned with the difficulty of obtaining sufficient energy from a single quantum for the transfer of an electron to the level of reduction of coenzyme, and that of the biochemist who prefers the simpler view that one electron is transferred per quantum. Kamen's article on the possible role of cytochromes is an excellent example of the biologist stating his view to the physical chemist. Such conferences as that at Gatlinburg fulfil a real need in stimulating discussion between workers from different scientific disciplines.

The general reader will find the book primarily of use as a source book of references. Unfortunately, from his point of view, it was not possible to include much of the work concerning the carbon metabolism of photosynthesis. The conference was intentionally limited to a detailed discussion of a few topics rather than attempting a complete survey.

C. P. Whittingham

NUCLEAR CHEMISTRY

La Chimie Nucléaire et ses Applications

Par M. Haïssinsky. Pp. vi+652. (Paris : Masson et Cie., 1957.) Broché, 5,000 francs ; Cartonné toile, 5,600 francs.

It is fitting that the country in which radioactivity was first discovered should be the first to publish a major text-book which surveys virtually all the sciences and techniques in which radioactivity has come to play a part.

The first chapter, "La chimie nucléaire—ses grandes étapes", is an admirable account of the early work on radioactivity. There is the story of Becquerel's mystification over the strange trick of Nature that gave some uranium compounds both radioactive and strong fluorescent properties, and the way the Curies solved it in discovering the other radioactive elements : "la lucidité et la sûreté avec lesquelles ils ont advancé vers le but qu'ils s'étaient proposé, sur une voie jamais encore tracée". In this chapter there are included interesting pictures showing the blackening of the photographic plate which Becquerel first observed, and facsimiles of pages from the note-books of the Curies and of Rutherford.

Following this beginning, there are five chapters on the physical basis of radioactivity and three chapters on the radioactive elements, including the transuranium elements. The transuranium elements are divided into the 'uranides' (multivalent elements) and the 'curides' (mainly trivalent elements), but I feel this subdivision leads to words that sound badly in an English pronunciation, and it is not a clearly defined subdivision. These chapters lead up to the applications of radioactivity in geology and astrophysics, and there are good accounts of such problems as the determination of the age of the Earth. Following this, there comes a section comprising almost a third of the whole book, devoted to radiation chemistry. Separate chapters are given to the effects of radiation on gases, water and aqueous solutions, organic systems, solids and fluorescent systems. There is also a valuable chapter on the chemical effects associated with nuclear transformations. The last part of the book describes radioactive tracers and their applications and includes chapters on electrochemistry, reaction mechanisms, analysis, biochemistry and industrial processes.

A criticism of the book is that it attempts to make into one subject something that is really dispersed over a great many quite separate subjects. Nuclear chemistry in Britain, and in the United States, is normally regarded as a rather small subject restricted to a study of atomic nuclei and their reactions. Of this there is comparatively little in the book and it is discussed rather briefly. The chapters on radiation chemistry, on the other hand, constitute a major review suitable for a research student who would be interested neither in the nuclear problems, nor in the behaviour of radioactive tracers. The book is a notable attempt to bring order into a confused situation, but in practice, if the book were to be translated into English, it is not clear what type of student in Britain would find it useful.

The references are very full and up to date throughout the whole book, and in this respect the author has done a great service in assembling them. Minor criticisms are that there is no collated information such as a complete table of isotopes, or of cross-sections, and that the author index often lists several different people under one name by being restricted to one initial. There are also numerous typographical errors, particularly in such details as the alignment of subscripts, but errors in the actual text are very few for a book covering such a wide field.

G. N. Walton

PAPER-MAKING

Fundamentals of the Beating Process

The Theory of the Development in Pulps of Paper-making Characteristics by Mechanical Treatment. By H. W. Emerton. Pp. xvi+198 (145 figures). (Kenley : British Paper and Board Industry Research Association, 1957.) 42*s*.

This volume refers to the mechanical treatment undergone by pulp fibres in preparation for paper making, and its author is principal research officer (physics) of the British Paper and Board Industry Research Association. It is addressed primarily to the paper-mill chemist, but it can also be read with much profit by all interested in fibre and cellulose science. A special feature is the numerous light- and electron-micrographs illustrating techniques of which Emerton is a recognized leading exponent.

Part I deals with the chemistry and structure of cellulose fibres. Part II covers the theory of beating (the most important and controversial chapter of the book), factors affecting the beating behaviour of pulp, methods for the determination of the progress of beating, and the effect of beating on the properties of paper. It is concluded that beating to produce strength increases the bonded area between fibres by making them plastic, so that they deform by surface tension during drying. Deformation provides the opportunity for bonding, the extent of which will depend on the degree of dispersion of the cellulose and other polysaccharides of the surface layer.

It will be seen that the general treatment is on a relatively elementary scientific plane, the purely practical mill aspects of the subject being deliberately excluded. There are a full index, and a liberal bibliography for the benefit of scientific readers outside the industry.

Julius Grant

THE THEORY AND PRACTICE OF SHIELD DESIGN

Radiation Shielding

By B. T. Price, C. C. Horton and K. T. Spinney. (International Series of Monographs on Nuclear Energy. Division 10: Reactor Design Physics, Vol. 2.) Pp. ix+350. (London and New York: Pergamon Press, 1957.) 60*s.*; 10 dollars.

TWO books which deal solely with radiation shielding are now available to shield designers. Until the volume by Price, Horton and Spinney appeared, one had to be content with either a miscellaneous number of unrelated reports or the U.S. Atomic Energy Commission's "Shielding Design Manual", which while of great value as a comprehensive collection of data, remained very much a handbook. The first impression one obtains from the present volume is that a real effort has been made to put this untidy subject in order and, furthermore, a praiseworthy and generally successful attempt has been made to apply a fundamental and critical approach throughout. It is, in fact, a textbook on the subject, and although the theoretical interpretation and analyses, particularly those of Chapter 4, may appear tedious and complex to the engineer, they nevertheless form a substantial and reliable base from which to work into the future.

The book contains six chapters, the first of which deals briefly but adequately with the health physics aspects of nuclear radiation. The second analyses the attenuation of gamma rays and high-energy electrons and considers in detail the modes of interaction and sources of radiation. These effects are well understood and amenable to calculation except in so far as gamma build-up factors are concerned, and here the authors discuss the moments method due to Spencer, Fano, Goldstein and Wilkins. This, while applicable to massive bulk shields, which approach the idealized system for which the method was derived, is difficult to apply to the complex laminated shields of small mobile reactors and is likely in such cases to be subject to large errors. Nevertheless, this is a lucid chapter, as is Chapter 3, which presents the basic nuclear physics theory essential to any understanding of the problem of neutron attenuation. The following chapter, and perhaps the most important, deals with neutron attenuation in thick shields, and it is in the theoretical analysis of this aspect that the greatest uncertainties in shield design are to be found. The secret of success in the design of a reactor shield system, in terms of achieving the desired attenuation with minimum weight and cost, lies in the accuracy with which one can predict the neutron energy and spatial distribution in the shield. The authors advocate the use of a semi-empirical method based on age and diffusion theory using a fast group consisting of an integrated flux greater than 1 MeV. described by a simple attenuation process, an intermediate group described by an age kernel integrated over $1/E$ spectrum, and a thermal group described by diffusion theory. They show that good accuracy is obtained by this method for bulk concrete shields, but difficulty will again be experienced in applying it to the complex metal hydrogenous shields of small mobile reactors. One would have welcomed consideration of simple multi-group diffusion theory, which is showing promise as a straightforward and accurate method of predicting neutron distribution in this type of shield. This chapter also includes a section on the effects of ducts and voids in shields and provides a sensible treatment of a problem which has not generally been aired. Chapter 5 offers a well-balanced selection of basic mathematical formulæ encountered in shielding calculations. The engineering factors of shield design, including fabrication techniques, heating and thermal stress effects, and their inter-relationship with the physics considerations dealt with earlier, are discussed in Chapter 6. It is a necessarily compressed chapter but will be found to be of considerable interest. A genuine attempt has been made in the section on concrete to give guidance to design engineers in various practical matters, including the avoidance of cracks and streaming paths. Sections on the cost of shielding materials, induced activation of materials and coolants, on beam traps and shielding windows conclude the chapter.

The subject index is extensive and free of anomalies and each chapter is followed by an exhaustive list of modern references. This is a well-written and worthwhile book on a subject which has for too long been kept in comparative theoretical obscurity.

J. EDWARDS

GRAIN BOUNDARIES IN METALS

Grain Boundaries in Metals

By Dr. D. McLean. (Monographs on the Physics and Chemistry of Materials.) Pp. x+346. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 50*s.* net.

TECHNICAL metals are polycrystalline, and many of their properties depend on the grain boundaries. That is reason enough to have a book on the subject. But it takes five parameters to define merely the orientational relationships at a grain boundary: it is not very surprising that there is still no general exact theory of their behaviour. There has been progress, though, accelerating in the past decade. Some myths have been eliminated, the more sensible of the earlier ideas have won general acceptance, and a broad understanding has been attained within the compass of admitted approximations. If for nothing else, this book is to be welcomed as a reasoned index to the now very extensive body of literature on the subject. The free energies of grain boundaries and their effect in determining microstructure, the adsorption and diffusion of solutes at grain boundaries on intragranular deformation, grain-boundary migration, grain-boundary sliding and intergranular brittleness are all fully discussed.

The author is an efficient reporter of the work of others. His own contributions are for the most part sensible rather than penetrating. His grain-boundary model for the discussion of grain-boundary adsorption (three atoms thick, a mixture of three classes of atom sites, one-third large, one-third small and one-third normal) is probably worth still further detailed consideration for lack of a better. The author occasionally makes elementary mistakes. His claim on p. 50 to measure the line tension of a triple junction of grain boundaries is based on an obvious misconception of surface-tension phenomena—he should look at any liquid surface meniscus in a sharp corner. The subject of grain-boundary melting in pure substances frequently gives trouble, and here is no exception. Somehow the author's thermodynamics teaches him (p. 100) that if λ_B and λ_{SL} are the free energies per unit area of grain boundary and of solid–liquid interface, respectively, then at some temperature below the melting point, at which ΔF is the free energy of melting per unit volume, a thickness $t = (\lambda_B - 2\lambda_{SL})/\Delta F$ should melt at the boundary, and he is left wondering why there is so nice a balance as there appears to be between λ_B and $2\lambda_{SL}$. He could have reflected that it is the property of a free energy to tend to a minimum, rather than to the value you first thought of, and $t\Delta F + 2\lambda_{SL}$ is minimum when t is zero. Nevertheless, by carefully reviewing all the experimental evidence he reaches the sane conclusion that grain-boundary melting has probably only been observed where there are impurities. A sharper-minded theoretician might have skipped the experimental evidence, to our loss.

F. C. Frank

LATTICE DEFECTS IN IRRADIATED SOLIDS

Radiation Effects in Solids

By G. J. Dienes and G. H. Vineyard. (Interscience Monographs in Physics and Astronomy, Vol. 2.) Pp. viii + 226. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 6.50 dollars.

THE production of various types of lattice defects in solids by the action of high-energy radiation, and the changes of physical properties brought about by these defects, have become in recent years one of the most actively studied branches of solid-state physics. This activity is a double response to the development of nuclear technology; on one hand, the experimentalist is now provided with sources of high-energy radiation far beyond those available fifteen years ago, and on the other he is expected to provide materials for nuclear reactors that are able to withstand intense radiations for long periods of time. The subject of 'radiation damage' is thus quite unique in the way that it links solid-state physics directly to both nuclear physics and the technology of materials.

Although several review articles have been published, this is, to the best of my knowledge, the first book that has appeared on the subject, and the authors are to be congratulated on a very successful outcome to their efforts. They have concentrated deliberately on effects of 'knock-on collisions', in which atoms are displaced from their lattice sites by particles such as fast neutrons, protons, electrons, and fission fragments, rather than on ionization effects. This is reasonable because these collisions are particularly important in nuclear reactors and because they can be exploited to study atomic binding forces in the solid state.

The book brings out clearly the tantalizing stage that the subject has now reached. Looked at qualitatively, or semi-quantitatively, the physics of radiation damage is fairly clear. The underlying theory of displacement collisions has been given a good start by Bohr and Seitz, and appears not to contain any major mysteries. Furthermore, the basic perfection of the crystal lattice has enabled us to define fairly sharply the nature of the various atomic defects that are possible, such as vacancies, interstitials, divacancies, and clusters; also, to understand in broad terms the ways in which they can move about and anneal themselves, and their effects on physical properties. The experimental study of annealing kinetics, and of changes in electrical resistivity, lattice constants, stored energy, and other properties, has also shown that this physical picture is certainly broadly correct. On the other hand, as soon as we ask for precise quantitative values, for example, for the numbers of displaced atoms, for the energies of formation and movement of the various defects, and for their effects on physical properties, the subject becomes difficult and progress is slow. Basically the reason is that we have very few techniques as yet for 'seeing' these lattice defects individually, with the result that their experimental study is mainly inferential, from changes of bulk properties, and uncertain. It seems doubtful that the subject will advance far beyond the semi-quantitative stage until new techniques are developed.

All these aspects are discussed clearly by the authors. The practical problems of radiation damage are less fully treated, although embrittlement of steel and radiation growth of uranium are mentioned, and an interesting account is given of the method used to anneal away the stored energy in the graphite moderator of the Brookhaven reactor. Transmutation effects, and the interesting behaviour of inert gases in solids, are not discussed; this is a pity, although it may perhaps be argued that the important aspects of these belong more to the theory of solid solutions than to the theory of lattice defects.

In conclusion, this book can be recommended as a useful introduction to the physics of radiation damage in solids.

A. H. Cottrell

HYDRAULIC SYSTEMS IN AIRCRAFT

Aircraft Hydraulics

Vol. 1: Hydraulic Systems. Edited by H. G. Conway. Pp. ix + 146. 35*s.* net. Vol. 2: Component Design. Edited by H. G. Conway. Pp. ix + 198. 45*s.* net. (London: Chapman and Hall, Ltd., 1957. Published under the authority of the Royal Aeronautical Society.)

THESE two volumes are text-books sponsored by the Royal Aeronautical Society; and several well-known authorities in the aircraft hydraulics field have contributed chapters on their own special subjects. These have been edited by Mr. H. G. Conway, who also contributes himself.

Vol. 1 deals with the more general aspects of the subject. Mr. Bingham, in Chapter 1, discusses the requirements for an aircraft hydraulic fluid and then goes on to deal with the properties of various fluids. Their effect on different sealing materials, storage and inflammability characteristics, etc., are described, and a very useful collection of graphs and tables of the physical properties of these fluids is also provided.

In Chapters 2 and 3 Mr. Collinson deals briefly but effectively with hydraulic theory and fluid flow in orifices and pipes, providing some useful nomograms and charts for determining rates of flow. There are sections on surface tension, viscosity, compressibility and Bernoulli's theorem, to mention only a few. A brief account is included of the gas laws, with which one is obviously concerned when designing accumulators or air bottles.

Next Mr. Parker and Mr. Conway discuss hydraulic systems and circuits. It is obviously impossible to lay down a set of rules for designing a complete system in a text-book; but in Chapters 4 and 5 various aspects, including pumps, piping, jacks and circuits, are considered and sound advice is given on both desirable and undesirable features for a system.

Finally, Mr. Black considers the installation, operation and testing of a hydraulic system in an aircraft. He very wisely emphasizes the importance of good filtration and careful attention by operating personnel to clean working methods and conditions, and in the section on fault-finding he warns the reader never to assume that a component is too simple to go wrong. Mr. Black also discusses the design and use of full-scale rigs for ground-testing complete hydraulic systems, prior to flight-testing in prototype aircraft.

Vol. 2 deals in detail with components for aircraft hydraulic systems. Separate chapters are devoted to seals, pumps, jacks, servo-controls and many other devices. Space limitations preclude a detailed review of each of the subjects treated, but it may suffice to say that they are all discussed and explained thoroughly. The book abounds with sectional drawings and diagrams of components made by both British and foreign firms; the information given is remarkably complete and represents hard-won and up-to-date experience.

These volumes cover the whole field of aircraft hydraulics and yet the individual subjects are treated so thoroughly that a very good working knowledge is obtained. Particular emphasis is placed on the practical aspects throughout, but this is backed by suitable theoretical explanations. These books can be recommended highly and should prove very valuable to students or technicians starting work in this field. They should also be useful to those more experienced specialists who may wish to refresh their memories on the other man's problems.

THEORY OF SOLUTIONS

The Molecular Theory of Solutions

By Prof. I. Prigogine, with the collaboration of A. Bellemans and V. Mathot. (Series in Physics.) Pp. xx+448. (Amsterdam: North-Holland Publishing Company, 1957.) 48 guilders.

IN theoretical physics it is often more useful to circumvent an intractable problem than to solve it; this is nowhere more true than in the statistical theory of solutions. In principle (as can so often be claimed) the thermodynamic properties of any mixture of molecules are determined precisely by the intermolecular potentials, and one should, therefore, be able to calculate the equation of state from a knowledge of intermolecular forces alone. In practice, however, this is a fruitless undertaking except at densities so low that a virial expansion can be performed with accuracy. Our failure to construct an exact theory of the liquid state is a sufficient indication of the hopelessness of attempting an *a priori* theory of liquid solutions. It therefore becomes pertinent to ask: What should be the aim of theories of solutions and how are we to judge their success or utility? Only to ask this question suggests a promising line of attack. The primary aim of solution theories must be to express in terms of the relevant intermolecular potentials the change in free energy which accompanies the mixing of pure fluids with one another. In order to yield useful results the theory of solutions must, therefore, make full use of the experimental properties of the pure components under conditions which resemble as nearly as possible the condition of the solution itself. This philosophy, in recent years, has led to notable advances, and these are fully and carefully described in Prof. I. Prigogine's book.

Of particular interest in solution theory are mixtures of molecules the intermolecular potentials of which are of the Lennard-Jones type, leading to a short-range repulsion and a long-range attraction. Pure species of this sort obey the law of corresponding states, and this law can be generalized to mixtures of Lennard-Jones molecules provided their force fields are isotropic, and do not differ too greatly in strength. The theory of such mixtures, now known as 'conformal solutions', must, however, be extended in order to describe adequately the properties of mixtures in which there are specific interactions or in which the molecules are of very different size. Prof. Prigogine and his colleagues have been largely responsible for this expansion of the theory, and have also accounted successfully for the properties of special classes of mixtures such as associated solutions, mixtures of isotopic species and certain types of polymer solution.

The mathematical methods used in the book are sufficiently elementary to be followed by the ordinary physical chemist, and the book contains many numerical examples which enable the reader to test his understanding of the theory. The physical arguments are clearly and fully expounded and there is much valuable new material which has not yet appeared in the literature. Altogether this is a thoroughly up-to-date and critical book which can be warmly recommended to those wishing to acquaint themselves with the most important recent developments in the theory of non-electrolyte solutions.

H. C. LONGUET-HIGGINS

SOLUTION OF EIGENVALUE PROBLEMS

Variational Methods for Eigenvalue Problems

An Introduction to the Methods of Rayleigh, Ritz, Weinstein, and Aronszajn. By Prof. S. H. Gould. (Mathematical Expositions, No. 10.) Pp. xiv+179. (Toronto: University of Toronto Press; London: Oxford University Press, 1957.) 48*s*. net.

IF H is a linear operator, the values of λ, real or complex, for which the equation $Hx = \lambda x$ has solutions in x satisfying given boundary conditions, are the eigenvalues of the equation.

If the space of the elements x is finite-dimensional, the eigenvalues can be obtained by standard methods; but these methods may become impossibly difficult when this space is infinite-dimensional (for example, Hilbert space), and it is then that the variational method is of great value in many practical cases. This consists in finding the minima of certain expressions associated with the above equation. If now we introduce more stringent prescribed conditions, then the desired minimum will be raised, or at least not lowered, and we obtain upper bounds for the eigenvalues of the original problem; this is the essence of the well-known Rayleigh–Ritz method. If, instead, we weaken the prescribed conditions, the minimum will be lowered, or at least not raised, and we obtain lower bounds for the desired eigenvalues; this is the essence of the Weinstein method. Aronszajn then dealt with the question as to whether these successive approximations actually converge to the desired eigenvalues.

Prof. S. H. Gould's book sets forth in an admirably clear way the details and proofs of the above, together with practical applications to vibrating rods, membranes, and plates.

The ten chapters are on: systems vibrating with a finite number of degrees of freedom; variational principles for finite-dimensional systems; vibration of systems with infinitely many degrees of freedom; reproducing kernels and functional completion; vibrating rods, membranes, and plates; the Weinstein method in its original form; linear operators in a Hilbert space; the Weinstein–Aronszajn method for linear operators in Hilbert space; application of the Weinstein–Aronszajn method in Hilbert space to the differential problem of the vibrating plate; application of the approximate methods to general differential problems.

The general theory is of interest to the pure mathematician, while the applications will interest the applied mathematician and physicist.

The book makes a valuable contribution in setting forth the above ideas and theories in a systematic way, and it is easily readable by any good postgraduate student. R. G. Cooke

RECENT ADVANCES IN APPLIED MATHEMATICS

Modern Mathematics for the Engineer

Edited by Prof. Edwin F. Beckenbach. (University of California Engineering Extension Series.) Pp. xx+514. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 56*s*. 6*d*.

A CARELESS glance at the cover of this book might lead the reader to expect a text-book on engineering mathematics similar, perhaps, to Kármán and Biot's well-known "Mathematical Methods in Engineering". However, the important word in the title is "modern", as the book is actually a collection of mathematical essays describing some of the developments which have taken place in mathematics during the past fifty years. Each essay is by a different author, and the contributors include such distinguished mathematicians as Solomon Lefschetz, Richard Courant and Norbert Wiener.

The subject-matter is divided somewhat arbitrarily into three sections. The first, entitled "Mathematical Models", is largely concerned with the theory of ordinary and partial differential equations, and most of it will be familiar to anyone with a training in mathematical analysis. There is a chapter on non-linear vibrations, an account of the calculus of variations, and chapters on elliptic and hyperbolic partial differential equations. The use of complex variable methods in problems of plane elasticity is dealt with in sixteen pages, and there is also a short survey of exterior ballistics.

The second section covers less familiar ground, as it deals with problems which the editor calls "Probabilistic". It begins with an account of prediction theory, and the subsequent chapters cover the theory of games, operations research, dynamic programming and Monte Carlo methods. In spite of the title, there is no account of ordinary statistical theory. Much of the material in this section is new, at least in the sense that it is not usually found in general textbooks on mathematical analysis.

Although the final section is entitled "Computational Considerations", a considerable part of it might well have been included in Section 1. The chapters on non-linear analysis and relaxation do include some details of computational techniques, but the sections on matrices, conformal mapping, and functional transforms are devoted entirely to analysis. It is worth noting that the chapter on "Methods of Steep Descent" describes techniques for minimizing a function in n-dimensional space, and is not an account of the 'method of steepest descents' used in the evaluation of contour integrals. The final chapter deals very briefly with high-speed computing devices.

To say that this is a book for engineers is misleading, except in the sense that almost any part of mathematics may have some engineering application. There are few references to engineering problems, and indeed one contributor admits to having very little contact with engineering. But whether the reader is an engineer or not, he is certainly expected to be a competent mathematician. Most of the contributors have tried to present concise yet comprehensive surveys of their chosen subjects, and to do this they have necessarily had to assume a good working knowledge of the main branches of mathematical analysis.

Although all the chapters are well and authoritatively written, there is little cohesion between the various sections. The most valuable parts of the book are probably those describing topics such as game theory in which there are at present considerable developments, and where it is difficult for the newcomer to find his way. The lists of references attached to these chapters will be especially useful. It is less easy to justify the inclusion of sections on such well-known subjects as matrices and the calculus of variations, where there is already no shortage of easily available literature. R. K. Livesley

MATHEMATICS IN SECONDARY SCHOOLS

The Teaching of Mathematics

(Issued by the Incorporated Association of Assistant Masters in Secondary Schools.) Pp. ix+231. (Cambridge: At the University Press, 1957.) 15*s*.

THIS volume, the seventh in a series, concerns itself mainly with a general consideration of the purpose of teaching mathematics in secondary schools. The Committee expresses frankly its lack of authority to comment upon the work in secondary modern schools, though it has a good deal to say about the methods of teaching arithmetic in primary schools. Great stress is laid on the needs of the pupil in relation to the substance and not to the structure of the subject, and the old theory of 'transfer of training' is firmly rejected. Nunn's contribution to this change of emphasis receives full consideration, and reference is made to the effect of the Jeffery Report (printed in full in an appendix).

Two detailed chapters develop the work up to the ordinary level of the General Certificate of Education, and the failure of some pupils is regarded as due to unsuitable teaching methods in primary schools. A suggested minimum syllabus for this pre-entry course is given, with a lengthy discussion of the work of the first five years in the grammar school. "Some General Teaching Topics" contains much material for careful consideration by all engaged in teaching mathematics. Far too many men and women are gallantly tackling work which is beyond their own capability as teachers, and this chapter should be of great value to them.

The chapter on the sixth form is less successful than the rest of the book, and it suffers from an attempt to deal with a big topic within the compass of 25 pages. Although expansions and infinite series come into the basic course there is no mention of the vital question of convergence. There is no mention of mass in the basic mechanics course, though one of the main teaching points in school mechanics is surely the distinction between mass and weight. In the section on analytical geometry the correspondence between a locus and an algebraical equation is developed; it could well have been extended to the realization that the curve separates the plane into areas in which the function is either positive or negative; $f(x) > 0$ can be so much more interesting than $f(x) = 0$.

There is a sensible discussion of the mathematical library, with a good list of suitable books, and elementary books in foreign languages are recommended though none is quoted.

The place of practical work in the mathematics course receives serious attention, and a mathematics room with workshop is suggested.

Lastly, a strong plea is made for the inclusion of statistics in the school course. Even if the scope of the work given here is over-ambitious, the conclusion "that statistics, so long as it is taught as a practical subject, can help to make school mathematics more realistic" well expresses the attitude to this relatively new school subject.

Some fifteen misprints have been overlooked in this first edition, but the Association can expect confidently to need a reprinting very soon. The volume as a whole is of the standard that is expected from the Cambridge University Press. W. J. LANGFORD

A POPULAR ACCOUNT OF RADIO-ASTRONOMY

The Changing Universe

The Story of the New Astronomy. By John Pfeiffer. Pp. xi+244+16 plates. (London: Victor Gollancz, Ltd., 1956.) 18s. net.

WE are very familiar to-day with the problem of communications between scientists and the general public, and we have recently seen considerable and successful efforts in daily and monthly journalism to provide intelligent reporting of the more exciting scientific work of the present day. A more difficult problem is set by the popular text-book, which attempts to explain a whole subject to a reader whose only background is an intelligent, but rather vague, interest. An author determined to write such a book must face rigid restrictions—no mathematics, no formulæ, are allowed; all difficult terms such as frequency, wave-length, galaxy, must be explained.

Pfeiffer has written such a book, and in it he manages to cover the whole of radio astronomy up to the middle of 1956. He started with the severe restriction of knowing no radio-astronomy at all, but he had instead the advantages of twenty years experience of scientific journalism, and of two successive tenures of a Guggenheim Fellowship which enabled him to visit and talk at some length with many of the leading radio-astronomers. His account stems directly from his interviews with the men who did the work, and the history of the subject which he provides is the best we are likely to have for some time. The book is accurate in its facts; so accurate and in sufficient detail, that it can seriously be recommended as an introduction to radio-astronomy.

The contrast between the accuracy and interest of subject-matter, and the style of writing, is remarkable. Mr. Pfeiffer is an optimist. He believes it is possible to explain radio-astronomy in all its complexity to anyone able to read, and he consequently addresses himself to a public whose attention requires to be riveted to each page separately by the use of superlative, hyperbole, and simile. It is safe to say that no radio-astronomer could have written such a book, although such a style would, from them, be appropriate to short magazine articles or popular lectures. I find the style too obtrusive for comfort in such a large dose, and I would be surprised to find anyone who needed such a continuous stimulation of interest and who yet was able to read and appreciate the whole of the book. F. G. SMITH

INTO SPACE

Satellites and Space Flight

By Eric Burgess. Pp. vii+159+14 plates. (London: Chapman and Hall, Ltd., 1957.) 21s. net.

THIS book traces the expected future history of space-travel, from the instrumented artificial satellites which are already in being to the manned interplanetary space-ship which, Mr. E. Burgess thinks, may not come for fifty years or more. The first chapter deals with rocket motors, the dynamics of satellite orbits, and the scientific experiments which can profitably be made in unmanned satellites. The next step into space is the unmanned 'probe' missile, sent to investigate the Moon and Mars on our behalf. Mr. Burgess discusses possible circum-lunar orbits, the optimum transfer ellipse from Earth to Mars, and the design and instrumentation of a lunar-probe missile. Man's first sojourn in space will probably be inside a satellite space-station, and once he feels at home in this remote outpost, his next goal will be the Moon. For, despite its unattractive climate—a near-vacuum with extremes of temperature—the Moon will be prized as a base because it occupies a favourable niche in the hill-and-valley system of gravitational potential. Mr. Burgess describes the problems of the lunar base built either above or below ground, and outlines what is known of the Moon's surface. The last chapter, on manned interplanetary travel, includes a discussion of nuclear and ion rockets, and ends with some gentle speculation on interstellar flight.

Mr. Burgess, a seasoned campaigner in the realms of interplanetary space, is a confident guide, and his prophecies may well come true, if taxpayers choose

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to let their money be spent on space-travel. He is familiar with all the literature on the subject, and he gives a useful list of references at the end of each chapter. He steers a wary course half-way between a popular exposition and a text-book. Though he is careful to avoid mathematical symbols, he does not shirk detail: there is plenty of numerical grist, indeed perhaps rather too much, since all weights and distances are expressed in both English and metric units. This practice has something to be said for it, however, in a subject like space-travel, where the applied scientist, a slave to slugs, has to co-operate with his purer, gram-bound colleague.

In the choice of subject-matter there is little need for improvement, but it is a pity that the same cannot be said for the style of writing. Mr. Burgess can find the happy phrase when he tries, but at times he is content to be slipshod and repetitive, and occasionally it is none too clear what he means. Apart from this intermittent failure to communicate, Mr. Burgess is usually a reliable guide to the untrodden paths of space. But he is not infallible, and it has to be said that the book is marred by too many minor mistakes: on p. 97 and elsewhere he repeats the crucial error which misled the interplanetary theorists for so long, namely, their belief that the weight of structure and motor on any missile (or stage of a missile) could not be much less than 20 per cent of the total, though even in 1952 the *Viking* achieved 15 per cent; p. 63 needs thorough revision; Fig. 1.2 is in error; and there are more than thirty other trivial errors or misprints. D. G. KING-HELE

LOGICAL STUDIES AND INDUCTION

Logical Studies

By Prof. Georg Henrik von Wright. (International Library of Psychology, Philosophy, and Scientific Method.) Pp. ix + 195. (London: Routledge and Kegan Paul, Ltd., 1957.) 28*s*. net.

The Logical Problem of Induction

By Prof. Georg Henrik von Wright. Second revised edition. Pp. xii + 249. (Oxford: Basil Blackwell, 1957.) 25*s*. net.

A REVIEW of these two volumes together may serve to show the range and depth of Prof. G. H. von Wright's thinking. His "Logical Studies" comprises a series of eight papers—five of them published previously—and the "Logical Problem of Induction" is essentially his *doktor-arbeit* submitted to the University of Helsinki in 1941. The present book is a second, enlarged edition of the original work published as Vol. 3 of *Acta Philosophica Fennica*.

With regard to the "Studies", three essays are presented dealing with the problem of logical truth. This amounts to an attempt to clarify the statement that logical truth is at root a tautology; or otherwise expressed, that logical truth is a function of form but not of content. It is valuable to have this theme so competently handled. A general lack of understanding about it may well be one reason (no doubt there are others) why scientists are apt to complain that philosophers do little beyond echoing and complicating the less secure tenets of physical theory. Until some crucial issue focuses attention upon it, experimentalists in particular are naturally reluctant to take seriously a discipline which makes rigid demands upon the structure of ratiocination but has nothing to say concerning that which is in fact the subject, the thing-in-itself as Husserl would insist, and its associated correlates.

Underlying this dilemma is the failure to allow enough for the æsthetic content of each problem, whether scientific or logical. Mere applications or developments of existing knowledge are unlikely to prove coercive, since they rarely provide an opportunity for that contemplative factor which lifts the best human efforts above the useful and the pragmatic. It is for this reason that those about to embark upon any postgraduate course of study or research would find it rewarding to read the first chapter in this collection, namely, "Form and Content in Logic".

The next group of contributions is concerned with modality: it should have a wide appeal because of the relationship to probability and the study of norms. But perhaps the most interesting point here is the recognition that there can be—and actually is—a new modal logic which is relative rather than absolute, in the classical sense. The author maintains the Aristotelian origin of this distinction, namely, ὑποθέσεως against ἁπλῶς. Lexicographically, the emphasis of the former is upon 'that which is under', whereas the latter stresses simplicity or singleness. It would have been helpful if Prof. von Wright had enlarged upon this theme a little, because it would have strengthened his assertion that the relative should include the absolute as a limiting case. The concluding study (the concept of 'entailment') bears an epistemic slant, and gives a broad hint of how close we are to the notion of demonstratability.

Turning now to the "Logical Problem of Induction", this largely follows traditional lines in discussing any respectable justification for that which we all take for granted, and upon which so much of everyday life is based. The upshot is that, broadly speaking, induction cannot be rigorously defended, although this result does not necessarily involve such disastrous consequences as are sometimes feared. Prof. von Wright's treatment of this situation is as follows. The basic thesis is presented in the form, "It is impossible to guarantee, with certainty or with probability, that an unknown instance of the property *A* will also exhibit the property *B*, if *A* and *B* are different properties". (We may perhaps compare this with other 'postulates of impotence' such as that relating to electrostatics or with the second law of thermodynamics, or even with the negative existential quantifier $\sim\exists$, "there does not exist . . .".) It appears that, on contrasting a single statement with truth-frequency for a class of statements, it is reasonable to delete "with certainty or with probability". But criteria of the truth of inductive instances cannot be demanded, though this does not preclude the acceptance of 'symptoms' as applied to experience. Embedded in the whole domain of human thought is the temptation to confuse issues of language and of fact. The classification of the former as a lemma to the solution of Hume's problem is the critical task of philosophy, in contrast to the constructive task with its focus upon given conceptual structures. The analysis of inductive propositions can then be undertaken on mathematical principles. Constructive philosophy is not the tool to use for dealing with Hume's scepticism; it has sufficient material upon which to work in its own field, for which Prof. von Wright has provided a sound foothold, as well as a springboard for inductive studies.

F. I. G. RAWLINS

DAIRY RECORDS

Milk and Butterfat Recording

A World Survey. By E. D. Ashton. (Technical Communication No. 3 of the Commonwealth Bureau of Dairy Science and Technology.) Pp. x+197. (Farnham Royal: Commonwealth Agricultural Bureaux, 1956.) 30*s*.

THE only previous publication dealing comprehensively with this subject was that of the International Institute of Agriculture in 1935. Since then considerable progress has been made in methods of milk and butterfat recording and in the use made of such records, and the number of officially recorded cows has increased from 4½ million to the present figure of approximately 8 million.

This survey is a welcome and highly informative contribution to agricultural literature. The history and development of milk recording in some thirty countries is presented in a concise and comprehensible form, as are the financial and administrative problems inherent in the different systems of milk recording operating under the varying conditions which prevail in these countries.

The book appears to fall naturally into two parts: a general survey of the present state of milk and butterfat recording and a series of detailed accounts of the milk-recording movements in specific countries.

Chapters in the first part trace the development of milk recording from the small beginnings of private and breed society records to the start of official milk recording in Denmark in 1895 and on to the present position wherein more than thirty countries have official milk recording schemes and between one-quarter and one-half of the dairy cows in the main dairying areas of the world are officially recorded. Organization of milk recording and methods of financing these movements are discussed very fully as are the practical aspects of milk recording such as identification of cows, methods of sampling, butterfat testing and milk recording personnel. An extremely interesting chapter is devoted to the use of milk recording on and off the farm, in feeding and breeding policies, and another presents the interest of international organizations in milk recording as a means of increasing economic production of milk to help meet the nutritional needs for animal protein in many parts of the world. In the final chapter of Part 1, the author links the future progress of milk and butterfat recording with other services of livestock improvement. An addendum to the first part comprises an excellent review of the literature on methods of milk recording.

The second part of this survey is devoted to milk-recording movements in different countries. The countries covered include the older agricultural countries of Europe, the newer agricultural countries such as Australia, Canada, New Zealand, Southern Rhodesia, the Union of South Africa and the United States of America and tropical and sub-tropical countries such as India, Israel, Jamaica, Japan, Pakistan, Kenya, Tanganyika, Uganda and Nigeria. Concise information is given concerning the national dairy herd, the development of milk recording, its organization and practice in these countries. Each country has its own particular problems and a system of milk recording which proves satisfactory in one is not always the most suitable in another.

Each section contains a summary and a list of references and there are forty-three illustrations. As might be expected in a book of this nature, there are a number of figures and tables. These are clear and well set out and are most informative. In addition, there are a number of useful appendixes.

The author is to be congratulated on assembling such a fascinating account of the world's dairy herds. The publication is of real value to all those seeking information about methods and achievements of milk recording, whether their interests lie in well-developed agricultural countries or in countries where such developments are growing or are yet to come.

HELEN R. CHAPMAN

SUSPENSION BRIDGES

The Theory of Suspension Bridges

By Sir Alfred Pugsley. Pp. vii+136. (London: Edward Arnold (Publishers), Ltd., 1957.) 42*s*. net.

THE several theories of suspension bridges are presented concisely and clearly in this book together with the principles of the study of the vibration of this type of structure.

After an interesting historical introduction to the subject, there are two chapters on theories of the simple suspended cable, including the analysis of stresses and deflexions for various conditions of loading. The well-known approximate theory due to Rankine is the first of the theories of suspension bridges dealt with in the book. Rankine assumed that the cable is parabolic and inextensible, that the deck girders are rigid and that live loading is distributed uniformly to the cable by the girders. This is followed by an account of the elastic theory due initially to Navier and developed more recently by Steinman, which is an improvement upon Rankine's theory only in respect of the allowance for the elasticity of the cable and girder in the determination of the intensity of uniformly distributed loading on the cable. Finally, the more accurate deflexion theory derived by Melan on the basis of the differential equations of the cable and stiffening girder and its approximation—the linearized deflexion theory due to Godard—are considered. The deflexion theory as developed in the United States by Moisseiff and others has proved extremely valuable for predicting the behaviour of modern long-span suspension bridges. In his treatment of the linearized deflexion theory, the author includes the use of trigonometrical series as well as his own contribution, the flexibility-coefficient approach. The use of the former for solving the equations of the general deflexion theory in the manner proposed by Timoshenko and Steuerman is described in a separate chapter.

There is a useful chapter summarizing approximate methods of analysis for preliminary design, which is followed by two chapters on the vibration aspect. The collapse of Moisseiff's Tacoma Narrows bridge in 1940, due to aerodynamically induced vibrations, emphasized the importance of this phenomenon to the designers of long-span suspension bridges. Thus, Chapter 11 deals with the prediction of natural frequencies and modes of vibration in flexure and torsion, while the final chapter gives an abbreviated treatment of the problem of vibration of suspension bridges due to lateral winds, including the use of scale-model tests.

The book is unique among British works on theory of structures, and its conciseness and lucidity are admirable. It is clearly set-out and contains references to original papers and a select bibliography.

T. M. CHARLTON

The Relationships Between Electroencephalographic and Psychological Data in Normal Adults

Dr. P. F. Werre. Pp. vii+152. (Leiden: Universitaire pers Leiden, 1957. Distributed by Messrs. Martinus Nijhoff, Lange Voorhout 9, The Hague.) 15 florins.

BERGER'S discovery of the potential changes in the brain, which he first published in 1929 and which was confirmed by Adrian and Matthews in 1954, led automatically to the foundation of the science of electroencephalography. Its value was realized when Gibbs, Gibbs and Lennox showed that epilepsy could be revealed or confirmed by the electroencephalogram, and this was further enhanced by its use by Jasper and Walter in locating brain lesions. In the Second World War the electroencephalograph was regarded as a valuable instrument in the localization and assessment of brain damage, mostly of traumatic origin. To the neurologist it is now almost as valuable as X-rays to the surgeon. The next step in the use of electroencephalography is obviously to unravel the problems of psychology. A certain amount of work has been done on patients suffering from psychopathic personalities but much remains to be discovered with normal people in such mental states as frustration, anxiety, insecurity, anger and depression. The aim of this thesis is to record some of this work performed by Dr. P. F. Werre in the Neurological Clinic of the Academic Hospital at Leyden.

The book consists of three parts, comprising a survey of the literature, records of experiments and conclusions. In his survey the author considers the literature on electroencephalographic findings in sleep, emotion, anxiety, fatigue and relaxation, the effect of sensory stimulation and mental activity, etc. In the records of his experiments he discusses its relation to the psychology of the subjects. He is cautious in his conclusions but thinks that some definite psychological grouping of people on the basis of the electroencephalogram can be made. This seems to be particularly so in such matters as social insecurity and frustration. All those interested in electroencephalographic work will wish to read this book. Indeed, it is valuable if only for the bibliography, which covers eighteen pages, and for the survey of the literature which occupies sixty-one pages. Although the experiments were conducted on only a small number of subjects the tentative conclusions offered are very suggestive.

CLIFFORD ALLEN

Reason and Chance in Scientific Discovery

By Dr. R. Taton. Translated by A. J. Pomerans. Pp. 171+32 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1957.) 30*s*. net.

IT is gratifying to see an English translation of Taton's dissertation on the art of scientific discovery. This is, of course, by no means the first attempt to analyse the operation of the creative process; but many of the Continental examples of originality selected by the author for analysis are perhaps new to many British readers. Relying largely on case-histories, the accounts of which are well illustrated by diagrams and many excellent plates, Taton discusses such matters as intuition, the automatic and unconscious activity of the human mind, the power of new instruments and the role of chance and accidental observations in the furtherance of human knowledge. It is, indeed, an exciting theme so long as the reader of these post-mortem analyses does not count it all to be an infallible prescription for discovery. Too often the discoverer, in retrospective self-analysis, is apt to conceal the amount of what Katherine Mansfield calls the "terrific hard gardening"—the laborious, conscious and voluntary informing and equipping of the mind which must precede the break-through on the scientific front. As for the great significance of being able to recognize the unexpected, it is relevant to recall the dictum of Pasteur that chance favours the prepared mind. Still, Taton's book is a scholarly contribution to scientific history, and might, for example, be recommended for parallel reading with Brewster Ghiselin's excellent book on the creative process in the world of music and letters.

EDWARD V. APPLETON

The Transformations of Man

By Lewis Mumford. (World Perspectives.) Pp. 192. (London: George Allen and Unwin, Ltd., 1957.) 15*s*. net.

IN this book the author, in seven successive chapters, analyses the transformations of man in a series of stages from his animal or pre-human existence, through what Mumford classifies as archaic man, civilized man, 'axial man', of the 'axial' or universal religions, old world man of the Old World societies, new world man of the New World, to 'post-historic' man of the present time. Pointing out that man's humanity is now threatened by the possibility of barbarism more elemental than was ever encountered in historic times, he postulates the need of a world culture, and that man's principal task to-day is to create a new self, adequate to command the forces that now operate so aimlessly and compulsorily. He believes that humanity still has the technological, as well as the spiritual and personal resources, to create a future which offers scope to human personality, and in his final chapter, "Human Prospects", attempts to indicate something of what is involved in checking the present dissipation of man's potential energy, vitality and creativeness and turning them to this purpose.

To readers of this series that began with "Technics and Civilisation" and ended with "The Conduct of Life" this will be a disappointing book. Neither in scale nor in execution does it match the earlier books. It is more difficult to read, and neither the philosophy nor the argument is expounded with the coherence and cogency that are demanded of an author who assays to cover his field on his own authority essentially unsupported by citation or reference.

Veterinary Toxicology (formerly Lander's "Veterinary Toxicology")

By R. J. Garner. Pp. vii+415. (London: Baillière, Tindall and Cox, Ltd., 1957.) 35*s*. net.

THE radical changes that have occurred in the sources of toxic hazards to animals can be seen in comparing the present volume with the early editions of its forerunner, Lander's "Veterinary Toxicology". In the latter, more than half the book was devoted to poisonous plants, while in addition, the majority of organic poisons described were of plant origin. Now plants form but one of six sections in the book, and it is clear that the domestic animal must face a barrage of synthetic compounds largely comprised of the herbicides used to destroy the plants themselves. Perhaps in future editions it will be necessary to expand the present short but valuable section on radioactive materials. The situation is summarized in the introduction, where common causes of poisoning are tabulated. It is to be regretted that this section of the book is not fuller and indeed that more statistics are not available. This lack of information, which was emphasized by the Zuckerman Report on Toxic Chemicals in Agriculture, necessarily limits the effective direction of policy to reduce the incidence of poisoning.

The author has organized his voluminous material in an admirable way; inorganic substances are dealt with in alphabetical order, but this codical system has been dropped in considering drugs and pesticides. However, this allows the rational grouping of agents with similar modes of action, and hence economy in the text: it is the approach that is familiar in experimental pharmacology. The whole book is well documented with references which will be of value to practitioner and student alike, and indeed the general sections of the book could be read with advantage by students at their preclinical stage.

P. Jewell

Jets, Wakes, and Cavities

By Garrett Birkhoff and E. H. Zarantonello. (Applied Mathematics and Mechanics: a Series of Monographs prepared under the auspices of the Applied Physics Laboratory, Johns Hopkins University, Vol. 2.) Pp. xii+353. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 10 dollars.

While the subject of jets, wakes and cavities is of considerable interest in fluid dynamics and has attracted the attention of many engineers, physicists and mathematicians, accounts of the field as a whole are very rare. Thus, the attempt to collect the available information in one volume is most welcome, and from this aspect alone the book under review with its almost overwhelming number of references is extremely useful. But since the first author, in particular, has himself contributed much original work to this subject, the presentation bears his stamp and draws together and co-ordinates many fragmentary and seemingly unrelated pieces of information. A wide and complex field is covered and interest in the subject is still very much alive. It is in these still vigorously growing branches that the authors' preferences are most apparent and, perhaps, lead to a slightly one-sided presentation. Altogether, the book affords an excellent introduction to a fascinating subject and will profitably be studied by graduate students as well as general readers who are curious about applied mathematics, hydraulics, or aeronautics.

D. Küchemann

Nuclear Reactors for Research

Edited by Clifford K. Beck. (The Geneva Series on the Peaceful Uses of Atomic Energy.) Pp. xii+267. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1957.) 8.50 dollars; 64*s*.

So much information was presented in such a short time at the 1955 Geneva Conference on the Peaceful Uses of Atomic Energy that several publishers recognized the need for producing edited collections of papers on particular topics. The book under review is such a collection. In Part 1 the uses of research reactors are first discussed and illustrated by extensive references. Descriptions of particular types of research reactors are given in subsequent chapters which comprise Part 2.

Most of the material in the book has appeared elsewhere, but Dr. Beck has made deletions and rearranged parts of the original papers so that with his own additions assimilation is easier. Anyone currently considering whether research reactors can be of use in his particular field would do well to study this book as a guide to what can be done.

Part 1 is bound to attract most interest, and unless the reader is directly concerned with choosing a particular type of reactor or for some other reason concerned with comparing details of the different types, Part 2 may prove a rather long catalogue. However, the number of people with such interests is increasing in both industry and the universities, and to them the book should be more easily read than the alternative sources referred to.

F. W. Fenning

Medical Radiation Biology

By Friedrich Ellinger. Pp. xxxiv+945. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, Ltd., 1957.) 150*s*.

This is a book written by a physician for physicians and as such it should prove a useful textbook for radiotherapists and a valuable reference book for medical men whose contact with radiation problems is more intermittent.

The book is written almost in lecture-note form. It is strictly systematic and exhaustive, with very adequate cross references. This, together with the 5,000 references, makes it a very valuable information source for all workers in radiobiology. It will not, however, rank as a scientific treatise on radiobiology, for the treatment is rather elementary and didactic. The early chapters on the fundamental aspects of radiation and radiation effects are rather unsatisfactory and some would consider them occasionally misleading. For example, the early statement that it is possible to consider all the effects of radiation under a single biological concept as a 'stimulus' would scarcely appeal to the physiologist.

The greater part of the book is concerned with a detailed description of the effects of radiation on the various tissues and organs of the body in health, disease and malignancy. The effect of externally administered X- and γ-radiation is, of course, the main theme, but the effects of ultra-violet and visible light are also fully dealt with. There is also a valuable section on the effects of radiations arising internally from administered isotopes. Health hazards are kept to the fore and discussed at appropriate points throughout the text.

Glossary of Indian Medicinal Plants

By R. N. Chopra, S. L. Nayar, and I. C. Chopra. Pp. xx+330. (New Delhi: Council of Scientific and Industrial Research, 1956.) Rs. 8.

The object of this glossary is to present a concise record of the information regarding the properties and uses of the medicinal plants of India as a guide to those interested in indigenous drugs.

Much of the information is a result of an all-India survey of medicinal and poisonous plants, visits to centres of learning of indigenous medicine and consulting the literature on local herbaria and libraries.

The plants have been arranged in alphabetical order according to their scientific names, so that there will be no difficulty for readers in finding any particular drug. Many of the commonly used synonyms have been inserted as cross-references to their modern scientific names. Abbreviations have been used in order to compress data into a small handy volume and a list of these has been included for ready reference. When a number of plants belonging to the same genus is discussed, the name of the family to which the plants belong is supplied with the scientific name of the genus. Important vernacular names commonly used in different regions of India have been given, and an index of these names has been provided at the end. The diseases for which the particular plant is used are also briefly described.

A special feature, which will not fail to attract attention, is the inclusion of brief accounts of the active principles of plants so far as they have been worked out. An index of chemical constituents is provided. Under the name of each plant, there are abundant references to scientific journals and books.

S. B. Challen

Cloud Study

A Pictorial Guide. By F. H. Ludlam and Dr. R. S. Scorer. Pp. 80. (London: John Murray (Publishers), Ltd., 1957.) 12*s.* 6*d.* net.

THE basis of this book is a selection, preceded and accompanied by explanatory text, of seventy-three photographs with a frontispiece in colour, from the fine collection of the Royal Meteorological Society, the files of its monthly magazine *Weather* and other sources, including the private collections of the authors themselves who have added much to our knowledge of clouds. All the familiar types of cloud are well represented, but possibly the most commanding picture shows the stupendous wall of cumulo-nimbus cloud surrounding the clear 'eye' of a Western Pacific typhoon. From this, one can well believe the statement that a tropical cyclone is an "organized system of cumulo-nimbus clouds". A useful inclusion for purposes of identification is the photograph of the seldom seen but peculiarly beautiful cirriform noctilucent clouds probably consisting of small dust particles instead of water droplets. These form high up in the stratosphere at altitudes of about 80 km. and may be seen in the higher northern latitudes on summer nights between May and August. The authors explain very clearly the fairly well-known physical transformation of large cumulus clouds into showery cumulo-nimbus. Yet one feels there is more to learn about the great cumulus clouds. What is the critical factor which gives them their sharp outlines and rock-like solidity of aspect notably when piled on the horizon like a mighty range of mountains? Ruskin used to expatiate upon this a hundred years ago.

L. C. W. Bonacina

The Physics and Chemistry of Life

(A *Scientific American* Book.) Pp. xi+270. (London: G. Bell and Sons, Ltd., 1957.) 13*s.* 6*d.* net.

THESE eighteen short essays first appeared in the magazine *Scientific American*. The book begins with a discussion of the origin of life and ends with an article on the electrical activity of the brain. Most of the writers are recognized leaders in the field of work which they have chosen to describe. The subjects include photosynthesis, nitrogen fixation, the structure of proteins in general and of insulin in particular, the nature of genes, enzymes, viruses and nucleic acids, the mechanisms of cell division and differentiation, and the properties of muscle and nerve. The standard of 'popularity' varies a good deal from one essay to another. Some of the authors have assumed that their readers will have an elementary knowledge of organic chemistry; others might have been wiser to have made this assumption: for example, it is not easy to give a clear account of the modern view of fatty acid oxidation without using any structural formulæ.

The article by G. Beadle on the genes of moulds and man shows the way in which the study of the bread mould *Neurospora crassa* has helped to explain how genes act. It may perhaps be selected as an example of popular scientific writing at its best.

Taken as a whole, these essays give a broad picture of some of the more exciting topics of present-day biological research. Considering the very reasonable price of the book it would perhaps be ungenerous to complain of the poor standard of production of some of the diagrams.

D. C. Harrison

Tables of the Non-Central *t*-Distribution

Density Function, Cumulative Distribution Function, and Percentage Points. By George J. Resnikoff and Gerald J. Leiberman. (Stanford Studies in Mathematics and Statistics, Vol. 1.) Pp. x+389. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1957.) 100*s.* net.

THE quantity known as 'Student's *t*' is widely used in statistics to test the significance of a mean; it is, in effect, the ratio z/s, where z is a normal variable with zero mean and unit standard deviation and s^2 is an independent variance estimator distributed as χ^2/ν with ν degrees of freedom. The quantity called 'non-central' t is the quantity $(z + \delta)/s$, where δ is some given constant. Its distribution requires tabulation by triple entry, according to t, ν and δ. Originally, it was required for the power function of tests based on 'Student's *t*', but more recently has found application in a number of other fields.

These tables present the frequency, the distribution function and the percentage points of non-central t to four decimal places for $\nu = (1)24(5)49$; with standardized argument $t/\sqrt{\nu}$; and for values of δ determined as $\sqrt{(\nu + 1)}K_p$, where K_p is a standardized random normal deviate with probability integral $1 - p$. The tables were computed on an IBM card programmed computer and are legibly reproduced from photographed typescript. Statisticians will be grateful to the authors and to the Stanford University Press for making this work, which was done under a Naval research contract, available for general use.

Modern Computing Methods

Department of Scientific and Industrial Research: National Physical Laboratory. Notes on Applied Science, No. 16. Pp. vi+129. (London: H.M. Stationery Office, 1957.) 10*s.* 6*d.* net.

THIS work is based on lectures delivered by various members of the staff of the Mathematics Division of the Laboratory during a vacation course on "Computers for Electrical Engineering Problems". It gives a brief account of those computing methods which are likely to be of general use, and its emphasis is essentially practical. There are twelve chapters, the first four of which deal with algebraic problems including the determination of the real and complex roots of polynomial equations, the inversion of matrices and the determination of their latent roots and vectors, and the solution of simultaneous linear algebraic equations. Chapter 5 introduces the theory of finite differences which is used in the following two chapters to solve ordinary differential equations of the boundary-value and initial-value types. Chapter 8 is mainly concerned with quasi-linear partial differential equations of the second order in two independent variables and uses the method of 'characteristics' for the solution of the hyperbolic equations. The treatment of the elliptic and parabolic partial differential equations is given in Chapter 9, and relaxation methods are discussed in Chapter 10. The last two chapters discuss the various problems which arise in the computation, construction, checking and presentation of numerical tables of mathematical functions. The account is necessarily condensed, but it is supplemented by an extensive and most useful bibliography of reasonably accessible literature. S. WEINTROUB

The Physiology and Biochemistry of Lactation

By Dr. S. J. Folley. Pp. viii+153+19 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 18*s*. 6*d*. net.

IN the past twenty years the Physiology Department of the National Institute for Research in Dairying, under the leadership of Dr. S. J. Folley, has made outstanding contributions to knowledge of the biochemistry and physiology of lactation. The present book is based on a series of lectures given by Dr. Folley at the Collège de France. It presents a commendably clear and readable account of the important advances that he and others have made in the subject, and adequately describes modern methods by which these advances have been achieved. The first of the six chapters discusses the growth of mammary tissue and how it is influenced by œstrogen, progesterone and some of the anterior pituitary hormones. The second and third chapters deal with the initiation and maintenance of lactation, and the fourth with the milk ejection reflex, the nature of the milk ejection hormone and the effector contractile tissue of the mammary gland. The last two chapters describe modern views on the methods by which milk fat, lactose and milk proteins are formed in the gland. The book is well illustrated, the figures and tables are clear and concise, and a valuable list of references accompanies each chapter. It is a book that can be highly recommended to students, lecturers and research workers and indeed to all whose job it is to understand the functioning of the actively secreting mammary gland. J. A. B. SMITH

The Armored Scale Insects of California

By Howard L. McKenzie. (Bulletin of the California Insect Survey, Vol. 5.) Pp. v+209+3 plates. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1956.) 45*s*. net.

THE wide range of species of the armoured scales, or Diaspididae, to be found in California include many that are primary pests of major agricultural crops. The object of the present work is to enable the thousands of specimens received annually by the State Department of Agriculture to be accurately identified and their occurrence within the State recorded, so that the economic importance of the species may be evaluated. The book, by a well-known authority on this group of insects, is admirably designed to meet this objective.

Keys to genera and species are given as well as excellent detailed figures of each species. The species are not described but the more important taxonomic references are listed and can be consulted where the identity is in doubt. Excellent colour photographs of some of the more important species are included; but it is open to question whether these are of any great aid to recognition, as closely allied forms are often so very much alike in appearance. Type locality and host as well as other known hosts are given for each species as well as other useful information. There are an index to the genera and species, a host index and a host list including the Diaspidid species, arranged alphabetically under plant families.

This book is very well arranged and brings together a wealth of information that will be invaluable to workers in California. But although it deals with the fauna of a restricted area, many of the species have a very much wider distribution, not only in North America but also throughout the world. It will therefore be of considerable value to all those interested in this group of insects of considerable economic importance. W. J. HALL

Rocket Propulsion Elements

An Introduction to the Engineering of Rockets. By George P. Sutton. Second edition. Pp. xii+483. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 82*s*. net.

IT is surprising that in spite of the growing importance of rockets since the Second World War so few books have been written dealing with rocket propulsion from the point of view of the design and development engineer. When first published in 1949, this book was the only one of its kind and even to-day it has no equal. This second edition brings the subject up to date and remedies some of the weaknesses of the first edition. The book has been enlarged by approximately 60 per cent and includes new material on both liquid- and solid-propellent motors, the subject-matter of the latter in particular being a considerable improvement on the first edition. A more comprehensive treatment of heat transfer is also included, although radiation could have been dealt with more fully. The many worked examples and the problems at the end of each chapter are useful features although the student would appreciate answers to more of the problems. In a book of this nature covering such a wide field it is inevitable that certain aspects of rocket propulsion cannot be dealt with as fully as some people would wish, and so for those wishing to delve more deeply into specialist subjects there is a greatly enlarged and well-arranged bibliography at the end of the book.

This is a comprehensive technical book covering both the theory and practice of rocket engines and can be thoroughly recommended to all those, whether students or practising engineers, who are concerned with rocket propulsion.

Through Alchemy to Chemistry

A Procession of Ideas and Personalities. By Prof. J. Read. Pp. xvii+206. (London: G. Bell and Sons, Ltd., 1957.) 18*s*. 6*d*. net.

THOSE who have an acquaintance with Prof. Read's earlier books, "Prelude to Chemistry" (1936), "The Alchemist in Life, Literature and Art" (1947), and "Humour and Humanism in Chemistry" (1947), will know how ably and with what charm of style he can draw on his fund of specialized knowledge of the chemistry of the past and the personalities of its practitioners. A new book by him in this field may be expected to be good, and this latest one from his pen amply fulfils expectations.

It is, as he says, in some way a digest of the earlier works, to which material from his "Direct Entry to Organic Chemistry" (1949), which was awarded the Cortina-European Prize of a million lire, has been added. The text takes the reader from the ideas of the earliest civilizations through the long period of alchemy to modern times, the age of the benzene ring, electrons, atomic structure, and chemistry in space. The illustrations, including many excellent plates, add interest and understanding to the story; many of them would be difficult to find elsewhere. The book is designed to be intelligible to the educated reader not familiar with the details of chemistry; the only chemical equation in it is $2H_2 + O_2 = 2H_2O$, and anyone who knows the full history of all that lies hidden in this simple expression will have an idea of what could be expounded from such familiar things.

Prof. Read's book can be warmly recommended to all who care for the better things of science; to the chemist, to the young reader who will be attracted by its clarity and interest, to the historian, and to the many who are now aware that the history of science is not only of value in itself but also forms an integral, although sometimes neglected, part of the whole history of civilization.

J. R. PARTINGTON

A Practical Guide to Plant Sociology for Foresters and Agriculturists

By Prof. F. R. Bharucha and Dr. W. C. DeLeeuw. Pp. viii+44. (Bombay; Calcutta; Madras: Orient Longmans Private, Ltd., 1957.) Rs. 5.

WITH the revival of the Botanical Survey of India, the authors have brought out this little book to provide, in easily available form, some tangible suggestions for methods of studying the ecology of Indian vegetation. They have, in fact, outlined the methods of the Zurich–Montpellier school of phytosociology. The difficult task of doing this within the space of forty pages has been well tackled, but it seems questionable whether the emphasis on brevity has not been too great. One cannot help feeling that the inexperienced ecologist, when he comes to use the book for practical field studies, is likely to be left a prey to unsolved doubts as to just how he should begin. Nevertheless, the book does put into his hands useful data on the Zurich–Montpellier techniques, which, with some general guidance, should enable him to contribute towards a systematic description of Indian vegetation.

The book can also serve to give botanists who are unfamiliar with the work of the Zurich–Montpellier school a nodding acquaintance with its methods. That many British ecologists are critical of these methods is irrelevant here, but the widespread lack of understanding between the two schools of thought might be lessened by a better knowledge on both sides.

MAURICE ASHBY

Plastic Design of Portal Frames

By Dr. Jacques Heyman. (Cambridge Engineering Series.) Pp. viii+104. (Cambridge: At the University Press, 1957.) 10*s*. 6*d*. net.

QUITE apart from the interest of its subject, Dr. Heyman's book is attractive because of two features not usually encountered in modern technical publications. First, it is inexpensive, and secondly, it does not pretend to be a fully-exhaustive treatise on a wide field. The text deals with single-story portal-framed buildings only, and does not stray outside the terms of reference so set.

It is worth noting that the conception of the steel frame as part of a finished structure is constantly kept before the reader. He is not given the theoretical background only, and left to apply this to design as well as he can; throughout, the emphasis is on completing the task of translating the ideas developed at Cambridge into the completed building.

Dr. Heyman has the valuable faculty of realizing that the student of his subject may well find difficulties even in the elementary stages. He makes a considerable effort to ensure that the simplest application of plastic design—to continuous beams and purlins—is thoroughly understood, and then builds logically and gradually on this basic understanding until such complex frames as multi-bay portals and tied portals under wind loading are being considered.

The book achieves its purpose of introducing the newcomer to this powerful British method of steel design, but Dr. Heyman realizes the limitations of his space and has confined himself to a type of structure where strength of sections rather than stiffness of stanchions is likely to be the controlling factor. Those readers interested in instability or multi-story construction must turn to the excellent bibliography for further direction.

W. FISHER CASSIE

Trilinear Chart of Nuclides

By William H. Sullivan. Pp. ii+4+chart. (Washington, D.C.: Government Printing Office, 1957.) 2 dollars.

W. H. SULLIVAN'S "Trilinear Chart of Nuclides" has just appeared in its second edition. One can surely say without exaggeration that every nuclear physicist and chemist, and, in addition, the large group of people who require nuclear data in their work, will be delighted to be able to embellish the walls of their offices or laboratories with this very useful atlas of nuclides or, at least, have it handy for ready reference in their desks.

I am sorry to find that the colour scheme of the first edition has been replaced by printing the hexagons in heavier or lighter print for the naturally occurring isotopes and the artificial ones. Even with the advantage of a lower price for the chart, the sacrifice of beauty seems regrettable.

The organization of the new chart is identical with that of the first edition. The amount of information presented is very large, and great pains seem to have been taken to ensure accuracy. At a price of 2 dollars the chart should be extremely popular with the scientific world.

E. BRETSCHER

Complexometric Titrations

By Prof. Gerold Schwarzenbach. Translated and revised in collaboration with the author by Dr. Harry Irving. Pp. xviii+132. (London: Methuen and Co., Ltd.; New York: Interscience Publishers, Inc., 1957.) 21*s*. net.

MOST chemists are familiar with at least a few of these elegant methods, but all will welcome this survey and be surprised at the variety and extent of the applications. More than 300 references are given to papers, nearly all of which have appeared in the past decade or so.

Prof. Schwarzenbach, the pioneer of complexometric titrations, gives a very clear discussion, aided by numerous neat diagrams, of the theory underlying the stability of the complexes and the titrations. The use of dyes as metal-indicators arose from a chance observation made when hard tap-water containing calcium was being employed for washing vessels in which a complexone and murexide had been used. (The chance observation would probably have been wasted had it not been made by the eye of a genius.) The indicators are so sensitive that end-points are very sharp even with 0·01 *M*-titrants.

The use of masking agents, enabling mixtures to be titrated, is fully explained, as is also the preparation of the necessary *p*H buffer solutions. Nearly forty detailed determinations include examples of direct, indirect, substitution, and back titration and suggest many further applications.

This 'translation' is much more than the dry bones often covered by that term, for Dr. Irving has been associated with the author in the preparation of a second German edition and has not hesitated to make such alterations as seemed desirable. There are a few misprints, and some of these are important.

The publishers are to be congratulated on the production of a well-printed and well-bound book at a reasonable price. A. D. Mitchell

Biological Staining Methods

By George T. Gurr. Sixth edition. Pp. vi+102. (London: George T. Gurr, Ltd., 1957.) 5*s*.

THE diversity of staining techniques has increased so greatly in recent years that it is often difficult for the non-specialist to choose those most applicable to his problem. A book of this type, which presents clearly a wide selection of methods, is thus of great value, not only to students but also to all who use staining methods. This new edition of Mr. G. T. Gurr's book follows the plan of previous issues, devoting sections to bacteriological, hæmatological and general methods. Some new techniques have been added, together with a section on fluorescence microscopy, a method which is of increasing importance in biological research. A most useful feature of the book is the expanded formulary, giving the composition of many staining solutions, and also the appendix which lists the solubilities in water and in alcohol of many common chemicals and stains. A possible improvement which might be incorporated in any later edition would be the separation of the histochemical methods from the general stains and their expansion into a separate section. This, however, is a minor criticism, and the book in its present form will, I feel, prove a most useful reference work, particularly to students and laboratory technicians.

S. Bradbury

Metrology and Gauging

By S. A. J. Parsons. Pp. xxii+286. (London: Macdonald and Evans, Ltd., 1957.) 25*s*.

THE ever-present demand for greater precision in manufactured articles has created the need for a wider knowledge of metrological techniques among those engaged in production processes, not least the designer himself. It is becoming increasingly recognized that instruction in this subject should form part of the curriculum of the engineering student, and the book under review has been particularly designed to cover the syllabus requirements of examinations leading to corporate membership of the Institution of Mechanical Engineers and the Institution of Production Engineers, and similar examinations. However, the author's treatment of the subject makes the book equally valuable to the practising engineer.

An introductory chapter deals with the fundamental standards of length, and this is followed by a description of the use of light-waves as length standards and various forms of interferometer embodying this principle.

After a chapter on the interchangeability of components, the author discusses in considerable detail the design, manufacture and testing of limit gauges. This is followed by several chapters on commercially available measuring instruments, which have been grouped according to their principle of operation, namely, optical, mechanical, electrical or pneumatic. The application of these instruments to screw thread measurement and the testing of straightness, flatness and alignment follows. Two chapters are devoted to the measurement of gears and surface finish. The appendixes include a list of relevant British Standards and some typical examination questions.

This book, having regard to its purpose, quite adequately introduces the subject of metrology, and clearly indicates present trends in measuring techniques. However, the author's presentation of his material could have been improved by re-grouping it in a more logical sequence, and the list of chapter contents could with benefit be shortened. The illustrations are plentiful, and a clear fount makes the book pleasant to read. P. W. Harrison

The Rolling of Strip, Sheet and Plate

By Eustace C. Larke. Pp. xi+404. (London: Chapman and Hall, Ltd., 1957.) 63*s*. net.

IN this book a remarkable amount of material has been compressed into one volume. The opening chapter deals with modern rolling plant. Then a chapter on multi-roll mills describes the fascinating Sendzimir mill and its advantages. There follow chapters on roll cambers, gauge variation of rolled strip, rolling loads and rolling schedules. Numerical and graphical methods for computing the latter are fully described in simple terms, and nowhere is the text so condensed that the reading becomes difficult. A whole chapter is given to the influence of coiler and decoiler tension on the rolling load. Then come chapters on deformation, hot rolling and the calculation of hot-rolling loads. Finally, there are chapters on the energy consumed in cold and hot rolling and on the productive capacity of strip mills. This last chapter presents practical methods for calculating the capacity, and effects considered include handling time, waiting time, length and weight of coils and rolling speed.

A considerable part of the book is devoted to methods of calculation, and it may not be out of place to make two comments. The amount of *ad hoc* approximation made in order to simplify complex mathematical equations might be largely avoided by using an electronic computer to solve some of the design problems; and, for complicated situations where the validity of the assumptions leading to the theory are in doubt, there may be something to be gained by using statistical design in experimentation. For example, improvement in the use of existing productive plant may be sought by the use of the Box technique of evolutionary operation.

It is to be hoped that the book will be of interest to mill managers and their technical staff as well as students. L. S. Goddard

Peculiar Disorder of Plasma Thromboplastin Production

One of the several functions of platelets is participation in the formation of plasma thromboplastin. Recently, we encountered in the blood of a patient an agent with the unprecedented action of specifically hindering this activity. Thus, the presence of his plasma or serum in the incubation mixture inhibited the generation of plasma thromboplastin[1]. Compared with a normal control (Table 1) the derangement, as estimated from the clotting time of the substrate, was more apparent on reducing the number of platelets (experiments *B* and *C*) and practically abolished on using a concentrated suspension (experiment *D*).

Table 1. Effect of Platelet Concentration on Inhibitor Activity

Experiment No.	Platelet suspension (10^3/mm.^{3})	Clotting time of substrate (sec.)* Source of plasma or serum Normal	Patient†
A	600	10	14
B	300	12	19
C	150	14	25
D	1,200	8½	9

* Equal volumes of plasma treated with aluminium hydroxide (1 : 5), diluted 1 : 10 serum, platelet suspension and 0·025 *M* calcium chloride were incubated at 37° C. for 6 min. The activity of the mixture was tested by taking 0·1 ml. together with 0·1 ml. 0·025 *M* calcium chloride and adding them simultaneously to 0·1 ml. normal citrated plasma (substrate), and recording the clotting time.

† In this case the incubation mixture contained either patient's plasma and normal serum or patient's serum and normal plasma.

Antihæmophilic globulin and Christmas factor levels[2] were determined in the presence of excess platelets; normal results were obtained. The patient's platelets were fully active in the thromboplastin generation test. Pre-incubation of normal platelets with patient's plasma or serum did not cause further deterioration in the production of plasma thromboplastin, indicating that the inhibitor has a retarding but not a destructive action on the platelet thromboplastin component. Further study has shown that this inhibitor counteracts the combination of platelets with antihæmophilic globulin and Christmas factor; the activity of other blood-clotting factors or their intermediate products were uninfluenced.

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[1] Biggs, R., and Douglas, A. S., *J. Clin. Path.*, 6, 23 (1953).

[2] Nour-Eldin, F., and Wilkinson, J. F., *J. Physiol.*, 136, 324 (1957).

Salt Intake, Adrenocortical Function and Hypertension

A recent communication[1] proposed that the high levels of salt consumption current in modern societies were beneficial since the salt stimulated adrenal cortical function and thereby set in motion various adaptive mechanisms that make the individual more responsive to the stresses of modern living. Space does not permit examination of whether modern living actually has more stresses than a primitive life: one American anthropologist, Prof. G. P. Murdock of Yale University, several years ago[2] expressed strong doubts that such was the case.

Although the addition of salt to food is as old as recorded history, many vigorous groups have used none except that which occurred naturally in foodstuffs; for example, Eskimos, certain of the Chinese and North American Indians, the Lapps, and the Masai of Africa. Available data indicate that the sodium intake on these natural diets would range from about 1 to 2 gm. (2·5–5 gm. as sodium chloride) and sometimes less. Beginning with the pioneering work of Allen[3], drastic salt restriction has been used widely in the treatment of various diseases. During the past ten years I have studied some 75 patients in metabolic wards for long periods before and after sodium restriction of 40–175 mgm./day. These people have maintained sodium balance and normal activity, and evidence of impaired adrenocortical function has not been observed. One walking hospital patient has now been restricted to about 115 mgm. sodium/day for more than four years; she remains in electrolyte balance, and numerous clinical and biochemical tests of adrenocortical function, including the response to intravenous adrenocorticotrophic hormone[4], which were made recently, indicated a normally reactive adrenal cortex. In other patients, psychiatric interviews, psychometric studies and electroencephalograms before and after drastic salt limitation revealed no changes. It has been concluded that adrenocortical function is normal on a low salt diet.

Finally, is a high salt (sodium chloride) diet itself disease-producing? I believe there is ample evidence to indicate that salt is a primary cause of 'essential' hypertension which, after atherosclerosis, is the commonest form of cardiovascular disease in Western society. For some years, I have been intrigued by the apparent low incidence of hypertension among many primitive races; it was of interest to find that among such groups for which data were available, a low dietary intake of sodium was a common factor, generally 1–2 gm. per day. (All experimental and clinical evidence indicates that it is the sodium, not the chloride ion, which is toxic.) Up to the present time I have found no reports of groups which habitually consume low sodium diets and have hypertension to any significant degree.

It has been known for several years that feeding salt to rats will produce a disease which mimics human hypertension[5]. Beginning in 1954, I have published evidence indicating that individuals customarily on a high salt diet will have significantly more hypertension than those on a low salt diet[2,6]. It is known that the West Indian Negro has a much greater incidence of hypertension than the Whites in the same area[7], and according to Prof. Murdock the evidence suggests that from early childhood the Negroes eat a diet high in salted pork and fish. The Southern Negroes of the United States have several times as much hypertension as the Southern Whites[8]. My interviews with Negroes from that region indicate that for most of them salted pork in one form or another has been a prominent article in the diet from early childhood.

Prof. A. Halawani, director-general of the Research Institute of Tropical Medicine, Cairo, informed me last year that the Egyptian peasants ordinarily ate large amounts of heavily salted cheese, and when available, salted fish: he had no precise statistics, but it was his impression that hypertension was relatively common among these peasants in contrast to most Africans and Orientals[8].

It has been axiomatic that Orientals have little or no hypertension[8]. From the work of Prof. T. Fukuda, Physiology Department, Chiba University, Japan[9], and a Japanese Government bulletin[10], the following data emerge: (1) hypertension is a widely prevalent and serious disease in Japan; (2) fatal cerebral apoplexy is the commonest cause of death and is 1·5–2·0 times more frequent than in the United States; (3) in the Prefecture of Akita, where hypertensive cardiovascular disease is especially common, the daily sodium chloride intake (based on 24-hr. urinary chloride excretion of 268 adults) averaged 26·3 gm.—about twice the average Japanese intake, and 2·5 times the average intake of the American male[11]; (4) among 2,082 unselected men studied in Akita the following blood-pressure data were found: at ages 20–40, about a quarter had systolic pressures greater than 140 mm. mercury and a fifth had diastolic pressures of 90 mm. mercury or more; at ages 40–60, 35–62 per cent had systolic elevation and 37–50 per cent had diastolic elevation in excess of 140 and 90 mm. mercury, respectively. A similar incidence of elevated blood pressures was found in the 3,219 women who were examined. At corresponding ages this frequency of elevated blood pressures is about twice that of the Japanese population as a whole and is in striking contrast with areas in China and India where low salt diets are the rule and hypertension is a rare or an uncommon disease. I do not know of other areas in which such a high incidence of elevated blood pressure is present, although they presumably exist.

From the foregoing, the following conclusions seem justified: (1) a low salt diet is associated with normal adrenocortical function; (2) a high salt diet is associated with a markedly increased incidence of hypertension and cerebral apoplexy; (3) evidence discussed elsewhere[2,6c] suggests that the high salt intake is a cause of, and not caused by, the hypertension; (4) sharp reduction of current levels of salt intake could be carried out without harm and probably with great benefit, by reducing the incidence of hypertensive cardiovascular disease. Furthermore, I predict that wherever low salt diets prevail (that is, less than about 2 gm. of sodium per day) hypertensive cardiovascular disease will be uncommon; conversely, where high salt diets (that is, more than perhaps 5 gm. of sodium per day) are the rule, hypertension and its complications will be frequent.

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Intestinal Carcinoma in Mice following Injection of Herring-Sperm Deoxyribonucleic Acid

THE transmission of genetical characteristics from one strain of bacteria to another by means of deoxyribonucleic acid is now well recognized. However, apart from the claim by Benoit *et al.*[1] to have altered the hereditable features of certain ducks, the method does not appear to have been applied clearly and successfully to the higher organisms. Nevertheless, it seems theoretically possible, by analogy with the achievements in bacterial transformation, that some characteristics of cancer cells might be transmitted to normal cells by means of tumour deoxyribonucleic acid, and experiments are being carried out here with that end in view.

It was felt that adequate controls should reasonably include not only the parallel administration of normal deoxyribonucleic acid of the same species and strain and preferably of the same tissue as that from which the tumour was derived, but also that of an entirely foreign species which might reveal non-specific effects on cell metabolism. From bacteriological evidence it seemed that direct interaction between the deoxyribonucleic acid of the host and that newly introduced might occur only if the new acid were highly polymerized and derived from a source showing close genetical relationship.

Experiments were carried out on young line-bred *C3H* mice, and the foreign deoxyribonucleic acid chosen was a commercial preparation of herring sperm. In the course of investigations, two three-weeks old females of a litter of four received five daily injections of the deoxyribonucleic acid of herring-sperm. On the twenty-third day after the first injection, one died and the other, being moribund, was killed. Both bore a solid whitish tumour mass involving duodenum, jejunum and mesentery, together with small deposits scattered over the peritoneum and in adjacent lymph nodes. A considerable amount of blood-stained ascitic fluid containing numerous tumour cells was present, and the general picture was similar in both cases.

Histological examination showed an adenocarcinoma arising in the mucosa of the duodenum. In some areas there was tubular differentiation, but elsewhere the tumour was undifferentiated. The solid tumour has been passaged with difficulty to other *C3H* mice but not to other strains. The ascites cells have been transmitted to both *C3H* and albino mice (laboratory strain), resulting in the growth of both solid and ascites forms, with some animals dying as early as six days after injection as a result of tumour proliferation.

The two litter mates (females) which received no treatment have remained healthy, and we have as yet found no reference to such a tumour developing spontaneously in mice of any strain. It is true that we have not so far been able to repeat this result; but in our view the development of a tumour so unusual in its site of origin and in its behaviour in young mice in these circumstances cannot be disregarded. This *C3H* strain of mice has, of course, a high incidence of spontaneous mammary carcinoma transmitted by the Bittner milk factor, which develops normally in adult females. We think it most unlikely that the foreign deoxyribonucleic acid was incorporated into the nuclei of the mouse tumour, but it may well owe its carcinogenic effect to an interference with the synthesis of a normal acid in the cells of the duodenal mucosa, which is developing extremely rapidly at this stage.

If we had achieved this result by using deoxyribonucleic acid derived from a mouse tumour we should have been tempted to suppose that the abnormal acid had been assimilated in the genetical material of the mucosal cells in the manner of bacterial transformations. The production of a tumour in this control group indicates the need for extreme caution in interpreting positive results in work of this kind.

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Mast Cells

Influence of Cobalt on White Mouse Skin Mast Cells

Observations on the action of cobalt compounds on living organisms revealed that this is to some extent similar to that of histamine. Therefore, as mast cells may produce and/or store histamine and histamine-like substances attached to heparin molecules, it was of interest to see if the cells examined were influenced by cobalt compounds. These were given intraperitoneally to white mice in a single dose of 100 mgm. cobalt/kgm. body-weight, in the form of cobalt nitrate, acetate and chloride. Another series of mice received 5 mgm. cobalt/kgm. in the same salts daily for 3 weeks. Specimens of the skin were fixed and stained by a modified Nowak and Zahl stain[1].

Within 1–1½ hr. of receiving a single dose of any of the cobalt compounds an enlargement of the granula and an increase of their metachromasy were observed. The nuclei of the cells were enlarged, and amitotic cell divisions that occurred during full secretion activity of the mast cells were seen frequently, after which the cells were destroyed by clasmatosis. The metachromatic granula then lay in the substantia fundamentalis for more than 5 hr. The separate nuclei underwent pycnosis, and after clasmatosis occurred there was no way of measuring them.

In white mice receiving only 5 mgm. cobalt/kgm. the increased activity observed in the above experiments is much less. After receiving cobalt compounds for 23 days the cells described are found fairly frequently in the specimens, almost all being disrupted, with their granulations often orthochromatically stained. They remain in the proximity of the intact cells forming crown-like structures.

When the same concentration of the cationic components of the cobalt compounds were used the results were similar.

From the experiments described above it follows that cobalt may stimulate the activity of the mast cells, cause their disruption and finally their degeneration. It also stimulates mitosis within the range of doses used and in this way may liberate the substances produced by these cells.

Diurnal Variations of the Mast Cell Activity

Work over several years has revealed that mast cells secrete heparin and/or histamine[2,3]. We wished to determine whether there are significant morphological variations of the mast cell activity, similar to those described in other organs examined for 24 hr. The observations were made on white mouse skin at 3 hr. intervals for 27 hr. The specimens were stained by a modified Nowak and Zahl method[1]. The kariometric analysis revealed that a definite rhythm exists in the activity of these cells. Detailed data are given in Table 1. The cytoplasmic granula of the cells are most delicate during the morning, at 6 and 9 a.m. The maturity, that is, the extent of metachromatic staining, is also minimal at these times. The metachromasy of cell granula increases towards the night and reaches a maximum at midnight. Clasmatosis during the day is minimal and increases during the night.

Table 1. Mean Diameters of the Nuclei of Skin Mast Cells during 24 hr.

Hr.	Percentage of nuclei with a diameter (μ)								
	2·4	3·6	4·8	6·0	7·2	8·4	9·6	10·8	12·0
3	0	4	13	47	21	8	5	2	0
6	2	10	37	21	16	9	5	0	0
9	5	11	31	38	10	5	0	0	0
12	1	7	18	43	21	6	4	0	0
15	0	2	9	31	39	14	3	2	0
18	0	1	2	6	22	27	20	17	5
21	0	0	4	15	31	38	10	2	0
24	0	0	6	23	36	19	9	7	0

The results show that mast cells, as probably all cells of living organisms, are influenced by day and night changes. This fact is of interest not only in the examination of the fate of heparin and histamine in the organism, for the diurnal factor must be taken into account as a very significant one in any observations on labrocytes, that is, on mast cells.

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A Lipopolysaccharide Antigen of the *Treponema*

Immunochemical studies carried out by D'Alessandro *et al.*[1] on a non-pathogenic, culturable treponeme, the so-called Reiter treponeme, revealed the presence of four antigenic components: (1) a thermolabile protein; (2) a specific, thermostable antigen with polysaccharide characteristics; (3) a lipoid, corresponding to the ubiquitous lipidic antigen cardiolipin; (4) another lipoid similar to the organ-specific cerebral antigen of Witebsky[2]. These studies led to the conclusion that the treponemes, like other organisms, are mosaics of antigens, and a safe basis was established for a better understanding of the complex serological response of the infected host.

In the serodiagnostic field the interest has been focused so far on the Reiter protein antigen, which proved to be a valuable antigen in syphilis serology. The reactivity of the protein antigen, which shows a remarkable specificity and sensitivity, in the complement fixation test with syphilitic serums, is understandable on the assumption that a common antigenic component exists in the Reiter and in the pathogenic *Treponema pallidum*, as indicated by experiments of Dardanoni and Censuales[3].

From the investigations carried out in 1949, the polysaccharide antigen of the Reiter treponeme appeared to be of minor interest from the serodiagnostic point of view. The antigen isolated from the treponemes by trichloracetic extraction of organisms treated with sodium hydroxide, behaved as a haptene: it failed to elicit antibodies in the rabbit and its *in vitro* reactivity with syphilis serums was sparse and weak. These results discouraged further investigations.

However, bacterial polysaccharide or lipopolysaccharide antigens are generally considered to be outstanding components of the organisms in relation to their immunogenicity and *in vitro* reactivity. With this in mind, the problem of the polysaccharide treponemal antigen has been re-investigated in this laboratory. This led to the preparation of a lipopolysaccharide antigen which appears to be clearly reactive in the complement fixation test with syphilitic serums.

Reiter organisms grown in Brewer thioglycholate medium are centrifuged and treated with sodium deoxycholate[4]. Enough 40 per cent trichloracetic acid solution is added to the viscous fluid resulting from the deoxycholate treatment of treponemes to give a final concentration of 5 per cent. The mixture is then kept at 4° C. for 4 hr. After centrifugation the supernate is harvested, the trichloracetic acid removed by dialysis and 4–5 volumes of ethanol added. In a few hours a precipitate is obtained which is centrifuged, redissolved in water and again precipitated. This procedure is repeated three times. The antigen is finally dissolved in water and lyophilized. For use, 1 mgm. of the lyophilized preparation is dissolved in 1 ml. of saline, giving an opalescent solution without sedimentable turbidity.

The antigen inoculated intravenously in rabbits produces antiserums which react definitely with homologous antigen in the complement fixation test; heterologous lipopolysaccharide antigens derived from some Gram-negative enteric organisms did not react with such serums. The Reiter lipopolysaccharide antiserums give a positive complement fixation test with suspension of intact Reiter organisms; similarly, Reiter organism antiserums react with the lipopolysaccharide antigen. Serums obtained from rabbits experimentally infected with Nichols strain of pathogenic *Treponema pallidum* react strongly and regularly with Reiter lipopolysaccharide.

While a small group of normal human serums gave consistently negative results, a positive complement fixation test was obtained in 76 of 85 human syphilitic serums tested so far. Negative results have been observed in nine biologically false positive serums with more or less pronounced cardiolipin reactivity.

Chemical assays of the antigen are now in progress; a phosphorus content of 2·26 per cent has been found, indicating its lipopolysaccharide nature, which appears to be in keeping with *in vivo* and *in vitro* reactivity. From cross-absorption experiments it seems that the antibody reactive with the lipopolysaccharide antigen is not to be identified with either anti-lipid or with anti-protein antibody.

The consistently negative results observed when the lipopolysaccharide antigen is tested with normal rabbit serums or normal human serums and especially biologically false positive serums indicate the specificity of the antigen. The presence of the Reiter anti-lipopolysaccharide antibody in rabbits infected with the pathogenic Nichols strain, and in a high percentage of human syphilitic serums, strongly suggests that an identical or very similar lipopolysaccharide antigen is common to the Reiter and pathogenic *Treponema pallidum*.

Extensive research is needed in order to establish the practical importance of the lipopolysaccharide antigen in the serodiagnostic field. However, in our opinion modern syphilis serology will be based more and more on the detection of the three distinct anti-protein, anti-lipid and anti-lipopolysaccharide antibodies.

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Influence of 4-Methyl-2-thiouracil on the Teratogenic Activity of Hypervitaminosis-A

IT has previously been reported that the incidence of deformities of the skull, brain and palate in the young of female rats exposed to the effects of hypervitaminosis-A during pregnancy is greatly increased if large quantities of cortisone are given to the dams during the period of vitamin A administration[1,2]. It has also been shown that this 'potentiating' action of cortisone in relation to hypervitaminosis-A can be abolished by the administration of insulin to the pregnant female[3].

It is apparent, therefore, that the endocrine glands may play an important part in regulating the teratogenic activity of vitamin A. The present communication is concerned with the influence of 4-methyl-2-thiouracil when administered in doses sufficient to cause loss of thyroid activity in the rat.

Female white rats of the Wistar strain, each of which had previously given birth to a normal litter, were used in these experiments. At the beginning of the experiments the rats were given 2,000 I.U. of vitamin D and 50 mgm. of vitamin E by mouth to ensure that they had an adequate supply of these vitamins. Day 1 of pregnancy was taken as the day on which spermatozoa were detected in the vagina at 9 a.m. The pregnant rats were divided into three groups.

Group 1 received 60,000 I.U. of vitamin A acetate daily from the eighth to the thirteenth day, inclusive, of pregnancy.

Group 2 received 60,000 I.U. of vitamin A acetate daily from the eighth to the thirteenth day, inclusive, of pregnancy and, from the first to the tenth days of pregnancy inclusive, was given a 0·1 per cent solution of 4-methyl-2-thiouracil in lieu of drinking water.

Group 3 was given a 0·1 per cent solution of 4-methyl-2-thiouracil in place of drinking water daily from the first to the tenth days of pregnancy inclusive.

Vitamin A was given by intubation. During the course of the experiment each rat in groups 2 and 3 received on average 240 mgm. of 4-methyl-2-thiouracil.

The rats were killed on the twentieth day of pregnancy and the young removed from the uterus and examined for deformities of the skull and brain. The deformity of the brain encountered was exencephaly.

The findings of the experiment are shown in Table 1. It will be noted that the number of young in group 2 is much smaller than that in the other two groups. This is due to the total resorption of the litters in ten animals.

Table 1

Group	No. of rats	Total No. of young	No. of young with deformities of brain and calvaria	Percentage of young with deformities of brain and calvaria
1	12	77	6	7·8
2	18	45	31	68·8
3	9	62	0	0

The most striking feature to emerge from these experiments is the marked effect of 4-methyl-2-thiouracil on the incidence of deformities of the skull and brain. In previous experiments in which cortisone was given in conjunction with vitamin A, the incidence of deformities of the skull and brain was 36·6 per cent. Cortisone was, however, administered on the ninth to twelfth days of pregnancy, that is, towards the end of the critical period for this deformity.

The results of these experiments suggest that 4-methyl-2-thiouracil has a potentiating effect on the teratogenic activity of vitamin A similar to that previously described for cortisone[1,2].

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Effect of Trauma on Growth of Hair

It has recently been reported that ionizing radiations produce local stimulation of growth of hair in the rabbit[1]. Subsequent to this observation, the stimulating effect of some nitrogen mustard derivatives was recorded[2], and it was suggested that "It should be of interest to determine whether the observed effects can be obtained with other radiomimetic agents or carcinogenic substances".

It seems to me that no specific effect of radiation or radiomimetic agents is required to explain the observed phenomena. During studies on hair growth I have often observed that simple mechanical trauma such as scratching or cutting the rabbit skin causes a sudden hair growth to occur around the site of injury. The effect is most dramatically seen in the quiescent phase of the hair-growth cycle. A clipped area of skin may stay quiescent and free from hair for as long as 3–4 months at a time. Trauma to the centre of such an area results in growth of hair around the site of trauma, with the result that a tuft of hair is soon seen lying in the centre of the hairless zone. The accompanying photograph (Fig. 1) shows the effect of a small incision, 0·5 cm. long, into the entire thickness of the skin in the quiescent phase of the cycle. Failure to appreciate the mechanics of the hair-growth cycle has led to many errors in the past, and a brief summary of some of the important facts is as follows.

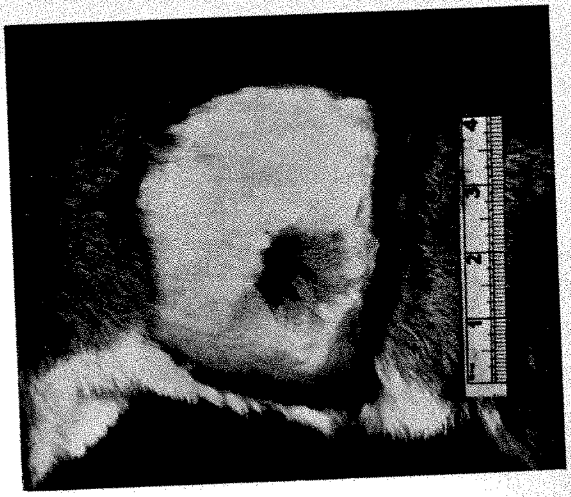

Fig. 1

Hair replacement in the mouse[3,4], rat[5,6] and rabbit[7] is discontinuous and occurs in cyclical waves of active growth. In the mouse and rat cyclical waves of activity start on the ventral surface and spread upwards over the trunk. In the rabbit the hair replacement on the back and flanks occurs in a progressive cycle starting at the dorsum and spreading downwards over the flanks. Hair replacement on the abdomen occurs quite independently of the main dorso-lateral cycle. The progress of a cycle over the trunk creates linear bilaterally symmetrical bands of active growth which can be demonstrated clearly in the clipped animal.

There are many differences between such active and quiescent skin. Hair follicles in the active zone show significantly more mitoses than follicles in the quiescent zones[8]. Proliferative pathological lesions can also be induced more readily in areas where hair growth is active. Thus, painting the rabbit flank with carcinogen produces tumours more quickly and abundantly in an active zone[9]. Inoculation of Shope papilloma virus into skin showing active hair growth and into quiescent skin results in the development of larger and more numerous tumours in the active skin[10]. Intravenous inoculation of vaccina virus into rabbits showed that lesions almost invariably developed in the active zone[10].

In the guinea pig and in man there is no gross hair-growth cycle as seen in the rat, mouse or rabbit. Nevertheless, each hair does show an independent cycle of growth and quiescence. Thus hairs in anagen, catagen, and telogen may be seen lying side by side in any small area of skin in the guinea pig, but they are grouped together in the rabbit and show as large zones of actively growing hair or resting hair.

The problem of growth of hair in man and laboratory animals is of importance not only because of its intrinsic biological significance[6,11], but also because the effect of agents such as X-rays[1] and nitrogen mustards[2] on growth of hair can only be rationally analysed against a background of the dynamic hair-growth cycles and patterns.

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Rotatory Dispersion of Cytochrome *c*

The iron atom in hæm compounds has its six covalences directed toward the six corners of an octahedron; there are four co-planar bonds with the porphyrin nitrogen atoms and one bond on each side of the plane of the porphyrin. The only possible plane of symmetry in such molecules is the plane of the porphyrin; the iron must constitute a centre of asymmetry if one of two requirements is satisfied: (1) different groups are linked to iron on the two sides of the porphyrin plane or (2) groups co-ordinated to iron are also attached to porphyrin side-chains, thus forming chelate rings.

Both these conditions are fulfilled in cytochrome *c*, since the amino-acid composition differs on the two sides of the porphyrin[1], and since the protein is linked to both iron[2] and to porphyrin side-chain[3]. The iron atom of cytochrome *c* should, therefore, contribute to the optical activity of the molecule, unless it is racemized, and racemization is not expected in biological compounds.

It has been observed that the oxidized and reduced forms of *tris*-orthophenanthroline-ruthenium exhibit marked differences in optical rotation, with no change in the organic portion of the molecule[4]. Optical activity due to iron in cytochrome *c* may thus be differentiated from the optical activity due to the protein by looking for a difference in rotation resulting from the gain or loss of an electron.

Sigma cytochrome *c* was purified by passing it through a column of *XR*-64 resin[5]. A 0·5 *M* solution in phosphate buffer (*p*H 6·5) was oxidized with potassium ferricyanide, reduced with hydrogen over platinum, and re-oxidized with ferricyanide. Optical measurements were made in a 0·5 cm. cell at 26° with a Rudolf polarimeter, using a zirconium light source and a Beckman monochromator. Fig. 1 shows rotatory dispersion curves for the oxidized and reduced forms; the curve obtained by oxidation of the reduced form is identical with the curve for the solution prior to reduction.

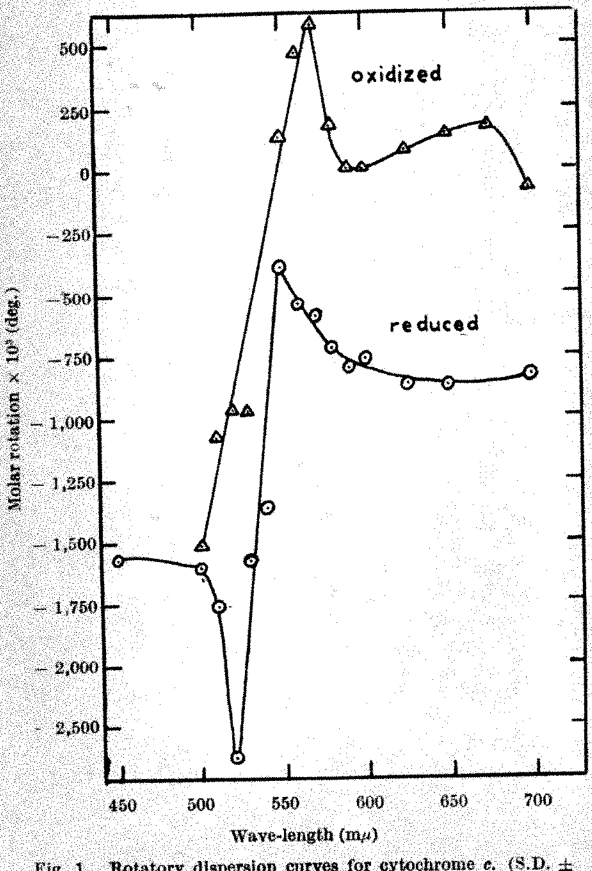

Fig. 1. Rotatory dispersion curves for cytochrome *c*. (S.D. ± 50 × 10⁻³ deg.)

Both oxidized and reduced cytochrome *c* show 'anomalous' dispersion in the region of 550 mμ, where the greatest difference exists in the spectra of the two forms[6]. The absorption in this region probably involves the absorption of the iron–nitrogen bonds; the 'anomalous' dispersion is another indication that the iron is asymmetric.

Similar investigations are being made for other biological porphyrin compounds.

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Isolation of a Glycine-Carbohydrate Residue from Muscle Collagen

One of a group of related, macromolecular substances composed of an amino-acid linked to a polysaccharide has been isolated and partially characterized. This group of substances, obtained by means of proteolysis of muscle collagen by carboxypeptidase and subsequent electrophoresis of the non-dialysable fraction, suggests the existence of a polysaccharide residue linked to the C-terminal amino-acid.

Collagen was prepared from rat muscle by a combination of the methods described by Neuberger *et al.*[1] and by Fitch *et al.*[2], employed in the order stated. The collagen preparation used in these experiments was obtained from rats which had been injected intraperitoneally with eight doses of glycine-2-^{14}C (total counts per min. injected, 6·35 × 10⁶; specific carbon-14 activity, 1·88 × 10⁷ c.p.m./mgm.). The rats, which were killed 56 hr. after the injection of the last carbon-14 dose, were also used in related studies reported elsewhere[3]. Similar experiments using D-glucose-U-^{14}C will not be described here in detail.

In a typical experiment, 50 mgm. of muscle collagen was incubated at 37° C. for 20 hr. with 4 mgm. of thrice recrystallized carboxypeptidase in the presence of 0·05 *M* phosphate buffer, *p*H 7·8 and 1·2 *M* lithium chloride. At the end of the incubation period trichloracetic acid was added to obtain a final concentration of 5 per cent, and the resulting precipitate was removed by centrifugation. The supernatant solution was extracted several times with ethyl ether. The residue obtained upon evaporation to dryness was taken up in a small volume of water and was dialysed against running tap water for 24 hr. Paper chromatography carried out subsequent to dialysis in the solvent system[4] 2-butanol/90 per cent formic acid/water, 75 : 15 : 10, v/v/v, revealed the presence of six ninhydrin-reactive substances, all of which had migrated from the starting point. In addition, there was found a large immobile fraction (*A*) which, when sprayed with aniline–phthalate reagent[5], formed a brownish-coloured spot. This spot fluoresced with a yellow colour in ultra-violet light and reacted with ninhydrin slowly to form a yellowish spot.

The entire immobile fraction (*A*) was isolated by means of a 'streak' chromatogram, developed in the solvent system mentioned earlier. This fraction was eluted in water at a slightly alkaline *p*H and a small aliquot was hydrolysed with 6 *N* hydrochloric acid in a sealed tube at 100° C. The following amino-acids could be identified in this hydrolysate: lysine, glycine, glutamic acid, alanine, leucine, phenylalanine, valine and serine. The remainder of the eluate was subjected to continuous paper electrophoresis in 0·090 *M* borate buffer, *p*H 7·8, for 24 hr. at 450 V. and 2–3 m.amp. The eluate was dropped on the centre of the paper sheet above tube No. 12 of a series of 22 tubes. (Tube No. 1 was at the anodic side and No. 22 at the cathodic side.) About 63 per cent of the total carbon-14 activity of the eluate was collected in tubes No. 11–16 (*B*), each tube containing 4 ml. The contents of these tubes were combined and rechromatographed by means of continuous paper electrophoresis at *p*H 5·4 in 0·025 *M* acetate buffer using 610 V. and 2–3 m.amp. Under these conditions, the fractions containing carbon-14 activity had migrated significantly toward the anode and were confined largely to three of the 22 tubes (No. 7–9. (*C*)). The combined contents of the three tubes were again subjected to continuous paper electrophoresis in 0·02 *M* phosphate buffer, *p*H 7·8, at 410 V. and 3 m.amp., whereupon, after 48 hr., almost all of the carbon-14 activity was found in four tubes (No. 11–14 (*D*)), each containing 3 ml. of effluent. Since the point of application of the solution to the paper was directly above tube No. 11, there was a slight displacement toward the cathode, as was the case with electrophoresis in borate buffer at *p*H 7·8. The contents of tubes No. 11–14 were pooled, evaporated to dryness *in vacuo* and the resulting residue subjected to reductive cleavage by adding 500 mgm. of lithium borohydride and 50 ml. of tetrahydrofurane to the dry residue. This reaction was carried out at 65° C. for 5 hr.[6].

Finally, the solution was made 6 *N* with respect to hydrochloric acid and hydrolysed in a sealed tube at 100° for 20 hr. after dinitrophenylation. Paper chromatography in the solvent system described by Grassmann *et al.*[7] yielded only one dinitrophenyl derivative, namely, that of ethanolamine. These findings suggest that glycine is the only amino-acid present in the fraction isolated by continuous paper electrophoresis and that the remainder of the molecule is composed of a substance with macromolecular dimensions, presumably a polysaccharide. Electrophoretic studies of the material remaining after lithium borohydride reduction indicate the presence of a positively charged molecule, the positive charge being perhaps due to the amino-group in hexosamine residues. The carbon-14 activities present in the initial sample of collagen and in various derived fractions are shown in Table 1.

Table 1. TOTAL CARBON-14 ACTIVITY IN FRACTIONS ISOLATED

Fraction	Total carbon-14 activity in fraction (c.p.m.)
Muscle collagen	90,100
Immobile fraction (*A*)	26,000
Electrophoresis in borate buffer (*B*) (tubes No. 11–16)	16,553
Electrophoresis in acetate buffer (*C*) (tubes No. 7–9)	2,069
Electrophoresis in phosphate buffer (*D*) (tubes No. 11–14)	563

The findings reported here indicate that the polysaccharide moiety of collagen is indeed linked to certain C-terminal amino-acids and that this polysaccharide–amino-acid complex is split by carboxypeptidase from the polypeptide chain as an intact macromolecule. One such complex was characterized further by demonstrating the presence of a single amino-acid (glycine) by means of reductive cleavage with lithium borohydride.

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Incorporation of Disodium *p*-Nitrophenylphosphate in Solid Medium for the Detection of Phosphatase Production by *Micrococcus pyogenes* var. *aureus*

THE production of phosphatase by *Micrococcus pyogenes* var. *aureus* has been demonstrated using a solid medium incorporating phenolphthalein phosphate[1]. The presence of phosphatase has also been correlated with coagulase production[2], which in turn has been shown to be linked with exotoxin production[3]. Therefore it is assumed that all exotoxin-producing staphylococci are coagulase- and phosphatase-positive. The quantitative study of the phosphatase activity of *Micrococcus pyogenes* var. *aureus*[4] has shown that the production of phosphatase can be used as an index to toxin production.

A medium incorporating disodium *p*-nitrophenylphosphate has been devised in this laboratory with the object of using a single medium for the detection of *Micrococcus pyogenes* var. *aureus* in spray-dried milk powders. Preliminary trials have confirmed earlier work that the use of disodium *p*-nitrophenyl phosphate is much superior to other phosphatase substrates.

The medium consists of nutrient agar to which is added a sterile solution of disodium p-nitrophenyl phosphate. This medium is used in the normal way. The streaked Petri dishes are examined after 24-hr. incubation at 37° C. and the presence of phosphatase is indicated by the yellow colour of liberated p-nitrophenol surrounding colonies of *M. pyogenes* var. *aureus*. Positive results are readily discernible after 16–18-hr. incubation.

The incorporation of high concentrations of sodium chloride in the media has only a slightly inhibiting effect on phosphatase production. This effect is less than the inhibition caused by sodium chloride in a medium using phenolphthalein phosphate as substrate[1], probably because of the high sensitivity of the disodium p-nitrophenylphosphate[5].

Investigations are proceeding to determine the optimal level of substrate concentration and to examine the incorporation of inhibiting agents for Gram-negative organisms.

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Metabolic Role of Xanthopterin

ALBERT[1] has suggested that xanthopterin would be found in higher amounts in neoplastic tissues than in normal. In anticipation of confirming this by direct experiment, we have analysed for their pterin content, normal kidney tissue of the golden hamster and transplantable neoplasms in the golden hamster, derived from stilbœstrol-induced renal tumours[2]. No xanthopterin could be found. The largest amount of tissue used was 1 gm. of normal tissue and 8 gm. of neoplastic tissue, and the smallest amount of xanthopterin that could be detected by the paper chromatographic technique used was 0·1 μgm.

Xanthopterin has been isolated from human urine[3]. If, however, xanthopterin is present as a tissue metabolite, some of it should be oxidized to leucopterin by xanthine oxidase[4]. This expectation is borne out by the occurrence of leucopterin in the kidney tubules of golden hamsters given massive doses of xanthopterin[5]. An analysis of human urine failed to reveal leucopterin (which would have been found between the origin and 2-amino-4-hydroxypteridine-6-carboxylic acid in the propanol–5 per cent aqueous acetic acid (2 : 1 v/v) solvent system used)[6].

Kalckar *et al.*[7] found that xanthopterin was not present in freshly voided urine, but that a colourless non-fluorescent substance was present which was converted to xanthopterin by air oxidation. Futterman and Silverman[8] found a labile substance in human urine the properties of which resembled an unformylated reduced folic acid, and Blakley[9] has demonstrated that di- and tetra-hydrofolic acids are readily oxidized to xanthopterin.

Slavik *et al.*[10] found xanthopterin in the urine of rats fed tetrahydrofolic acid but showed that the xanthopterin was formed during isolation by the non-enzymic oxidation of tetrahydrofolic acid.

The present burden of evidence is therefore that xanthopterin is absent from mammalian tissues. The biological effects of xanthopterin in mammals should therefore be attributed only to the disturbance of a normal metabolic pathway by an artificially introduced substance.

A fuller account of this work will be published elsewhere in due course.

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Chromatographic Separation of Lactalbumin from Human Milk Whey on Calcium Phosphate Columns

ACCORDING to Deutsch[1] and Wegelin[2] bovine and human milk wheys differ to a certain extent in electrophoretic patterns. On the basis of paper electrophoretic data, Fontaine[3] considers it probable that the electrophoretic fractions in human milk whey closely correspond to different proteins found in bovine whey (serum albumin, β-lactoglobulin, α-lactalbumin and immune globulins). As part of an investigation of the protein composition of human milk whey and its relation to bovine whey, I have studied the separation of a crude 'albumin'-fraction from human milk by means of chromatography on calcium phosphate.

Pooled, frozen human milk or fresh milk was used. After defatting the milk by centrifugation, the lactalbumin fraction was obtained by salting out with ammonium sulphate in the following way. A crude fraction consisting of casein and lactoglobulins was removed at 50 per cent saturation. The lactalbumin fraction was then precipitated by saturating the remaining solution with ammonium sulphate. This crude albumin consisted of three main components judging by paper electrophoresis (Fig. 1).

The calcium phosphate gel was prepared according to Tiselius[4]. 250-mgm. samples of lyophilized protein were dissolved in 10 ml. 0·03 M sodium phosphate buffer pH 6·9, containing 0·1 M sodium chloride. This solution was applied to calcium phosphate columns, 2·8 cm. × 8 cm., previously washed with the same buffer solution. Elution was performed with a slight external pressure giving a flow-rate of approximately 20 ml./hr. The effluent was collected in 5-ml. fractions and the protein concentration of each

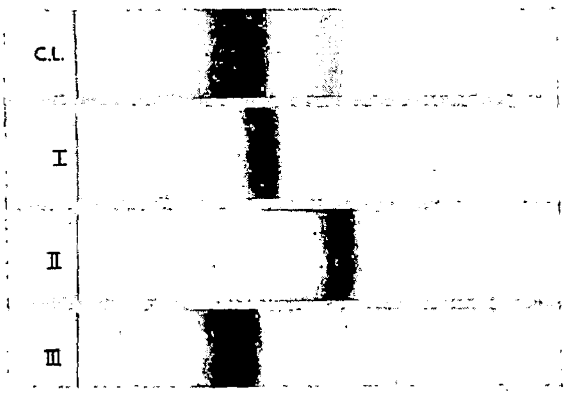

Fig. 1. Paper electrophoretic patterns of crude, human lactalbumin (*C.L.*) and different fractions obtained by chromatography on calcium phosphate

fraction arbitrarily determined at 280 mμ in a Beckman *DU* spectrophotometer. A typical chromatogram is shown in Fig. 2. Elution with step-wise increased concentrations of phosphate buffer gave three peaks at 0·03 M, 0·12 M and 0·5 M, respectively. With these concentrations no considerable tailing occurred. The different fractions were thoroughly dialysed against ice-cold distilled water and lyophilized. The yields of the different fractions estimated by Kjeldahl determinations were I, 45 per cent, II, 10 per cent, III, 30 per cent, the total yield thus amounting to 85 per cent. The reproducibility of two chromatographic runs on the same albumin preparation was found satisfactory. By paper electrophoretic investigations of the fractions (Fig. 1), fraction I was shown to be essentially homogeneous in veronal buffer at pH 8·6. However, electrophoresis by the moving-boundary method revealed a small impurity with lower mobility (Fig. 3). The protein appeared homogeneous in the ultracentrifuge with a sedimentation constant of 1·73 S., the value of which is very similar to the sedimentation constant of 1·75 S. for α-lactalbumin isolated from bovine milk whey[5]. Fraction II consisted electrophoretically of at least 80 per cent of a protein with the same mobility as human serum albumin. It was also immunologically identical with serum albumin when tested by Ouchterlony's technique[6]. In fraction III mainly a salmon-coloured component was found containing small amounts of iron, which could not be removed by passing the protein through a column with a cation exchange resin ('Dowex 50, X–12') at pH 6·9. Examination of the light absorption of the component in a wavelength range of 350–1,000 mμ revealed only a flat maximum at 460–470 mμ. No Soret band could be obtained.

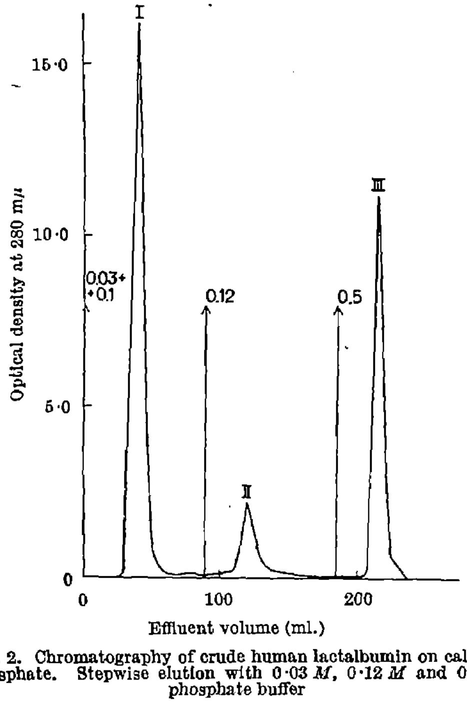

Fig. 2. Chromatography of crude human lactalbumin on calcium phosphate. Stepwise elution with 0·03 M, 0·12 M and 0·5 M phosphate buffer

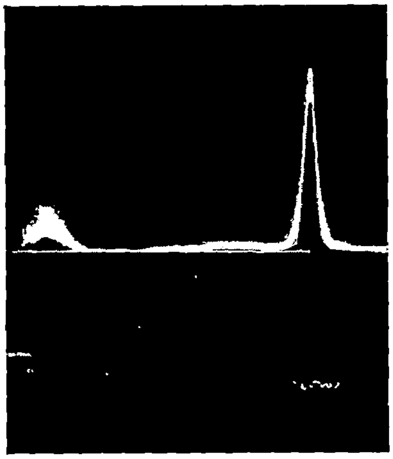

Fig. 3. Boundary electrophoresis of fraction I. Protein concentration 1 per cent. Veronal buffer: pH = 8·6, μ = 0·1. Ascending limb after 7,200 sec.

A more detailed communication concerning the isolation, composition and properties of the fractions described will be published later.

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Effect of Neutral Salts on the Structure of Collagen and Gelatin

In a current project in this laboratory, the optical rotatory properties of aqueous solutions of gelatin and soluble collagen from three different species of vertebrates have been examined in the absence and presence of lithium bromide. Results (Table 1) are in general agreement with the earlier work of Carpenter and Lovelace on bovine gelatin[1]. It will be observed that, although striking changes occur in the specific rotations of collagen and gelatin in the presence and absence of salt, the value of λ_c (obtained from the slopes of linear Drude plots of $\lambda^2[\alpha]$ vs. $[\alpha]$)

Table 1. EFFECT OF SALTS ON OPTICAL ROTATORY PROPERTIES OF COLLAGEN AND GELATIN

Material	Solvent	$[\alpha]_D^{25}$*	λ_c (mμ)	$[\alpha]_D$† configuration (calc.)
Rat tail collagen	Water	−289°	217	−200°
Rat tail gelatin	Water	−118°	217	−30°
Rat tail gelatin‡	12 *M* LiBr	−35°	207	+53°
Ichthyocol collagen	Citrate (μ 0·05, *p*H 3·7)	−330°	204	−240°
Ichthyocol gelatin (Ref. 12).	Citrate (μ 0·05, *p*H 3·7)	−110° (41° C.)	204	−20°
Ichthyocol gelatin	2 *M* KSCN	−86°	204	+4°
Ichthyocol gelatin‡	12 *M* LiBr	−56°	202	+34°
Bovine collagen	0·2 *M* KCl	−350°	220	−258°
Bovine gelatin	0·2 *M* KCl	−146°	217	−54°
Bovine gelatin	8·5 *M* LiBr	−60°	198	+32°

* Corrected for index of refraction.

† For amino-acid compositions of rat-tail, ichthyocol and bovine collagens, see ref. 11.

‡ Prepared by adding lithium bromide solution to the solid collagen.

changes only slightly and, if anything, may decrease somewhat.

The gelatin molecule in solution exhibits hydrodynamic properties approaching those expected for a random chain[2]. Consequently, a lowering of the water activity through addition of lithium bromide should favour a hydrogen-bonded configuration, as is observed in the case of oxidized ribonuclease, clupein, silk fibroin and serum albumin[3]. On the other hand, the high proline and hydroxyproline content of gelatin is not compatible with the formation of an α-helix if we assume that the proline residues do not exist as blocks in the polypeptide chain[4]. Moreover, a number of observations have demonstrated that the transition from a partially folded or random polypeptide chain structure to an extensively hydrogen-bonded configuration, although leading to a decrease in the absolute value of the specific rotation, is invariably reflected in an increase[5] in the value of the Drude dispersion parameter, λ_c, of between 30 and 100 mμ. Such a transition for a polypeptide chain of the molecular weight of bovine gelatin ($2–4 \times 10^5$ (ref. 2)) should also lead to a significant increase in the intrinsic viscosity of the solution. However, viscosity measurements on solutions of a commercial bovine gelatin in 0·2 *M* potassium chloride and in 8·5 *M* lithium bromide at a temperature of 35° C. yield, within the experimental error, the same intrinsic viscosity, namely, 0·39 (gm./100 ml.)$^{-1}$. The optical rotatory properties of gelatin in the presence of high concentrations of neutral salts cannot, therefore, represent the development of any extensive hydrogen-bonded configuration.

Recently[6], we have found significant alterations in the optical rotatory characteristics of aqueous solutions of poly-L-proline II[7] in the presence of lithium bromide and certain other salts. (Poly-L-proline exists in two forms, one exhibiting a specific rotation $[\alpha]_D^{25} = +40°$ in water (polyproline I) and the other exhibiting a specific rotation, $[\alpha]_D^{25} = -540°$ (polyproline II).) Thus $[\alpha]_D^{25}$ decreases from a value of $-540°$ (in water) to about $-250°$ (in 12 *M* lithium bromide), whereas, from linear Drude plots of the rotatory dispersion, λ_c is lowered from 202 mμ to about 185 mμ. These changes have been interpreted as resulting from a series of *trans–cis* isomerizations at the proline–proline peptide bonds of the polymer. Whatever the true nature of these changes, it would seem possible for similar phenomena to occur in solutions of soluble collagen and gelatin in lithium bromide, resulting in the optical rotatory properties described above. It should be noted that the repeating sequence glycine–proline–hydroxyproline, which chemical evidence suggests is common in collagen, would provide the required proline–proline peptide bond.

The specific rotation of a long polypeptide chain which is locked into an asymmetric configuration may be expressed as:

$$[\alpha]_D = \frac{100 \sum_i [R_i]}{n R_m} + [\alpha]_D, \text{configuration}$$

where $[R_i]$ is the intrinsic residue rotation of the *i*th amino-acid residue, R_m the mean residue rotation, *n* the number of residues in the chain, and $[\alpha]_D$, configuration, the structural contribution of the chain. $[R_i]$ of glycine may be taken as zero, that of proline and hydroxyproline[6] as $-250°$, and that of all other amino-acids[6] as about $-110°$. From the known compositions of the three gelatins and their specific rotations we have estimated the structural contribution, $[\alpha]_D$, configuration, in water and in concentrated lithium bromide (Table 1).

Inspection of Table 1 reveals a residual amount of left-handed (−) asymmetry (in the absolute sense, in conformity with the screw sense of polyproline II [9]) remaining in each of the gelatin molecules in water and in dilute salt solutions. Moreover, all the gelatin structures have a significant amount of right-handed (+) configuration in aqueous lithium bromide which, by analogy with the studies on polyproline II, could result from *trans–cis* isomerizations at the proline–proline peptide bonds. The three collagens in water exhibit very strong left-handed structural contributions, the values for $[\alpha]_D$, configuration approaching that found[5] for the proline II helix in water ($-300°$). The possibility that gelatin retains some polyproline II-like structure in water may be of importance in the association of gelatin molecules at low temperature to give the collagen fold[10].

In conclusion, I would point to the similarity between the effects of heat and neutral salts in contracting the collagen fibril and suggest that the shrinkage behaviour of collagen at elevated temperatures in the absence of salt, and at low temperatures in the presence of salt, could be strongly dependent on *trans–cis* isomerizations at the proline–proline peptide bonds.

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Structure of an Acidic Polysaccharide elaborated by *Aerobacter aerogenes*

ORGANISMS of the *Aerobacter–Klebsiella* group have been divided[1] into many serologically distinct types each of which produces its own type-specific polysaccharide. Only a few of the structures of these polysaccharides have been elucidated[2-4] since in general they are of a highly complex nature. Recently we isolated an acidic polysaccharide (4·45 gm.) from the culture medium (38·4 l.) of *Aerobacter aerogenes* N.C.T.C. 8172 (*Klebsiella* type 64). The bacteria were grown both in batches and in continuous culture in an apparatus of the type described by Elsworth, Meakin, Pirt and Capell[5]. A peptone–glucose medium was used, the culture was aerated, the *p*H 5·0 and the temperature, 37°. The acidic polysaccharide was freed from neutral polysaccharide by precipitation with 'Cetavlon'[6] and from nucleic acid by the preferential solubility of its cetyl trimethyl ammonium salt in 0·25 *M* sodium chloride. Isolated as its sodium salt, the acidic polysaccharide had C, 45·31 ; H, 6·19 ; N, 0·81 ; P, 0·11 per cent and its ultra-violet absorption at 260 mμ corresponded to about 1·8 per cent nucleic acid impurity. The polysaccharide contained 28·7 per cent uronic acid (by decarboxylation[7]) and the infra-red spectra of the polysaccharide as the free acid and as the sodium salt confirmed the presence of carboxylic acid groups[8]. The polysaccharide showed $[\alpha]_D^{17} + 29{\cdot}4°$ (conc. 0·272 in *M* sodium chloride).

Acidic hydrolysis of the polysaccharide (3·7 gm.) with 2 *N* sulphuric acid (75 c.c.) at 100° for 3 hr. and separation of the neutralized hydrolysate on 'Deacidite *FF*' (carbonate form) gave neutral sugars (2·3 gm.) and acidic sugars (1·03 gm.). Separation of a portion (2·0 gm.) of the neutral sugars on a cellulose column irrigated with butanol, ethanol, water, ammonia (40 : 10 : 49 : 1) gave one fraction (0·295 gm.) containing rhamnose and another (1·5 gm.) containing a glucose–mannose mixture. The rhamnose was obtained as crystalline α-L-rhamnose, m.p. and mixed m.p. 93–94°, $[\alpha]_D^{22} + 8{\cdot}2°$ equil. (conc. 4·13 in water). The glucose–mannose mixture was separated by treatment[9] with *p*-nitroaniline in methanol containing hydrochloric acid to give N-*p*-nitrophenyl-β-D-glucopyranosylamine dihydrate m.p. and mixed m.p. 184°, $[\alpha]_D^{22} - 196°$ (4 min.) → − 203° (equil.) (conc. 1·02 in dry pyridine), and N-*p*-nitrophenyl-β-D-mannopyranosylamine dihydrate m.p. and mixed m.p. 219°, $[\alpha]_D^{22} - 400°$ (4 min.) → − 333° equil. (conc. 0·12 in dry pyridine). Separation of the acidic sugars (1·0 gm.) on a cellulose column irrigated with *n*-butanol–acetic acid–water (4 : 1 : 5) gave fractions containing hexuronic acid (0·02 gm.), aldobiuronic acid(s) (0·41 gm.) and mixtures of these (0·45 gm.). The hexuronic acid and its lactone had mobilities on paper chromatograms identical with those of glucuronic acid and glucuronolactone. Reduction of its methyl ester methyl glycoside with lithium aluminium hydride and acidic hydrolysis of the product gave glucose with traces of mannose. This evidence indicated the presence of glucuronic acid together with a trace of mannuronic acid in the acidic polysaccharide.

Paper chromatographic analysis of an acidic hydrolysate of the aldobiuronic acid fraction showed the presence of unhydrolysed aldobiuronic acid, mannose, glucuronic acid and small amounts of glucose. Similar analysis of a hydrolysate of the reduced aldobiuronic acid fraction showed the presence of approximately equal amounts of glucose and mannose. No rhamnose was detected either in the aldobiuronic acid hydrolysate or that of its reduction product. This evidence indicates that the major component of the aldobiuronic acid fraction was a glucuronosyl–mannose.

The acidic polysaccharide consumed 0·303, 0·331, 0·337 and 0·423 moles of periodate per 162 gm. of polysaccharide after oxidation for 48, 72, 96 and 110 hr. respectively. The corresponding values for formic acid produced were 0·06, 0·091, 0·1 and 0·11. Paper chromatographic analysis of a hydrolysate of the periodate oxidized polysaccharide showed the presence of glucose, mannose and glucuronic acid, but no rhamnose. These results indicate (*a*) that rhamnose is present either as end groups or linked through the 2- or 4-position, (*b*) that the maximum number of residues present as end groups or linked 1 : 6 is about 11 per cent, (*c*) that most of the glucuronic acid residues are not end groups and (*d*) that large numbers of glucose, mannose and glucuronic acid residues are linked either 1 : 3 or are involved in branching.

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Colorimetric Detection of Human Cæruloplasmin Oxidase Activity after Electrophoresis in Agar Plates or after Immuno-electrophoresis

THE use of colour reactions combined with electrophoretic analytical methods in agar plates has allowed double (electrophoretic mobility and chemical nature) or triple (electrophoretic mobility, immunochemical specificity and chemical nature) characterization of proteins, lipids, glycoproteins and phospholipids in a variety of biological fluids[1].

Cæruloplasmin, the blue protein of human serum, was isolated in 1948 by Holmberg and Laurell[2] and characterized as an α_2-globulin containing copper. They also showed that the substance exhibited oxidase activity with a variety of substrates.

In previous work[3], we have studied this protein by electrophoretic and immuno-electrophoretic analysis followed by the colorimetric detection *in situ* of copper-bound cæruloplasmin. In order further to identify cæruloplasmin by another of its inherent properties, we have also developed a method for the detection of its oxidase activity.

The oxidizable substrates that we employed have previously been used in manometric[2] and spectrophotometric[4] methods for the estimation of the oxidase activity of cæruloplasmin. The method to be described is based on the fact that the final oxidation product of *p*-phenylenediamine is a quinoid compound insoluble in water called Bandrowski's base[5]. The formation of this deep brown base makes possible *in situ* measurement of the enzymatic activity of cæruloplasmin on compounds which have first been submitted to electrophoretic or immuno-electrophoretic analysis in agar gel. The apparatus employed and the method of agar electrophoresis have been described by Grabar and Williams[6].

Samples of human serum (0·02 ml. per analysis) or a solution of cæruloplasmin in 0·06 *M* sodium chloride (50 μgm. per analysis) are subjected for 4–5 hr. to a potential difference of 4–5 V./cm., in 1–1·2 per cent agar gel (3–4 mm. thick) containing a veronal buffer (*p*H 8·2, Γ/2 0·03).

We have employed the immuno-electrophoretic method of Grabar and Williams using the serum of horses immunized against whole human serum. When the lines of specific precipitation have formed, the plates are washed for three days in a solution of 0·15 *M* sodium chloride, which is changed once or twice a day.

After electrophoresis or after immuno-electrophoresis, the procedure is continued in the following manner. The plates are immersed in a 5×10^{-3} *M* solution of *p*-phenylenediamine in acetate buffer (*p*H 5·7, Γ/2 0·1) prepared immediately before use. In this solution they are incubated at 37° C. for 2 hr. At the end of the incubation period the position of the portions with oxidase activity is indicated by brownish spots or lines.

The plates are then washed twice for successive periods of two hours each in a solution of sodium acetate–acetic acid buffer (*p*H 4·7, Γ/2 0·1). This stops enzymatic activity and rids the agar plates of excess *p*-phenylenediamine. A typical result of such a run with normal human serum is shown in Fig. 1. The oxidase activity is seen as a zone corresponding to that of α_2-globulin. Only one of the lines of precipitation corresponding to the 18–20 antigenic constituents of human serum possesses oxidase activity with regard to *p*-phenylenediamine. The groups responsible for enzymatic activity are not blocked by the antigen–antibody combination. When sodium azide (10^{-3} *M*) is added to the solution of oxidizable substrate all enzymatic activity of the cæruloplasmin is destroyed.

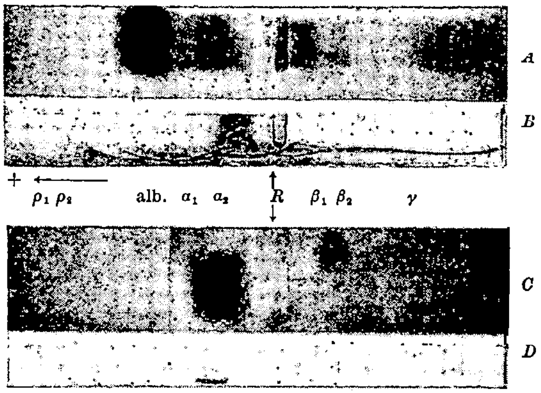

Fig. 1. *A*, Agar electrophoresis, a typical serum pattern stained with amidoschwarz; *B*, immuno-electrophoresis of human serum, lines of specific precipitation stained with azocarmine; *C*, oxidase activity in serum after agar electrophoresis; *D*, oxidase activity in serum after immuno-electrophoresis; *R*, starting place

Methods for the estimation of oxidase activity of cæruloplasmin in whole serum, either by oxygen consumption in the Warburg apparatus or by spectrophotometric determination, are open to the criticism that other redox systems in serum may act as competitive inhibitors on the substrate, *p*-phenylenediamine. Preliminary dialysis of the serum might prevent such interference in the case of small molecules (ascorbic acid, etc.), but it would be ineffective in the case of certain reducing groups on the surface of protein molecules.

With our technique the risk of encountering such difficulties is considerably lessened because of the preliminary electrophoretic separation of the protein constituents of the serum, and is practically negligible after immuno-electrophoretical analysis. We are now studying the exact conditions necessary for the quantitative estimation *in situ* of this enzymatic activity; preliminary results indicate that it will be possible to obtain quantitative measurements with the method[7].

A similar procedure to that reported here has been applied to the detection of catalase and peroxidase activities in hæmoglobin after electrophoretic separation in agar gels[7].

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Microwave Spectra of Diazomethane and its Deutero Derivatives

WE have measured rotation spectra, in the frequency-range 19,000–90,000 Mc./s., for three isotopic forms of diazomethane, and obtained the constants shown in Table 1, in Mc./s. A preliminary value of $1{\cdot}4_5 D$ is obtained for the dipole moment of diazomethane from Stark effect measurements on the $0_{00} \rightarrow 1_{01}$ transition. Nuclear quadrupole hyperfine structure is resolvable; its analysis is at present incomplete.

Table 1

Molecule	$(B_0 + C_0)$	$(B_0 - C_0)$	D_{JK}	D_J
CH_2N_2	22,150·7±0·2	460·2±0·2	0·39±0·01	<0·01
$CHDN_2$	20,640·7±0·2	578·3±0·2	0·27±0·01	<0·01
CD_2N_2	19,389·0±0·2	696·2±0·2	~0·2	—

The constants for CH_2N_2 correspond to a value of $(B_0 + C_0)/2$ equal to $0{\cdot}369433 \pm 0{\cdot}000004$ cm.$^{-1}$, compared with 0·368 cm.$^{-1}$ obtained from infrared spectra by Mills and Thompson[1], and with 0·371 cm.$^{-1}$ derived from similar data by Fletcher and Garrett[2]. Our results are consistent with the planar structure with C_{2v} symmetry indicated by the infra-red spectra. The moment of inertia, I_A, found for CH_2N_2 from the relationship $I_A = I_B - I_C$ is $3{\cdot}15 \times 10^{-40}$ gm. cm.^{2}, which is slightly greater than the value reported from infra-red measurements[2]. Independent estimates of I_A from the present microwave R-branch transitions are in agreement, but are necessarily approximate, and we expect to determine accurate values of I_A from Q-branch spectra. In view of the inertial quantum defect found for ketene, a rather similar molecule, from its microwave spectrum[3], the present agreement with the infra-red value of I_A is satisfactory.

If any quantum defect is ignored, and the effects of zero-point energies on internuclear distances are neglected, the following structure-parameters are consistent with the microwave data : $d_{\rm CH} = 1{\cdot}08$ A., $\angle$HCH = 127°, $d_{\rm CN} = 1{\cdot}32$ A., $d_{\rm NN} = 1{\cdot}12$ A. and $d_{\rm CN} + d_{\rm NN} = 2{\cdot}442 \pm 0{\cdot}005$ A. Because the central nitrogen atom is very close to the centre of gravity of the molecule, all the parameters, except $d_{\rm CN} + d_{\rm NN}$, can be varied considerably in proper phase with each other without excessive disagreement with the data. The above has been selected from the possible structures as reasonably consistent with all the evidence. There is general agreement with the electron diffraction results[4], but $d_{\rm CN} + d_{\rm NN}$ is considerably shorter than the upper limit allowed by the diffraction data.

To date we have detected no spectra attributable to a tautomeric form of diazomethane, the presence of which was suggested from infra-red evidence by Mills and Thompson[1]. A further search for such absorptions will be made, but there are indications[5] that the stability of the tautomer may be no greater than that of normal diazomethane, which decomposes with a half-life of the order of a minute in wave-guide cells of copper or coin-silver cooled to − 70° C. for most of their length.

Other aspects of the spectra are under investigation, and detailed results will be communicated later. We are grateful to Mr. J. S. Heeks for assistance with these measurements.

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Correlations between Localization Energies and Polarographic Half-Wave Potentials of Aromatic Hydrocarbons

Basu and Bhattacharya[1] recently claimed to have established a linear correlation between *para*-localization energies and polarographic half-wave potentials for some polynuclear hydrocarbons. Objections to their work have been raised by Pullman[2] and Fernandez-Alonso and Domingo[3], who criticize the values of the localization energies selected by Basu and Bhattacharya. All these authors use the polarographic data of Wawzonek and Laitinen[4], but all of them appear to have misunderstood the latter workers' statement that polarographic reduction consists of a two-electron addition process. It is true that the overall reaction consists of the addition of two electrons. But it is clear from the work of Wawzonek and Laitinen themselves, as well as from that of later authors[5-7], that the addition takes place by two one-electron steps. The least negative half-wave potential might therefore be expected to characterize the energy required to add *one* electron to the aromatic system, but could scarcely be related to the *para*-localization energy, which is a measure of the ease of addition to *two* positions in a hydrocarbon simultaneously[8].

A correlation between half-wave potentials and the localization energy for a single position is to be expected, since a straight line relation has already been reported between the latter and the logarithm of the methyl affinity[9,10], and another between log (methyl affinity) and half-wave potential[11]. This expectation is realized fairly satisfactorily in Fig. 1, where half-wave potentials measured in 'Cellosolve' solution by Bergman[12] are plotted against localization energies calculated by Coulson[9] (see also ref. 13), and by Dewar[14]. But it may be questioned whether this last correlation has theoretical significance, for the following reason. Coulson[9] and Szwarc[10] in relating methyl affinities to localization energies made the usual assumption that in the transition state the methyl radical is bound to a particular carbon atom which has sp^3 hybridization. On the other hand, Matsen[11], in correlating methyl affinities with half-wave potentials, suggested that the odd electron of the radical enters the lowest unoccupied orbital without binding the methyl to any particular carbon atom ; electrons added by polarographic reduction are also believed (for example, ref. 15) to enter the π-electron system in the same way and thus be delocalized. Hence the bases of the two earlier correlations seem to be incompatible.

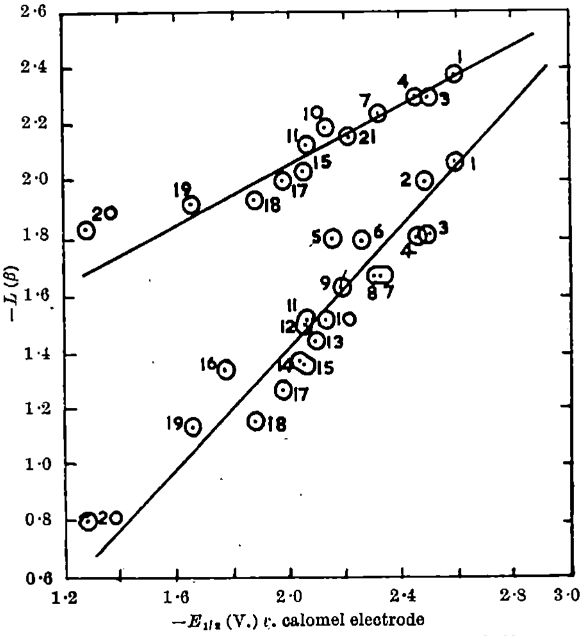

Fig. 1. Relations between localization energies and half-wave potentials. (*Upper curve*, localization energies of Coulson ; *lower curve*, those of Dewar.) *Key :* 1, diphenyl ; 2, triphenylene ; 3, naphthalene ; 4, phenanthrene ; 5, coronene ; 6, 3 : 4-benzophenanthrene ; 7, chrysene ; 8, picene ; 9, 1 : 2-benzopyrene ; 10, pyrene ; 11, 1 : 2-5 : 6-dibenzanthracene ; 12, 1 : 2-3 : 4-dibenzanthracene ; 13, 1 : 2-7 : 8-dibenzanthracene ; 14, pentaphene ; 15, 1 : 2-benzanthracene ; 16, perylene ; 17, anthracene ; 18, 3 : 4-benzopyrene ; 19, naphthacene ; 20, pentacene ; 21, *trans*-stilbene

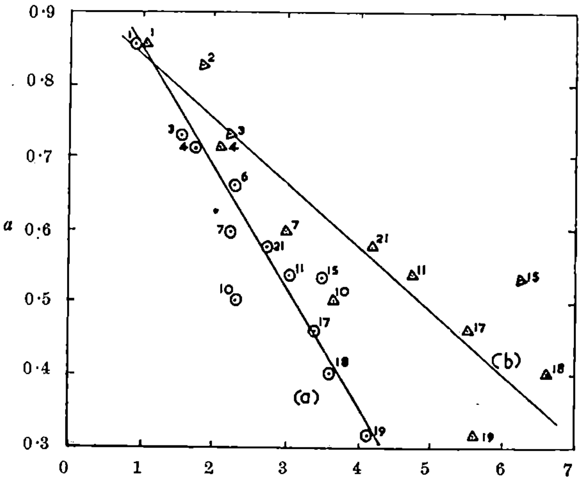

Fig. 2. Relations between partial rate factors of free radical additions and the root a of molecular orbital secular equation. (a), Addition of methyl; (b) trichloromethyl. (For key to points, see caption to Fig. 1)

This incompatibility may be less serious than appears at first sight: it has been pointed out[8] that the state visualized in the concept of localization energy is farther along the reaction path than the transition state (see also ref. 16), and therefore Matsen's suggestion may correspond to a different state, closer to the transition state itself. If this were true then the root, a, of the molecular orbital secular equation corresponding to the lowest unoccupied π-electronic level of aromatic hydrocarbons should predict correctly the relative reactivity of hydrocarbons to free radicals (assuming the resonance and overlap integrals to be constant). In Fig. 2 the logarithms of the partial rate-constants (relative to benzene) of the reactions of aromatic hydrocarbons with methyl[17] and with trichloromethyl radicals[13] are plotted against a (the rate-factors have all been divided by the number of equivalent positions of attack; the values of a were taken from Hoijtink[15] and were calculated on the assumption that $S = 0{\cdot}25$). The correlation is satisfactory for the methyl additions—only two points are seriously off the line—but is less so for the reactions of trichloromethyl; however, the experimental data for the latter are less precise[13].

Inasmuch as Hoijtink[15] and others have found a good straight-line relation between a and half-wave potentials of aromatic hydrocarbons, the correlation with rates of radical addition is not an independent one (since its existence could have been predicted from the other relations mentioned above). Indeed, a number of similar correlations have been described in the literature recently, such as Coulson's of log (methyl affinity) with free valency[9] and Szwarc's of the same parameters with singlet–triplet excitation energies[10]. Others are implicit in those already reported—for example, half-wave potentials with singlet–triplet excitation energies. Not all the correlations referred to in this communication can be of fundamental significance; distinguishing the fundamental from the coincidental should be a fruitful study for those concerned with the theory of reaction mechanism.

As already stated, the polarographic data of Bergman[12] were used in plotting Fig. 1; the half-wave potentials determined by Hoijtink *et al.*[6] using a 96 per cent dioxan–water mixture as solvent are on the whole closely similar to those of Bergman, but give a slightly less satisfactory plot against localization energy.

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Niobium in Sea-water

The presence of organically bound niobium has been demonstrated in ascidians[1], and unpublished evidence suggests that this niobium is absorbed in some way from sea-water. It is thus of importance to know if niobium can be detected in sea-water and to obtain some indication of its concentration. Consideration of the known amounts of niobium present in an adult *Molgula manhattensis*, its rate of development, length of life and rate of filtration of water leads one to suppose that if the water current is the sole source of niobium then, in regions where these species and other species of ascidians which utilize niobium flourish, it cannot be present in the sea in less concentration than 0·05 μgm./l. The chromatographic method of niobium analysis developed by Hunt, North and Wells[2] is capable of revealing the presence of 10^{-7} gm. of niobium. At a concentration of 0·05 μgm./l., this amount could be expected in 2 l. of sea-water.

For analysis, therefore, 20-l. samples were utilized. A known amount of niobium-95 was added to each sample, and the radioactivity of an aliquot assayed. To the remainder was added 175 μgm. of ferric iron. The pH was adjusted to 9·9–10·0 by the slow addition of ammonia with constant stirring. After settling, as much as possible of the supernatant was decanted off and the precipitate recovered by filtration. The precipitate was dissolved in a minimum quantity of hydrofluoric acid, transferred to paper, dried thoroughly and chromatographed using ethyl methyl ketone containing 15 per cent v/v of 40 per cent hydrofluoric acid. On the completion of the run the paper was dried and, after exposure to ammonia vapour, sprayed with a 2 per cent solution of tannic acid. Niobium was, under these conditions, detected as a narrow orange-yellow band in the solvent front. Estimation of the amount present was achieved by comparison with standards of varying amounts of niobium, each co-precipitated with 175 μgm. of ferric iron and chromatographed under identical conditions. After estimation of the amount present in each sample, the radioactivity of the paper strip was assayed to determine the proportion of niobium-95, and hence also of niobium-93, which had been recovered in the analysis. A correction based on this figure could then be applied. The recovery was always better than 50 and usually near 80 per cent. Additional tests were carried out using samples of seawater to which known amounts of niobium-93 had been added.

In water taken in summer from the sea surface at International Hydrographic Station *E*1 (about 40 km. south-west of Plymouth) no niobium was detected by this method if the water was first filtered through Whatman filter paper 542 or through a fine porcelain filter candle. With unfiltered water, however, niobium appeared to be present at a concentration of 0·01–0·02 μgm./l. Bottom water, which may differ widely, has not yet been analysed. In filtered water taken from Plymouth Sound niobium was detected at a concentration of 0·005 μgm./l., while in unfiltered water the concentration reached a level of 0·05–0·1 μgm./l., though in conditions of settled weather with little land water draining into Plymouth Sound the figure was sometimes as low as 0·01 μgm./l.

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Free-Radicals produced in Cigarette Smoke

IN attempts to determine a unifying principle of action for the many and varied carcinogenic agents, many workers have assigned an intermediary role to free radicals. The action of ionizing radiation and radiomimetic agents in this respect has been discussed by Brues and Barron[1]. It is stated that many, if not all, carcinogens are compounds capable of forming free radicals which may be stabilized as ions[2]. Oppenheimer *et al.*[3] discussed their possible role in the production of tumours in rodents by implanted films of various high polymers, and suggested, as a requirement for tumour production, the presence of foreign free radicals in a specific area for an extended period.

Primary consideration is normally given to aromatic polycyclic hydrocarbons as active agents in tobacco carcinogenesis. However, in view of the above, it seemed of interest to determine the concentration of free radicals in cigarette smoke. The following series of experiments, which utilized a high-sensitivity electron resonance spectrometer[4], have therefore been carried out. In order to prevent recombination of radicals as much as possible, the smoke was condensed at liquid-oxygen temperatures, and all measurements were made at this temperature.

British-type cigarettes were smoked in a manner simulating the normal human habit. The cigarettes were fixed in a small manifold which was connected to a filter pump so that intermittent drawing was possible. A sealed-off length of $\frac{1}{4}$-in. diameter tubing led down from the manifold chamber. This tube was immersed in liquid oxygen during smoking. A portion of the smoke was found to condense out in the tube as a pale yellow solid. When about $\frac{1}{2}$ gm. of condensate had been collected, the apparatus was quickly transferred to the electron resonance spectrometer and the tube was inserted into the centre of an H_{014} cavity, surrounded by liquid oxygen. The concentration of radicals in the deep-frozen material was then determined using 100 kc./s. modulation and phase-sensitive detection, so that the free-radical absorption was traced out as a derivative on the pen-recorder. The smoking apparatus was then removed from the spectrometer and the condensate in the tube was warmed to 60° C. for about five minutes so that any active radicals could recombine. The tube and contents were then deep-frozen, re-inserted in the spectrometer and the concentration of radicals again measured. In this way it was possible to distinguish between short-lived, active radicals and those that were stabilized sterically or by resonance[5].

The concentration of radicals obtained in the frozen smoke condensate before warming was of the order of 10^{15} free electrons per gm. It should be noted that this condensate contains large amounts of solid carbon dioxide and ice. On warming, the condensate separated into an aqueous and an organic or tarry phase. No radical concentration at all could be detected in the aqueous phase, and that in the organic phase was reduced by a factor of six approximately. The radicals that could still be detected in the latter were found to be highly stabilized, and no diminution of their concentration was found after several days.

It would therefore appear from these experiments that the tar constituents of cigarette smoke contain about 6×10^{15} free electrons/gm. Some of these radicals, being relatively short-lived, disappear when the condensate is warmed to 60° C. for some minutes. The remainder, however, appear to be very stable and long-lived.

Another set of experiments was carried out with the stable radicals, and their concentration after chemical fractionation was investigated. For this, cigarette smoke was trapped in a series of wash-bottles containing benzene at room temperature. Aliquots of this solution were washed a number of times with (*a*) water, (*b*) 2 *N* sodium hydroxide, (*c*) 2 *N* sulphuric acid, (*d*) 2 *N* sodium hydroxide and then 2 *N* sulphuric acid; (*b*), (*c*) and (*d*) were finally washed with water. The solvent was removed from the various extracted solutions and the free-radical concentrations of the resulting tars compared with a sample of unextracted whole tar by the method outlined above.

A decrease in the initial concentration of free radicals in whole tar was found to follow the various extractions. Washing with water reduced the initial concentration by 20 per cent, with alkali by 50 per cent, with acid by 57 per cent, while washing with alkali followed by acid reduced the concentration by 72 per cent. It would appear from this that a number of different species of free radicals exist in the stable group.

The combined evidence from these experiments suggests that there is sufficient concentration of free radicals in cigarette smoke (when compared with the expected concentrations in the polymer experiments[3]) to act as a carcinogenic agent if such a mechanism is possible. It is interesting to note in this connexion that the concentration of stable free radicals in atmospheric soot is about one hundred times larger than in cigarette smoke. But, as with the polycyclic hydrocarbons[6], adsorption on comparatively larger particles, and further stabilization as a result, are likely to render them inaccessible to the cells.

Most bioassays in tobacco carcinogenesis studies have been carried out using either condensates, which are afterwards taken up in solvents at room temperatures, or tars derived from smoke trapped in organic solvents. It is now clear that such materials are deficient in unstable free radicals initially present in smoke. The free-radical content of cigarette smoke as a parameter in the etiology of lung cancer would therefore seem to be a reasonable possibility.

We are indebted to Dr. P. R. Peacock, director of research, Cancer Research Department, Royal Beatson Memorial Hospital, Glasgow, for reading the manuscript and for helpful advice.

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Second Virial Coefficient of Methyl Chloride Vapour

Theoretical considerations, for example, those of Hirschfelder[1], indicate that the virial coefficients higher than the second cannot be large enough to produce, in the isotherms of vapours at reduced temperatures near 0·70, sufficient curvature to be detectable with the experimental techniques available at present. Nevertheless, there are several statements of curved isotherms in the literature. As pointed out previously[2,3], the greatest care is required if errors due to adsorption are to be avoided.

Hamann and Pearse[4] report measurements by a differential compressibility method on methyl chloride and methyl bromide and find that, at the low temperatures, there is an apparent non-linearity of PV with P which they attribute to either higher virial terms or to adsorption. In these experiments the vapour was compressed before an advancing mercury surface. By making reasonable estimates from the data of Bottomley and Reeves[3], it is clear that the non-linearity observed is of the order to be expected from neglect of the adsorption on the surfaces of the apparatus.

That adsorption errors are indeed responsible for this non-linearity is confirmed by experiments which we have carried out recently. The isotherms of methyl chloride have been determined at 22° C. in a differential compressibility apparatus similar to that used previously for xenon[5]. A strictly linear isotherm has been obtained over the pressure-range 750–150 mm. of mercury with eleven experimental PV values at both rising and falling pressures which show a mean deviation of ± 4 in 100,000 from the least-mean-square line. Adsorption has been rendered negligible by two factors. The surface/volume ratio is much lower in our experiments, and the bulbs containing the vapour were made of high-quality silica, which is much less adsorptive than other glasses.

In differential compressibility apparatus in which gas volumes are brought to the same pressure by a mercury manometer, there is a potential error. The mercury surfaces on the two sides of the null manometer are exposed to different gases: if one side contains a vapour near saturation the adsorption on the mercury surface may lower the interfacial tension, and hence the capillary depression, so that apparent equality in the two sides of the manometer does not correspond to equal pressures. This correction increases with increasing pressure of vapour, and is in the sense that equal mercury-levels correspond to the pressure of the vapour being greater than that of the non-adsorbed gas. Hamann and Pearse used a manometer tube of 5·7 mm. bore, giving a depression of about 1 mm., so that a mere 10 per cent change in depression amounts to a considerable uncertainty in pressure. Our null manometer is of 35-mm. bore (depression less than 0·001 mm.), and the associated difficulty of a large dead space is eliminated by a direct measurement of volume at each setting.

The final value for the virial coefficient for methyl chloride from our experiments is 416 ± 1 $cm.^3$/mole at 22° C.

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Promoting the Stable Eutectic Reaction in Magnesium-treated Iron Castings by Vibration during Solidification

By adding magnesium to cast iron in such a way that a few hundredths of a per cent are retained in solution it is possible to suppress the stable eutectic reaction, and in iron so treated the metastable reaction occurs instead, resulting in castings which contain large amounts of iron carbide. Addition (after the magnesium has been dissolved) of about 0·5 per cent of ferro-silicon (containing 80 per cent silicon) favours occurrence of the stable eutectic reaction during subsequent solidification, and spheroidal-graphite particles are so produced[1]. The ferro-silicon alloy inoculates the stable eutectic.

It has now been discovered that the stable eutectic may also be inoculated by vibrating the mould during solidification of the casting. In this way magnesium-treated cast iron, which would normally solidify primarily by the metastable process, is caused to solidify by the stable process, with precipitation of spheroidal graphite.

Castings substantially free from iron carbide have been produced in this way from magnesium-treated metal containing less than 0·2 per cent silicon, cast into graphite moulds. In such a case the combined effects of magnesium, low silicon content, and high rate of solidification normally preclude graphitization during solidification, even if ferro-silicon is added as inoculant. Nevertheless, castings in the form of balls 2½ in. in diameter, almost completely free from carbide and containing spheroidal graphite, have been produced under these conditions by vibrating the mould at a frequency of 100 cycles/sec. and with an amplitude of 0·040 in.

Iron castings of this composition and having such a structure, as cast, have never previously been reported. The mechanism whereby this effect is produced is not yet understood.

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Surface Hardening of Non-ferrous Metals by Spark Discharge

An earlier communication[1] from this Laboratory described experiments in which the thermal action of electric sparks was used to simulate the effects of frictional heating on the structure of rubbing steel surfaces. The high local temperatures which characterize rubbing contacts can, in certain circumstances, initiate austenite formation and, since conduction into the bulk metal provides effective quenching of the hot spots, martensite is formed and causes hardening of the surface layer. Similarly the brief but intense heat of an electric spark, struck between an electrode and the steel surface, can harden a small volume of material. If the sparking electrode traverses the surface a hard and wear-resistant skin develops.

There is evidence[1] that during frictional heating nitrogen and carbon can enter the surface from the atmosphere or lubricant and contribute to the hardness of the transformed product. Likewise during spark heating, the nature of the medium which the spark traverses is of importance in determining the constitution and properties of the hardened layer. Thus nitrogen assimilated during air sparking and carbon during sparking in oil can cause intense hardening (~ 900 V.P.N.) even of pure iron. It is, however, well known that, in sparking contacts, material may be transferred from one member to the other. If, therefore, a steel surface is sparked with an electrode of dissimilar metal, this transferred material can be expected to alloy with the steel and may also react with components of the environment to form hard compounds. By appropriate choice of electrode material and sparking medium, the hardness attained might considerably exceed that of quench-hardened steel.

Recent publications[2] reveal that surface hardening by spark discharge has been developed in the U.S.S.R. as a commercial process for improving wear resistance, and many successful applications are claimed. The surface to be treated is traversed with a vibrating electrode which repetitively discharges current from condensers. The sparking potential and capacitance usually fall within the range 50–220 V., 20–350 μF., the electrode having positive polarity to facilitate transfer of material to the cathode, namely, the workpiece surface. Electrodes of sintered tungsten and titanium carbides are commonly employed, and transfer of these carbides plays an important part in conferring wear resistance.

The Russian literature deals exclusively with the spark-hardening of ferrous metals. While, in general, non-ferrous metals cannot be expected to harden intensively by thermal cycling alone, the ability of the spark to transfer, or even generate, hard substances indicates means by which surface-hardening might be effected. Work in this Laboratory has shown that many non-ferrous metals can in fact be surface-hardened if suitable techniques are adopted. Two main principles can be recognized.

(1) Transfer takes place from an electrode of material, such as sintered carbide, which is already hard, the hardness of the alloyed layer produced tending towards that of the electrode material (1,300–1,700 V.P.N. in the case of cobalt-bonded tungsten carbide). Alternatively, the electrode may consist of material which is not initially hard but which hardens in the spark reaction as, for example, an electrode of steel or of a non-ferrous metal of the type to be discussed.

(2) Certain non-ferrous metals, notably those belonging to the fourth and sixth groups of the Periodic Table, will form extremely hard compounds by chemical reaction with elements easily made available in the sparking zone. For example, carbides of great hardness (1,300 V.P.N. to more than 2,000 V.P.N.) can be formed on the surface of titanium, zirconium, molybdenum and tantalum by sparking in a carburizing environment. This environment can be provided by sparking with a carbon electrode, or through the agency of liquid hydrocarbons or powdered graphite in contact with the surface.

The hardened layer produced by sparking is only a few thousandths of an inch in thickness, but, as the curves of Figs. 1 and 2 reveal, this thin skin can confer greatly improved wear resistance. The wear measurements were made by loading a cylinder of the non-ferrous metal against a rotating ring of hardened tool steel, no lubrication being provided. The sparking of nickel with an electrode of sintered tungsten and titanium carbides (Fig. 1) has produced a 600-fold reduction in rate of wear through the transfer of carbide to the nickel surface. Improvements of similar magnitude have been obtained by this technique on copper, brass, titanium and aluminium. The reduced rate of wear of iodide-titanium illustrated in Fig. 2 is the result of a skin of titanium carbide produced by sparking with a titanium electrode in the presence of mineral oil.

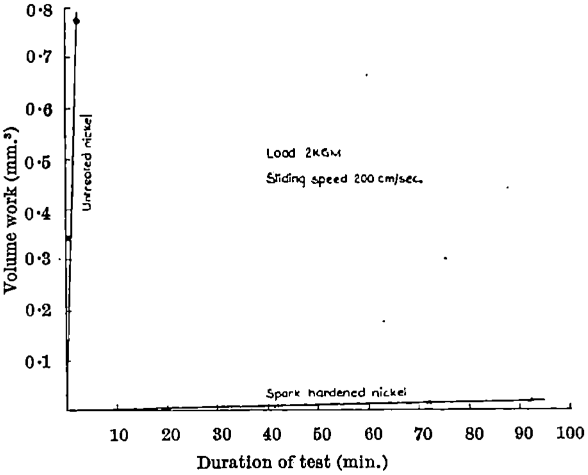

Fig. 1. Change of rate of wear produced by spark-hardening nickel

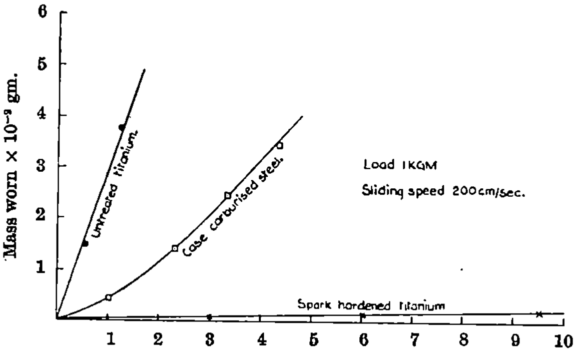

Fig. 2. Change of rate of wear produced by spark-hardening titanium, and comparison with case-carburized steel

For comparison a wear curve for mild steel, case-carburized by conventional means and tested under the same conditions, is also shown in Fig. 2. In these particular rubbing circumstances the spark-hardened titanium is plainly of superior wear-resistance, and it seems likely that spark-treated non-ferrous metals will find applications for wear-resistant parts in engineering practice.

A fuller account of this work will be published in due course.

I am indebted to Dr. W. Hirst for encouragement and advice, and to Mr. P. Watts and Miss B. Green for assistance with the experimental work.

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Strength of Glass Fibres

Previous workers have reported that the tensile strength of nominally identical glass fibres is very inconsistent, with coefficient of variation between 5 and 25 per cent[1,2]. In an attempt to reduce this variability, I have made and tested 'E' glass fibres under carefully controlled conditions. The fibres were drawn from molten glass in a platinum crucible, and were wound around a rotating drum. Only that part of the fibre between the crucible and drum was used for testing. The manipulation technique involved gripping the free length of fibre at its two ends, and mounting it with vacuum wax on a slotted paper mount, which when cut into pieces provided ten test pieces each 1 in. long. Each test piece on its mount was assembled in a special 'chain-o-matic' testing machine with controlled rate of loading, and the mount was severed before application of load. By this means it is possible readily to test large numbers of fibres with surfaces which are mechanically undamaged. To reduce atmospheric attack each batch of ten test pieces was tested within two minutes of manufacture, and in an atmosphere of less than 40 per cent relative humidity.

Using the above technique I have been able to obtain fibres of remarkably consistent strength; on some occasions the coefficient of variation of breaking stress of ten test pieces has been only 1 per cent.

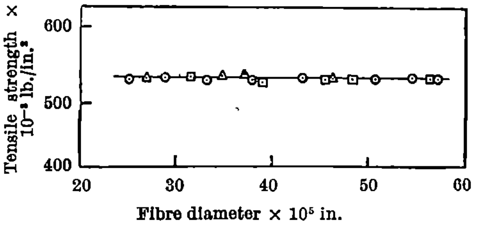

Fig. 1. Temperature of glass in crucible. △, 1,340° C.; ○, 1,300° C.; □, 1,260° C.

Another observation was also made. Over the range for which fibres of uniform diameter can be drawn with my apparatus (2–6 × 10^{-4} in.), the breaking stress is independent of fibre diameter and of the temperature of the glass in the crucible; it is also independent of the rotational speed of the drum. The results are illustrated in Fig. 1. Each point is the mean breaking stress of ten test pieces. Previous workers using different testing techniques have found a very appreciable reduction in breaking stress with increase in diameter for the range shown in Fig. 1.

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Spiral Pits on Silicon Carbide

The dislocation theory of crystal growth[1] suggests that the crystal growing at low supersaturation in the presence of a single dislocation is not composed of an infinite number of layers stacked on each other as ideally considered, but is a helicoid with the dislocation line as its axis and the point of emergence of the dislocation at the top. The observation of a growth hill in the form of a 'spiral staircase' on a number of crystals reported in recent years[2] has amply substantiated the theoretical predictions. Silicon carbide crystals have afforded evidence[3] of a large variety of spiral growths, for example, monomolecular as well as microscopic, and interaction of spiral growth due to two or more dislocations of same as well as of opposite sign. In some cases, hitherto unobserved, silicon carbide crystals exhibit spirally terraced pits. Fig. 1 shows a phase-contrast micrograph of a spirally terraced pit. It is easy to decide with the fringes of equal chromatic order that this feature is a pit. The step height of this terraced pit as determined from high-dispersion Fizeau fringes corresponds to 27 ± 2 A., which is the repeat distance of this crystal identified by X-rays as 33 *R* (Ramsdell's symbol).

Frank[4] has shown that when growth spreads from an isolated pair of dislocations, respectively right- and left-handed, the terrace line connecting them wraps around and meets itself on the other side: thus forming a short connecting terrace line again and an outward growing closed loop. Such an interaction has been exemplified on silicon carbide[5]. If these two dislocations are cancelled by moving together, as suggested by Mott[6], or by a process of double cancellation, as envisaged by Anderson and Dawson[7], flat-topped crystals would result. Fig. 2 is, however, an example of a flat-bottomed crystal. The

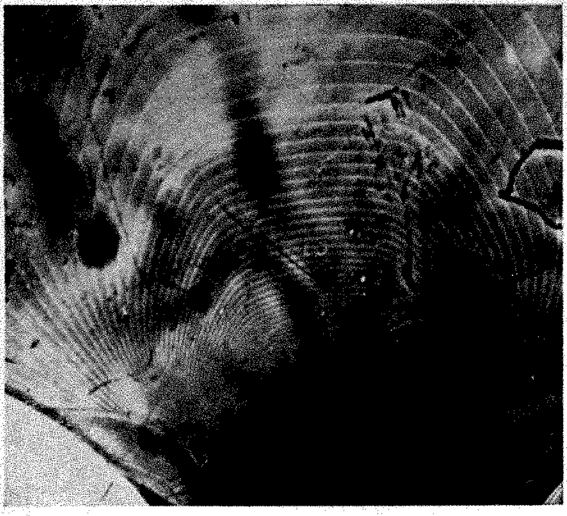

Fig. 1. Spiral pits on silicon carbide. (× 90)

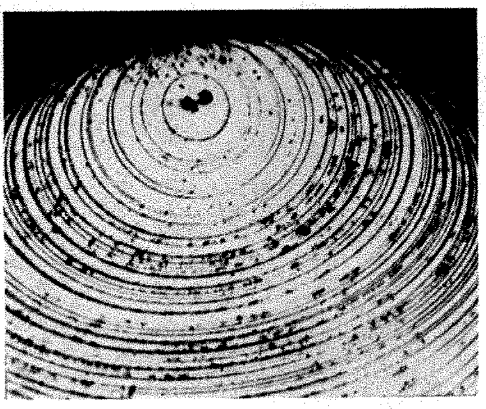

Fig. 2. Spiral pits on silicon carbide. (× 105)

fringes of equal chromatic order passing over the centre of the pit show beyond doubt that it is a pit having a step height of 1050 A.

Such spirally terraced pits are not foreseen as a growth feature on Frank's theory, which envisages spiral pits as a result of dissolution or evaporation. These observations, in conformity with Frank's prediction, suggest that evaporation also takes place in accordance with the dislocation mechanism.

My thanks are due to Prof. S. Tolansky for his kind interest and encouragement and to the Government of India for the award of a Modified Overseas Scholarship, during the tenure of which this work was done in the Physics Department, Royal Holloway College, Englefield Green, Surrey.

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Width of the Green Mercury Line from a 198-Isotope Lamp

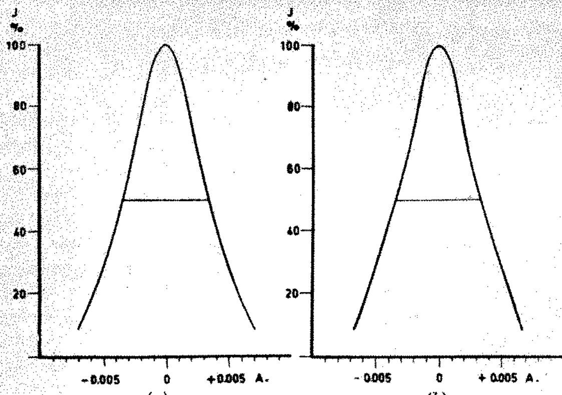
In recent years the mercury isotope lamp has been found most useful and convenient for producing fairly bright and extremely sharp emission lines for spectroscopic purposes. Only a fraction of a milligram of mercury-198 is needed for a discharge lamp of this kind, and this isotope can now be produced quite cheaply from gold. This light source has with good reason been proposed for use as a primary standard of wave-length[1].

Recently, Baird and Smith have pointed out[2] that in certain circumstances, depending on the carrier-gas and on the temperature, asymmetrical self-reversal may occur in such lamps, with a disturbing effect on both the line-width and the wave-length. They have also made useful suggestions as to how this self-reversal can be reduced, by the use of molecular carrier gases such as hydrogen and nitrogen[3].

As very little information has been published about the line-widths or the long-term behaviour of such lamps under ordinary laboratory conditions, the following remarks may be useful. The lamp under consideration was bought in 1951 from the General Electric Co., Ltd.[4], being one out of their serial production. It is a water-cooled internal-electrode discharge lamp; its positive-column tube has a length of about 40 mm. and an internal diameter of about 5 mm., with a coaxial water-jacket sealed around it. The lamp contains about 0·1 mgm. of mercury-198, with argon as a carrier-gas under a pressure of about 10 mm. of mercury. It is usually run from a mains transformer at a current of 25 m.amp., striking at about 500 V. and running normally at 200 V. If necessary, it can be operated from a 6-V. or 12-V. battery using a conventional d.c./a.c. converter. Cooling with water at temperatures of 10–20° C., a flow of about 1 litre in 6 min. was found to be quite sufficient. Should no running water be available, as, for example, under certain field conditions, it is quite possible to maintain a water circulation by hand from a small storage vessel. This particular lamp has now worked for several hundred hours over a period of seven years, mainly for calibrating line-widths with interferometers and large spectrographs. It has also been used by three astronomical research expeditions under very primitive field conditions[5].

The line-width for the green mercury line 5461 A. was measured some time ago with a high-quality Fabry–Perot interferometer of the multicoated type. Its crystalline quartz flats were figured to 1/40 λ and were coated with four quarter-wave layers of zinc sulphide and three quarter-wave layers of cryolite[6]. The reflectivity was at least 95 per cent; the 0·75-cm. spacer consisted of fused silica, giving a range of about 0·170 A. in air, with a resolving power not far from 10^6. In order to improve the resolving power, only a small area, 5 mm. × 7 mm., of the interferometer was used. Using a 'Tessar' lens of 50-cm. focal length to produce an image, exposure times of about 10 min. were needed on Kodak *I–G* spectral plates. The first twelve fringes were measured both by a micrometer and also by a recording microphotometer using a slit width of 0·01 mm. The line profiles of the second and third fringes are reproduced in Fig. 1 on a true intensity scale, derived from the intensity marks available for the plates.

Although these profiles are not intended as high-precision photometric data, they may give useful



(*a*) (*b*)

Fig. 1. Width of the green line of a mercury-198 lamp determined from the second (*a*) and third (*b*) fringes in a Fabry–Perot interferometer

indications of what to expect with a lamp of this kind under normal working conditions. No indication of self-reversal can be detected. However, the thickness of the discharge column was only about 5 mm. (giving quite sufficient light for most purposes) and water-cooling was used, so that the conditions were different from those reported in ref. 2. The half-width was found photometrically to be about 0·006–0·007 A., while the widths of the fringes measured by micrometer were found to be slightly smaller. Such a width is scarcely attainable so conveniently from any other light-source, and it is sufficiently small for investigations even with very powerful spectrographs. Moreover, this may not be the minimum width attainable since the values found here are restricted by the resolving power of the interferometer used, for which a longer spacer was not available. The real line-widths are probably very near the Doppler widths which, at room temperature, should be about 0·0055 A.

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A New Microwave Mixer

THE Hall effect in semi-conductors has been used at microwave frequencies for the measurement of power. It has recently been demonstrated that a simple modification to the power-measuring equipment leads to a mixer. The principle of operation of this mixer is straightforward. A local oscillator is used for establishing a field in a resonant cavity and a small piece of semi-conductor is placed at a point in this cavity where there is maximum magnetic field and no electric field. The semi-conductor is coupled to a second wave-guide carrying a microwave signal, the coupling being effected by a probe which causes a current to flow in the semi-conductor; the direction of the current is selected to be at right angles to the local oscillator magnetic field. Since the signal is coupled to the semi-conductor by electric field, whereas the local oscillator field at the semi-conductor is magnetic, there is no interaction between the local oscillator and signal channels. A Hall electromotive force is established, the instantaneous value of which is proportional to the product of the local oscillator magnetic field and the signal current. This electromotive force has therefore components of frequencies equal to the sum of the local oscillator and signal frequencies and to their difference. The latter signal can be amplified as in a normal mixer.

This form of mixer has been examined with a signal of approximately 8 cm. wave-length, giving an output of 60 Mc./s., and it has been confirmed that the mixing operation described above does take place. A simplified theoretical analysis shows that the conversion efficiency of the mixer is independent of the semi-conductor dimensions and is directly proportional to both the local oscillator power and to the square of the electron mobility in the semi-conductor, assuming that this is an *n*-type material. The output power from the mixer is proportional to the signal power provided that the signal power dissipated in the semi-conductor does not cause an appreciable temperature rise. The conversion loss is rather high, being about 60 db. for indium antimonide with a local oscillator power of 100 watts at 8 cm. This figure is based on calculations; experimental results using germanium appear to be in reasonable agreement with the theory.

The present conversion loss is much too high for the mixer to be of practical value in receiver design, but it is hoped that lower figures can be achieved with more efficient design of the local oscillator cavity and for higher frequencies. The main interest in the mixer at present is that it can be developed to provide a method for measuring mobilities at microwave frequencies.

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Germanium Enrichment in Lignites from the Lower Lias of Dorset

CERTAIN carbonaceous inclusions from the United States are exceptionally rich in germanium[1,2]; hitherto no such enrichment has been reported from the British Isles. A number of lignite specimens recently collected from the Lower Lias of Dorset have now been shown to have similar concentrations of germanium to those of the American samples.

The Lower Lias of Dorset consists of a series of marine shales and marls and subsidiary limestones attaining a thickness of about 170 m. Details of the succession, which is well exposed on the coast around Lyme Regis and Charmouth, are summarized by Arkell[3]. Scattered throughout these beds are fragments of lignite. The lignite is more common at certain horizons, for example, 'Grey Ledge' at the top of the Blue Lias and the 'Woodstone' of the Black Ven Marls. It is never easily detected in the cliff section, but may be found quite readily on the foreshore. Specimens of lignite embedded in several types of rock were collected from a 5-mile stretch of the coast centred about Lyme Regis. These specimens were mostly a few cm. long and varied in thickness from 4 to less than 1 cm.

The lignites may be grouped into two main varieties termed 'wood-like' lignite and 'jet'. The former is brown and fibrous and is frequently enveloped and intersected by veins of calcite or barite. Wood-like lignite is found in the form of rafts lying parallel to the bedding plane, and as cylindrical 'branches' enclosed in boulders. Occasional giant specimens of up to 3 m. long have been reported (Lang, W. D., private communication). The jet is black and possesses a vitreous lustre on freshly fractured surfaces, which are often conchoidal. Calcite and barite veins are generally less conspicuous. Jet is sometimes found associated with larger bodies of wood-like lignite; but in general, small, isolated samples of jet occur as lenticles parallel to the bedding plane. Microscopic examination of thin sections has shown that the wood-like lignite is composed of thick-walled tracheid cells infilled by calcite. In most specimens of jet, on the other hand, cell structure is completely obliterated, although in some cases partly preserved bordered pits and thin-walled cells infilled by red-brown structureless carbonaceous matter have been observed.

The germanium in the lignites has been determined by spectrographic analysis of their ashes. The ash contents of the lignites varied from about 5 per cent for some of the jet specimens up to 90 per cent for the highly mineralized samples. In 10 of the 29 samples examined, germanium concentrations in the ash exceeded 1 per cent, while concentrations approaching 1 per cent in the whole lignite were found for several samples. The mean concentration for the lignites is about 300 times the mean value for British coals. The results are summarized in Table 1.

Table 1

	Germanium (per cent)	
	Ash	Lignite
Maximum concentration	8·4	0·93
Minimum concentration	0·026	0·024
Mean concentration	1·48	0·18

The jet usually contained higher concentrations of germanium than the wood-like lignite. However, when the concentrations were expressed in terms of the carbonaceous portion of the lignite, the mean values for jet and for wood-like lignite were found to be not significantly different. In contrast to the high concentrations in lignites, the germanium contents of the parent rocks were of the order of a few p.p.m. only. The mean values for shale, marl, limestone and pyrite were 1·7, 2·5, 3·9 and 2·4 p.p.m. respectively. No correlation was found between the germanium contents of the lignites and those of their parent rocks.

There is little doubt that the lignites originated as coniferous driftwood which sank to the bottom of the Liassic sea in a water-logged condition. The wood probably became buried before it reached an advanced stage of decay. The results of the microscopic examination show that the differences between the two varieties of lignite developed during diagenesis. Thus driftwood enveloped in limestone became mineralized by the crystallization of calcite within the tracheid cells and gave rise to wood-like lignite. In marl and shale, however, calcite mineralization was limited and the cell structure progressively replaced by colloidal organic matter, the eventual product being jet.

It is unlikely that the wood from which the lignite originated was highly germaniferous. The element was probably introduced subsequent to the burial of the driftwood. If the enveloping sediments had access to a suitable reservoir of germanium, the element could be brought into contact with the organic material by means of circulating solutions and accordingly adsorbed by the carbon. The observation that both varieties of lignite have similar germanium concentrations relative to carbonaceous matter supports the idea that germanium is associated with this portion of the lignite. It is probable that the small size of the lignite inclusions was conducive to their germanium enrichment. Thin seams of carbonaceous material have been reported by several workers[2,4–6] to be abundant in certain trace elements. It was found that some of the Lyme Regis lignites also have revealed exceptionally high contents of other trace elements in addition to germanium; namely, vanadium and titanium. Since these latter two elements, like germanium, are likely to occur as anions in ground solutions, their abundance in lignite may be partly attributable to preferential adsorption of negative ions by the carbonaceous material.

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Twining of the Hop (*Humulus lupulus* L.)

CASUAL observations made by me on the twining of the shoots of the hop suggested that in the first phase of growth (in which the stem extends rapidly and the laterals remain suppressed) the angle made by the gyres of the helix with the horizontal varied with the diameter of the support.

In 1957, experiments were made upon the shoots arising from four sets of Fuggle *N*, a cultivated variety, to determine whether there was a strict relationship between these two quantities. The main crop of shoots appearing above ground in early spring was made to climb vertical rods of different diameters to a height of about 6 ft. Four of the rods consisted of three equal sections of different diameters, two with the broadest portion at the base and two with the narrowest. The remainder of the rods were uniform. Above the rods the shoots were allowed to tangle together and their climbing behaviour was not studied. Only in one shoot was there an outgrowth of the lateral buds, and this was confined to the upper portion of the rod.

The shoots, which ascended the rods very rapidly once twining began, formed almost uniform helices, as the small range in the size of the angle formed

Table 1

Radius of support (1 unit = 1/16 in.)	No. of observations	α Range (deg.)	Mean (deg.)
2	5	69·5–74·0	70·8
3	6	64·5–72·0	68·2
3 (Late stem)	4	61·0–67·5	63·9
4	8	63·5–71·0	66·8
5	9	60·0–67·0	62·1
8	3	49·5–57·0	54·3
8	3	56·5–57·5	57·2
16	1	42·0	42·0
16 (Lateral buds growing out)	1	52·0	52·0
24	1	20·0	20·0

with the horizontal (α) in a vertical series of readings along one rod will show (Table 1). Each stem can therefore be considered as describing a simple helix on a circular cylinder cutting the generators at a constant angle. The radius of curvature of such a helix (R) is related to the radius of the cylinder (a) according to the equation

$$R = a\sec^2\alpha$$

where $(90° - \alpha)$ is the angle with the generators and α the angle made by the tangent to the helix with the plane perpendicular to the axis of the cylinder[1].

The fact that the steepness with which the stem of the hop twines diminishes with increasing diameter of the support suggests that the radius of curvature of its helix may remain constant. We should then expect a straight-line relationship between the radius of the support and the square of the cosine of the angle at which the stem climbs. This line should not pass through the origin, but cut the a-axis at a negative value equal to the radius of the shoot, since we must consider the helix as being described by the longitudinal axis of the shoot upon the surface of a cylinder the radius of which extends to this axis. The results of eight series of observations show that the expected proportionality does in fact exist (Fig. 1). Owing to shoots catching and transferring themselves to adjacent rods in the experiment, only one grew up the whole length of one of the rods of varying diameter. The values given by it fall into alignment with those of shoots climbing uniform rods or portions of rods. A line fitted by eye to the points cuts the co-ordinate axis 1·2 units below the abscissa, a value of the same order as half the diameter of a hop stem.

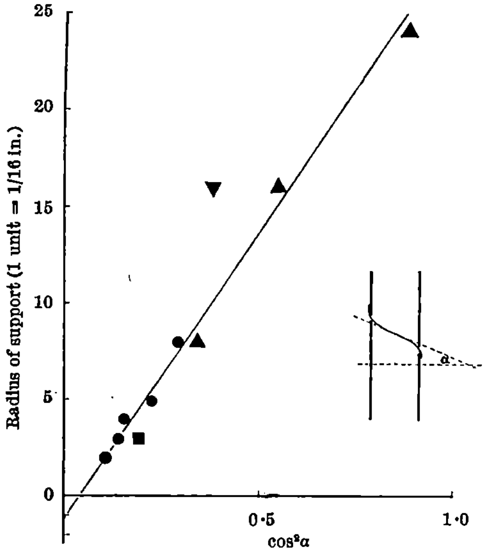

Fig. 1. ▲, Values given by one stem climbing a rod of sections of different diameter; ▼, a stem in which the lateral buds had grown out; ■, a stem ascending after the first flush

These observations agree with Darwin's contention that the twining of the hop is brought about by a wave of growth travelling around the shoot in the extending region[2]. It follows that the intensity of this wave, which will determine the curvature of the helix, is independent of the diameter of the support and consequently must be a property of the stem. It is difficult to decide whether or not the steepness at which the stem twines affects the position of the apex in relation to gravitation, since the upper 6 in. or so of the stem show constant and wide circumnutation, but it can be said that any difference is slight. It is conceivable, therefore, that the gravitational stimuli received by the apex are not affected by the position assumed by the lower regions. A constant curvature in the region of most pronounced internodal extension, where alone the stem first applies itself closely to the support, could then be brought about entirely by an area of vigorous auxin production revolving around the apex as it grows. A comparison of the parenchymatous cells of the cortex on the convex and concave sides of a short median section taken in the plane of the curvature from a stem climbing a support ⅜ in. in diameter showed that the ratio of their lengths was of the same order as would be expected were the curvature attributable entirely to differences in cell elongation (Table 2). This is in conformity with the above hypothesis, but it could also result from a lateral displacement of auxin, such as may occur in haptotropism. Haptotropism by itself, however, could not account for the twining, nor for the constant curvature of the helix.

Table 2. TWENTY-TWO CELLS TAKEN FROM EACH SIDE

	Mean length (μ)	Ratio Observed	Ratio Expected
Convex side	27·7	1·15	1·13
Concave side	24·9		

Only one stem continued to twine around a support three inches in diameter. Others came away from the support after beginning to twine, suggesting that as the radius of the support approached the radius of curvature of the helix the twining system became unstable. One record from the upper part of a stem which had entered the phase of growth in which the laterals grow out is included in Fig. 1. The outgrowth of laterals appears to be accompanied by a diminution in the curvature of the main axis. One of the weaker shoots arising later was also included in the experiment, and the mean curvature of its helix is seen from the results to have been greater than that of a shoot of the first flush.

Further experiments on this and other twining plants are planned.

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Relationship between *Merulius lacrymans* and *M. himantioides*

The relationship between the brown-spored species under *Merulius* is not certainly known. The two species, *M. lacrymans* (Wulf.) Fr. and *M. himantioides* Fr., are regarded by Cooke[1] as morphologically alike but distinguishable on the basis of physiological activity and habitat. He therefore considers them as varieties under the same species. He has, however, stated that "more than one species may be indicated if unsuccessful monospore culture pairings are used as indicators of specific barriers". This criterion is used for studying the relationship between *M. lacrymans* and *M. himantioides.*

M. lacrymans was collected from wood of *Pinus sylvestris* in buildings in Denmark at Kibaek, Jutland and at Copenhagen. The latter collection was flown over to Dehra Dun for study. In both our Institutes, the fungus was brought to polyspore and monospore cultures. The spores germinated within 12–15 days after they were planted on 2·5 per cent malt agar at *p*H 5·0 at 18° C. During germination, the spore usually put out a vesicle which finally produced a germ tube. Clamp connexions, which were common in the polysporous mycelium of *M. lacrymans*, were absent in the monosporous mycelium of the fungus, in the hyphæ of which simple septa were present. When two compatible monospore mycelia were paired, clamps developed on the mating hyphæ. In incompatible matings, clamps did not develop. By pairing the monospore mycelia in all possible combinations, they were found to fall into four sexual groups. *M. lacrymans* was thus found to be heterothallic and tetrapolar.

M. himantioides was collected from the open forests in the Western Himalayas (above 6,000 ft.) in India growing on bark of conifers (*Cedrus deodara* and *Picea morinda*). In Denmark, the fungus was collected from floor boards of pine (*P. sylvestris*) in a house at Hundested, North Sealand. Polyspore and monospore cultures of the fungus were obtained from fruit bodies collected from both localities. Germination of spores occurred freely within two days on 2·5 per cent malt agar at *p*H 5·0 at 18° C. On germination, the spore put out a germ tube directly. In this it differed from *M. lacrymans*, where the spore usually germinates by production of a vesicle. In *M. himantioides*, the single-spore cultures did not possess clamps in the hyphæ, which occurred only in polyspore cultures. The spores fell into four sexual groups, and the fungus is heterothallic and tetrapolar.

Crosses were then made between the monospore cultures of *M. lacrymans* and *M. himantioides* by pairing the four sexual strains of the former with those of the latter in all possible combinations. In this test, the Jutland and Copenhagen collections of *M. lacrymans* were paired respectively with North Sealand and Indian collections of *M. himantioides.* Clamps did not develop in any of the pairings, proving that the two fungi are mutually intersterile.

M. lacrymans differs from *M. himantioides* in habitat, the former being usually domestic and the latter wild. The two fungi also differ in the morphology of the sporophore and in culture, particularly in the texture and colour of the mat and formation of profuse liquid drops in *M. himantioides* and their absence in *M. lacrymans.* In culture the optimum growth of *M. lacrymans* occurs at about 18° C., while with *M. himantioides* it is at about 28° C., at which *M. lacrymans* ceases to grow. These differences are believed to be sufficiently diagnostic for identifying the two fungi as distinct species, and this is confirmed by genetic studies as reported above. A detailed account of this work will be published later.

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Occurrence of Spermatophores in the Genus *Dolops* (Crustacea : Branchiura)

According to all those who have defined the group, one of the diagnostic characteristics of the Branchiura is the absence of spermatophores. Indeed, the mating habits of members of the genus *Argulus* are sufficiently well known to enable it to be stated that here no such structures are involved in sperm transfer, and recent unpublished observations on various species of the genus *Chonopeltis* (some as yet undescribed) indicate that here also no such structures are found. On the other hand, the existence of spermatophores in the genus *Dolops* has recently been established.

These structures were first observed in Africa during the course of an examination of specimens of *Dolops ranarum* (Stuhlmann), which is the only known African representative of an essentially South American genus. Later, when an opportunity was taken to examine the rather small collection of South American species of *Dolops* in the British Museum (Natural History), a single female of *D. geayi* (Bouvier) was found to be carrying a spermatophore, thus suggesting that the employment of these structures may be a regular feature of the reproductive process throughout the genus.

The following remarks apply particularly to *D. ranarum* ; but the spermatophore of *D. geayi* appears to be essentially similar to that of its African relative.

Spermatophores, which bear a most striking resemblance in form, colour and lustre to pearls, are attached singly in the mid-ventral line of the female at the base of, and just behind, the fourth pair of legs. Their size appears to vary according to the size of the male which produced them, and possibly according to other and, as yet, unknown factors. The length of the longest axis of these subspherical structures may be as much as 560μ.

Transference of spermatophores from male to female has been observed, and is a relatively simple process, as might reasonably have been inferred from the almost complete lack of accessory copulatory organs in *D. ranarum*, which contrasts strongly with the presence of extremely complex organs in the males of all known species of *Argulus* and *Chonopeltis*.

While the purpose of this communication is essentially to announce the discovery of spermatophores, a note of caution must be sounded to those who would cite their existence as evidence of a close relationship of this taxonomically enigmatical group to the Copepoda. It is true that the possession of spermatophores by *Dolops* suggests that the Branchiura is quite distinct from the Branchiopoda with which some would group it. On the other hand, however, spermatophore formation need not necessarily represent the retention of a characteristic exhibited by a possible common ancestor of the Copepoda and Branchiura. It could equally well be a device which has arisen independently in the genus *Dolops* in order to facilitate successful sperm transfer in the absence, in some species at least, of the complex accessory copulatory organs found in allied genera. Preliminary observations indicate that spermatophore formation in *Dolops* involves processes which are unknown in any of the Copepoda. It is hoped to pursue these studies further in due course.

Ironically, although spermatophores are reported here for the first time, they were in fact unwittingly mentioned more than sixty years ago by Stuhlmann[1], who described *D. ranarum*, and reported that "oft sieht man an der Geschlechtsöffnung des ♀ ein rundes, weisses Ei". What Stuhlmann took to be an egg was in fact a spermatophore.

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Retinal Pigments of a Labrid Fish

The distribution of visual pigments in aquatic vertebrates has been assumed to follow this pattern[1]: marine fishes possess rhodopsin ($\lambda_{\max.}$ 500 mμ), based on retinene$_1$, and freshwater fishes possess porphyropsin ($\lambda_{\max.}$ 522 mμ), based on retinene$_2$. Since the report by Wald[1] that labrid fishes have porphyropsin, the members of this family of marine teleosts have been regarded as exceptions to the general picture of visual pigment distribution. It should be made clear, however, that Wald did not study the visual pigment itself in the Atlantic species, *Tautoga onitis* and *Tautogolabrus adspersus*, which he examined, but based his conclusions on an analysis of the retinal vitamin A. Confirmation was reported by Kampa[2] for two unspecified corid (labrid) fishes in the Caribbean. She apparently studied the visual pigment, retinene and vitamin A, but only summarized her findings and has not published the full results. More recently, in a brief abstract[3], Wald has stated again that *Tautoga* possesses porphyropsin.

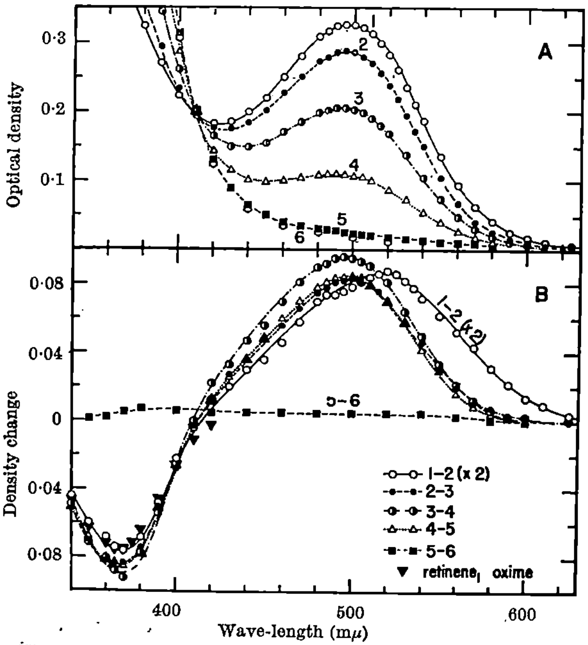

Fig. 1. *A*, Partial bleaching experiment. Curve 1, absorption of unbleached extract; curve 2, after 80-min. exposure to 650 mμ light; curve 3, after 20-min. exposure to 605 mμ light; curve 4, after 45-min. further exposure to 605 mμ light; curve 5, after 75-min. exposure to 590 mμ light; curve 6, after 10-min. exposure to white light. *B*, Difference spectra of partial bleaching experiment. Curve 1–2 (drawn to × 2 scale) is the result of the 650 mμ bleach, 2–3 and 3–4 the 605-mμ bleaches, 4–5 the 590-mμ bleach, and 5–6 the white light bleach. The inverted triangles are spectral densities of a digitonin solution (*p*H 8·3) of retinene$_1$ oxime scaled for comparison with curve 1–2

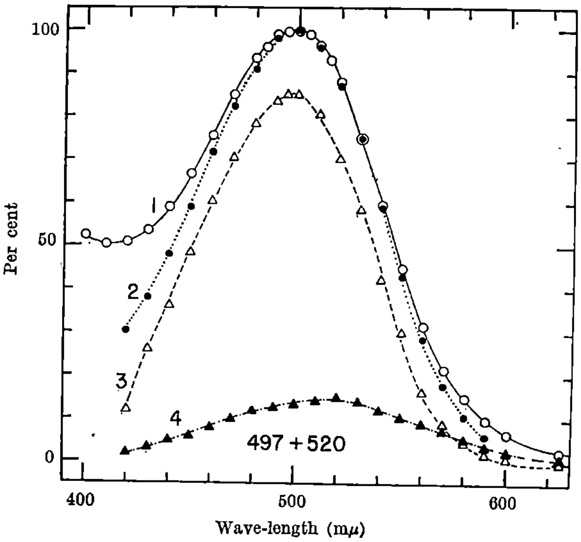

Fig. 2. Curve 1, absorption of unbleached extract; curve 2, constructed from Dartnall's nomogram, assuming $\lambda_{\max.}$ 500 mμ; curve 3, difference spectrum of red-insensitive component; curve 4, difference spectrum of red-sensitive component. Curves 3 and 4 scaled so as to approximate in sum the total difference spectrum

The sheep-head, *Pimelometopon pulchrum* (Ayres), is a labrid of the eastern Pacific. Over the last 30 months, four digitonin extracts of the retinæ of this species (gratitude is expressed to Marineland of the Pacific for the specimens used in this study) have been prepared and analysed by methods described elsewhere[4]. The results have been consistently the same: the chief photosensitive retinal pigment of the sheep-head is a retinene$_1$ pigment with $\lambda_{\max.}$ 497 mμ. In addition there is a small amount of another retinene$_1$ pigment with $\lambda_{\max.}$ 520 mμ. These two photolabile components were present in the extracts in the ratio 85 : 15. This mixture was disclosed by partial bleaching experiments without hydroxylamine (not figured) and with it (Fig. 1). Exposure to deep red light selectively removed the red-sensitive component (curve 1–2). Further exposure to non-isomerizing light of shorter wave-lengths then bleached the main photolabile component (curves 2–3, 3–4, 4–5).

The product of bleaching of both components is characteristic of retinene$_1$ pigments. In Fig. 1*B* the absorption spectrum (inverted triangles) of retinene$_1$ oxime (prepared from crystalline all-trans retinene$_1$) is plotted for comparison with the bleaching product of the red-sensitive component. In experiments without hydroxylamine the spectral position of the alkaline indicator yellow also suggested that retinene$_1$ is the chromophore. Neither light-sensitive component in the sheep-head retina, therefore, can be termed a porphyropsin.

Comparison of the absorption of the unbleached extract (Fig. 2, curve 1) and the nomogram construct[5] (curve 2) for a visual pigment with $\lambda_{\max.}$ 500 mμ shows that the nomogram curve is not broad enough to match the retinal extract. This suggests a mixture of components, confirming the result obtained in bleaching experiments. The hydroxylamine difference spectra (curves 3, 4) of these pigments are shown in about the proportion that they are present in retinal extracts.

It is clear that these results do not confirm the general statement of Wald[1] that the Labridae possess porphyropsin. In the sheep-head, at least, there are two pigments, one very similar to lamprey visual purple[6], the other to the visual pigments of geckos[7]. Whether the red-sensitive component of *Pimelometopon* is a cone pigment or a secondary rod pigment cannot be decided from the present observations. Unlike chicken iodopsin[8], the red-sensitive pigment of the sheep-head is stable under alkaline conditions and in the presence of hydroxylamine. It would be very desirable to re-examine the Atlantic labrid fishes to determine whether they really do have porphyropsin and whether this marine family is split into two groups, those with retinene$_1$ photopigments, and those with retinene$_2$ pigments.

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Effects of Ultra-Violet Radiation on Oysters

It seemed of value to examine the influence of ultra-violet light upon the rate of cleavage of artificially fertilized eggs of *Crassostrea angulata* L., the larvæ of *Ostrea edulis* L., as well as their adults. The oysters were collected in the summer of 1956 from their natural beds in south Brittany. The experiments were undertaken partly in the Auray Bacteriological Laboratory, and partly in the Arago Laboratory at Banyuls-sur-Mer. A wavelength of 3600 A. from a quartz mercury arc was used.

The gametes and the fertilized eggs of *C. angulata* were irradiated with graded doses up to 30 min., with the ultra-violet source 50 cm. above the water level. The sperms were found to be more resistant than were the eggs. After doses longer than 5 min., there was a pronounced reduction in the rate of cleavage; when the controls had reached the second cleavage stage, some of the eggs irradiated for 10 min. had not completed the first stage. Later, when 100 per cent of the controls had developed into ciliated trochophores, some of the irradiated eggs were still in the first, second and third cleavage stages and only 5 per cent had developed into free swimming blastulæ. With still stronger doses of 20–30 min., 10 per cent of the eggs developed into balls of motile cells, and 90 per cent remained with the germinal vesicle intact.

Normally, the newly hatched larvæ of *O. edulis* manifest positive phototropism and negative geotropism. When irradiated for 5–7 min. in a container 1 m. deep, with the ultra-violet source 35–125 cm. above the water surface, they showed a tendency to occupy the lower levels in the aquarium and finally to stop swimming freely and to settle down near the bottom with their shells almost closed. Evidently, it was a temporary tropistic response to avoid injury, as many were noticed, later, to regain their activity and to swim freely again. The percentage of larvæ recovered and the time of recovery depend largely upon the strength of the dose.

An exposure of 15 min. from a source at 35 cm. above the surface of water only 20 cm. deep was lethal. The ultra-violet effect was, however, eliminated when, in a new experiment, a glass plate was placed between the larvæ and the ultra-violet source, showing that the larval shell was not adequate protection against strong doses.

The adult *C. angulata* and *O. edulis* were found to resist strong doses of 30–60 min. with the source 35–50 cm. above the surface. All the oysters survived normally for the next two months, and some even showed a slight growth. Many of the parasites which happened to live on their shells were killed by the irradiation.

The radiosensitivity of many planktonic organisms, including some oyster enemies, was found to vary widely in the different forms. While worms like *Polydora*, bacterians and some fungi were highly susceptible, crustacean larvæ and copepods proved to be less sensitive.

In brief, the main conclusions are: 1, the cleavage of artificially fertilized eggs as well as the development of later stages of *C. angulata* is considerably retarded after irradiation; 2, the results of irradiating *O. edulis* larvæ help to explain—in the light of studies on solar radiation and its transmission through air and water—the variations noticed every year in the density of oyster spat setting at different levels on natural and artificial collectors; 3, the resistance of the animal, regardless of its size, depends upon the nature of its outer surface, its thickness, and the strength of the dose; 4, a great progress in artificial propagation of oyster culture would be achieved by discovering some control method involving the use of ultra-violet doses not harmful to the oysters, their larvæ, or feeding organisms, but destructive to the enemies which compete with them for food and space.

Although the practical application of such methods to natural shellfish grounds would be very difficult, I think they might be used on the small isolated bodies of water used for rearing oyster larvæ artificially and for growing their food cultures.

My special thanks are due to Prof. G. Petit, director of the Arago Laboratory, and to M. L. Marteil, chief of the Bacteriological Laboratory at Auray, for the many courtesies extended to me during my work in France.

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Labelling of Bull Semen with Phosphorus-32 *in vivo*

Recent work has indicated that when rams are injected intravenously with labelled phosphate and serial samples of semen collected, the various phosphorus components of the semen appear with maximal radioactivity in a definite time sequence[1]. In this communication these experiments have been extended to a bull, both with the view of obtaining information about various physiological processes in its reproductive tract and also for acquiring labelled sperm for other experimental purposes.

A Shorthorn bull (780 kgm.) was injected intravenously with 14 ml. isotopic saline containing 25 mc. labelled phosphate through a cannula inserted into the jugular vein. Semen samples were collected twice a week using an artificial vagina. The sperm were examined throughout the investigation for motility, morphological appearance and density, and no indication of any change became apparent. This showed that the testes cannot have suffered any gross radiological damage due to the administration of the isotope. The sperm and seminal plasma were then separated by centrifuging and the following fractions isolated and assayed for radioactivity and phosphorus: sperm acid-soluble phosphorus, phospholipids, deoxyribonucleic acid and residual phosphorus (Schmidt and Thannhauser[2], phosphoprotein + ribonucleic acid); seminal plasma glycerylphosphorylcholine and total phosphorus. The methods used for fractionation and analysis have been described previously[1]. However, due to the presence of considerable mucoprotein in bull seminal plasma compared with that of the ram, it was necessary to modify the procedure for the isolation of glycerylphosphorylcholine as follows. The seminal plasma (3–4 ml.) was treated with 7 ml. ethanol, centrifuged and the supernatant taken to dryness *in vacuo*. The residue was extracted with 10 ml. ethanol and the ethanol-soluble substances then partitioned between water, chloroform, butan-2-ol and chromatographed as described for the ram.

In Fig. 1 is illustrated the pattern of activity appearing in ejaculates collected over a period of 70 days. The seminal plasma glycerylphosphorylcholine acquired maximal activity in samples obtained 11 and 14 days after isotope injection and then its radioactivity slowly declined. The peak of its activity arrived before the activities of any of the sperm components appeared with maximal activity which is consistent with observations made upon the ram, and the conclusion that the source of semen glycerylphosphorylcholine is largely in the epididymides[1,3]. It is interesting that the specific radioactivity of the seminal plasma total phosphorus fraction closely followed that of the glycerylphosphorylcholine. Although this phosphodiester would be the major component in the seminal plasma phosphorus fraction, it is surprising that there is no evidence of an ejaculation of highly active phosphate immediately after the isotope administration or contamination of the semen with highly active urine phosphate. This is possibly because the injected labelled phosphate rapidly disappears from the blood stream and that equilibrium conditions are established long before the first semen sample was collected, that is, 4 days after the injection.

The sperm phospholipid, residual phosphorus and acid-soluble phosphorus in the ejaculates reached a maximum initial labelling at 21, 18, and 25 days respectively. The acid-soluble phosphorus in the sperm shows some evidence of an exchange with the phosphorus in seminal plasma as there is a distinct kink in the curve at the time when seminal plasma phosphorus shows its maximum specific radioactivity. This probably occurs after ejaculation; Bishop and Weinstock[4] have found, for example, that bull spermatozoa when suspended in saline containing labelled phosphate rapidly acquire radioactivity in their acid-soluble phosphorus fraction.

The main peak in the specific radioactivity time-curve of the sperm deoxyribonucleic acid phosphorus reaches a maximum 60 days after the injection, which compares with a time of 50–52 days found for the ram. Recently, H. H. Koefoed-Johnsen (personal communication), in similar experiments

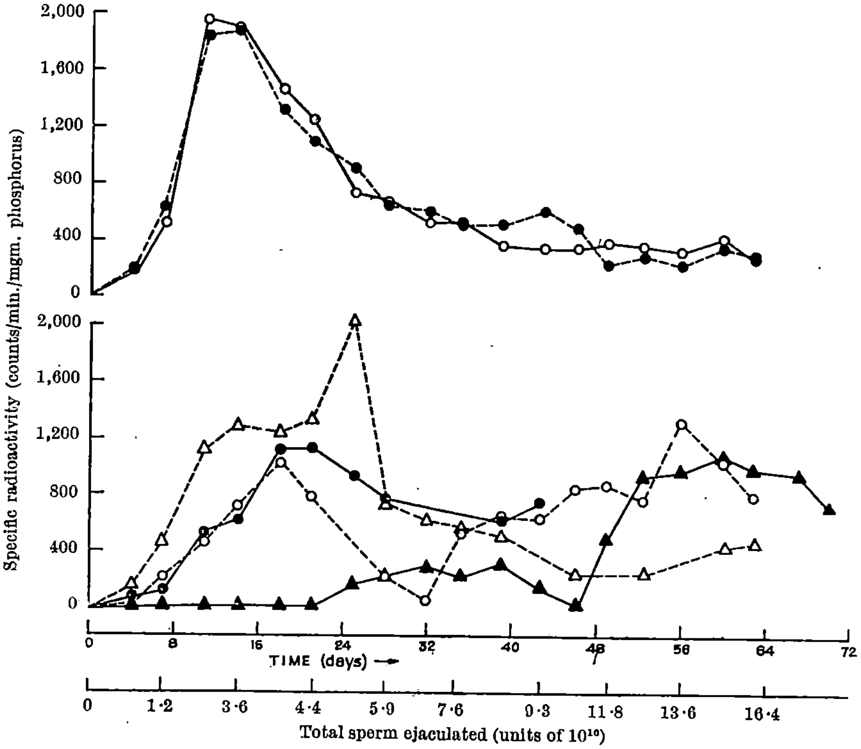

Fig. 1. The appearance of labelled phosphorus components in samples of semen collected from a bull injected with radioactive inorganic phosphate. The abscissa represents the time in days after the injection and on a lower scale is given the total number of sperm ejaculated after the administration of isotope. Upper curves, seminal plasma. ○—○, glycerylphosphorylcholine phosphorus; ●---●, total phosphorus. Lower curves, sperm. ●—●, lipid phosphorus; △---△, acid-soluble phosphorus; ▲—▲, deoxyribonucleic acid phosphorus; ○---○, residual phosphorus

which are as yet unpublished, found that in a bull dosed with labelled phosphate it required some 62 days for the sperm deoxyribonucleic acid to be ejaculated with maximal activity: a value which is in good agreement with the present results. The sperm deoxyribonucleic acid possesses some low activity before the appearance of the main activity peak; such a phenomenon did not occur in the ram and it is consequently difficult to assess its significance from an experiment on a single animal. In the ram it was suggested that the difference between the times of ejaculation of the main sperm phospholipid and deoxyribonucleic acid peaks was due to the fact that while the former would be added or turned over up to the end of spermatogenesis, no new deoxyribonucleic acid would be formed after the mitotic divisions forming the primary spermatocyte. If this explanation is correct, this would mean that in the present experiment the average time for the primary spermatocytes to be converted into the finished spermatozoa would be 39 days.

Bronsch and Leidl[5] have recently found that in bulls given labelled phosphate intramuscularly maximum activity was ejaculated in the semen 14 days after its administration: all the activity being found in the seminal plasma and none in the sperm. The present experiment agrees with these observations in that the seminal plasma total phosphorus reaches peak activity in the 11–14-day period after isotope administration, but shows in addition that at this time a small but significant part of the labelling is present in the sperm and cannot be removed from it by saline washing.

I am indebted to Miss N. Hemington and Mr. R. White for valuable laboratory assistance, and Messrs. Clarke and Wise for assistance in handling the bull.

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Glycerol Metabolism of the Brown Rot Mould *Poria vaillantii*

THE characterization of the chemically unchanged lignin of woody tissues requires the removal of the cellulose with which it is associated. The successful utilization of wood-destroying organisms for the isolation of large amounts of enzymically liberated lignin[1] and for the elucidation of the mechanism of the biogenesis of lignin building stones[2–5] prompted an attempt at the isolation of a cellulolytic enzyme from the wood-destroying mould *Poria vaillantii*[6]. During studies of the cultivation of the mould, an attempt was made to use a medium containing glycerol instead of glucose as the sole carbon source, since glucose interferes in the assay of the cellulolytic enzyme which is obtained from the filtrates.

After 4–6 weeks of growth on a glycerol medium, the culture filtrates were collected and found to contain reducing substances. Analysis of the concentrated filtrate revealed the presence of acetaldehyde, dihydroxyacetone, and glucose. Acetaldehyde was identified as its dimedone derivative. The product after three recrystallizations did not depress the melting point of an authentic sample prepared in the same manner. The concentrated filtrate gave positive Seliwanoff and phosphomolybdate tests, indicating the presence of dihydroxyacetone. Glucose was identified by extraction from a paper chromatogram as its 2,4-dinitrophenylhydrazone derivative. There was no depression of melting point of a mixture of this compound and an authentic hydrazone specimen.

A cyclic mechanism, by which glucose could arise from glycerol, was first postulated by Horecker[7].

The identification of the above intermediates in the metabolic filtrates of the mould *Poria vaillantii*, grown on glycerol as sole carbon source, suggests that this cycle may be operative in the metabolism of this organism.

This study was carried out within a programme sponsored by the National Science Foundation and the U.S. Public Health Service.

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Breeding of Dragonflies in Temporary Waters

THROUGHOUT Western Australia there are five or more consecutive months in which there is little or no rain. Over the greater part of the State the mean annual rainfall is less than 20 in., derived mainly from a few heavy falls. The surface-waters which result from these rains usually persist for a few months at the most; there are very few permanent, natural fresh waters. In the south-west (as at Perth), the rainfall exceeds 35 in. and is derived from more frequent lighter falls, but even here many of the surface-waters dry up from about November until April or May.

These temporary waters are colonized by many aquatic insects, and several species of both Zygoptera and Anisoptera, although not confined to such places, breed commonly in them. These include five species of *Austrolestes*, *Anax papuensis*, *Hemicordulia tau*, *Orthetrum caledonicum* and *Diplacodes haematodes*.

To breed successfully in temporary waters larvæ must either survive drying or complete their development in six months or less. Although Tillyard[1] found that larvæ of *Synthemis eustalacta* (a swamp species from south-eastern Australia) could withstand drying in sand for four months, there is no evidence that the common species of temporary ponds in Western Australia actually do so. Newly filled ponds have shown only young larvæ, and larvæ at all stages of development have been found dying in large numbers in pools from which the free water has evaporated. However, larvæ do complete development and emerge before the pools dry, and there can be little doubt that these have developed from eggs laid in the previous April or May when the ponds first filled.

These observations have been made in the vicinity of Perth where pond temperatures vary from 40–60° F. in winter, up to 70–80° F. in early summer. Summer water temperatures are probably higher inland, and in the tropics they show a daily range of 75–112° F.

In the laboratory, rearing experiments have been carried out on three Anisoptera of temporary ponds. During these experiments, larvæ were kept in individual containers in circulating water and given an excess of food. At the upper temperature (85° F.) mortality was initially high. The results of the experiments are shown in Table 1.

Table 1. GROWTH OF ODONATA AT DIFFERENT TEMPERATURES

Species	Growth period	Mean duration in days (No. of animals)		
		Outdoors 46–76° F.	70° F.	85° F.
Anax papuensis	Oviposition to hatching		14	
	4–10 mm. larva to emergence (~ 48 mm.)	176 (1)	70 (4)	45 (2)
Hemicordulia tau	Oviposition to hatching	20	10	6
	2–3 mm. larva to emergence (~ 21 mm.)	132 (6)	56 (10)	36 (2)
Diplacodes haematodes	Oviposition to hatching		10	6
	Oviposition to emergence		89 (2)	56 (3)

It is evident that, at the high temperatures found in many shallow ponds, these three Anisoptera can complete their aquatic life well within the time required to make use of temporary waters. Experiments performed by Gardner[2] with *Orthetrum stemmale capense* and *Palpopleura lucia* from Africa gave similar results, and it seems probable that other pool breeders will also show rapid growth rates. By contrast, *Acanthaeshna anacantha*, which breeds in permanent hill streams of the south-west of Western Australia, takes at least one and possibly two years to complete its development. Larvæ of this species have shown retarded growth and extremely high mortality at 85° F. and little or no acceleration of growth at 70° F.

The expenses of this investigation have been met from a University of Western Australia Research Grant. One of us (J. A. L. W.) was in receipt of a Commonwealth Scientific and Industrial Research Organization Studentship.

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Occurrence of *Donsiella limnoriae* Stephensen (Copepoda, Harpacticoida) in the Southampton Area

Donsiella limnoriae was first described by Stephensen[1] in 1936 from some 20 specimens which had been found in association with *Limnoria lignorum* at Trondheim, Norway. Since then this species does not appear to have been found again, hence its occurrence in waters near Southampton is of interest. Three females were found on *Limnoria tripunctata* collected at Cowes, Isle of Wight, and three females and two males from *L. quadripunctata* at Calshot. The 'infection' was very low, at least during October when the collections were made. Only three *Donsiella* were taken from 220 *L. tripunctata* from Cowes and five from 69 *L. quadripunctata* at Calshot. While the specimens collected near Southampton could undoubtedly be identified as *Donsiella limnoriae* Stephensen, they show certain differences in structure from the description of the Norwegian specimens.

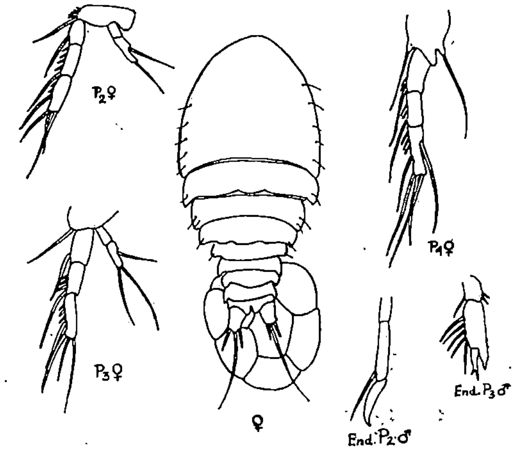

Fig. 1. *Donsiella limnoriae* Stephensen. ♀, Female with egg mass; *P*$_2$♀, *P*$_3$♀, *P*$_4$♀, second, third and fourth leg of female; *End. P*$_2$♂, *End. P*$_3$♂, endopodite of second and third leg of male

The specimens collected here are similar to those from Trondheim in general body shape and size. The structure of the endopod of the second leg, however, exhibits certain differences. It is two-jointed, the terminal joint being only a little longer than the proximal, and carrying only one inner and one apical seta; according to the original description the distal segment is more than twice the length of the proximal and carries one inner and three apical setæ[2]. In the third leg also, the second joint of the endopod is a little longer than the first in the Southampton specimens, whereas it is twice the length of the first joint in the Norwegian specimens.

In the male, the structure of the endopod of the second leg exhibits certain differences from the original description. The endopod is three-jointed, the second joint being longer than the first and carrying an inner seta; the terminal joint ends in a claw-like structure without setæ. In the Norwegian specimens, on the other hand, the terminal joint is shown as having an inner seta and to be nearly twice the length of the middle one. In the endopod of the third leg of the male, the terminal joint is small and narrow, ending in a bifid projection in the Southampton material; in the specimens from Norway, the terminal joint is broad with its outer end produced into a spinous projection and carrying two inner setæ.

When living, these copepods cling to the isopod 'host' with the help of the first leg or crawl about on the surface. They are often found in the spaces between the epimera of the body and the bases of the legs. It is likely that these copepods have been overlooked in the past because of their small size and transparent nature. Perhaps they are more widely distributed than appears from present records. A detailed description will be published when more specimens are available.

We wish to thank Prof. J. E. G. Raymont for several valuable suggestions and Mr. A. R. Hockley for some of the specimens.

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Internal Seed Disinfection with Pyridine-2-thiol-N-oxide and a Derivative

Conventional seed disinfectants are unsatisfactory in the combat of internal parasites in seeds because they do not penetrate far enough. Successful disinfection of pea seed carrying the internal fungal parasite *Ascochyta pisi* has, however, been achieved by Dekker[1–3] using the antibiotics rimocidin and pimaricin. Using the same methods and similar material we have now found that the strongly fungicidal agents pyridine-2-thiol-N-oxide and 2-pyridyl-N-oxide-isothiourea hydrobromide are as effective as these antibiotics.

Of pea seeds (variety Eminent) which showed a high percentage of internal infection with *Ascochyta pisi* lots of 25 peas were soaked for 24 hr. in 0, 10, 25 and 100 p.p.m. of pyridine-2-thiol-N-oxide. The seeds were afterwards placed on filter paper. The number of those from which *A. pisi* developed was 17, 3, 1 and 1 respectively. Seeds of another sample were sown in soil after soaking lots of 200 peas in aqueous solutions containing 0, 10, 25, 50, 100 and 200 p.p.m. of pyridine-2-thiol-N-oxide for 24 hr. After 13 days the number of diseased plants emerging from these seeds was 20, 9, 3, 3, 2 and 1 respectively. Germination of the seeds and development of the plants was unimpaired by the pyridine-2-thiol-N-oxide treatment. The effect of this treatment on *A. pisi* is quite clear from these two experiments.

Bean seeds (*Phaseolus vulgaris*) could not be soaked because immersion in water for 24 hr. proved harmful. Thus a slurry consisting of 92 mgm. pyridine-2-thiol-N-oxide, 40 mgm. carboxymethylcellulose and 0·4 ml. water was applied to 80 seeds which were afterwards sown in soil. Emergence of the plants from treated seeds was somewhat slower than that from untreated seeds. After 12 days, however, 54 plants had developed from the treated seeds and of these 2 showed disease symptoms. The 80 control seeds gave rise to 53 plants of which 39 showed *Colletotrichum lindemuthianum* infection.

Treatment of pea seeds with 2-pyridyl-N-oxide-isothiourea hydrobromide proved as good as with pyridine-2-thiol-N-oxide. Lots of 50 seeds were soaked for 24 hr. in 0, 50, 100 and 200 p.p.m. of 2-pyridyl-N-oxide-isothiourea hydrobromide in water and afterwards placed on filter paper. The number of seeds from which *A. pisi* developed was 35, 5, 0 and 0 respectively.

These results suggest that pyridine-2-thiol-N-oxide and 2-pyridyl-N-oxide-isothiourea hydrobromide are able to penetrate into the seeds. This could be confirmed by bioassay of internal parts of treated seed. Slight systemic protection by pyridine-2-thiol-N-oxide has been earlier reported[4] for cucumber seedlings against *Cladosporium cucumerinum* and for broad bean plants against *Botrytis fabae*.

It is possible that the volatility of pyridine-2-thiol-N-oxide facilitates penetration into the seeds. 2-pyridyl-N-oxide-isothiourea hydrobromide is not volatile, however, but it is suggested to give rise to pyridine-2-thiol-N-oxide by hydrolysis under physiological conditions, for it has been found (unpublished results) to have the same fungicidal activity and mode of action *in vitro* as pyridine-2-thiol-N-oxide[5].

The insoluble copper complex of pyridine-2-thiol-N-oxide, which is its actual toxic agent[5], shows no systemic effect on *Ascochyta pisi* in pea seeds, nor does the S-carboxymethyl derivative. This latter compound is not fungicidal *in vitro*, but showed a slight systemic effect when applied to broad bean plants[4].

We are indebted to J. C. Overeem of the Institute for Organic Chemistry T.N.O. for preparing the compounds.

This work was carried out as part of the programme of the T.N.O. Research Unit for Internal Therapy of Plants.

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Choice and Application of Fungicides to Plantation Crops, with Special Reference to *Hevea brasiliensis*

It is clear from the correspondence of this Institute during the past two to three years that the extent of care sometimes required in the choice and application of a fungicide to plantation crops is not invariably appreciated. The hazards in the latter case do not necessarily include a significant effect on the ecology of the area, but they do sometimes include a serious effect on the visual or technological quality of the plantations' finished product. This difficulty is encountered with an appreciable number of plantation crops, but it is probably particularly acute in the case of *Hevea brasiliensis* as so many valuable or potentially valuable fungicides are either (*a*) vulcanizing agents or accelerators of the vulcanization of natural rubber, for example, sulphur, which is used in the control of defoliation due to *Oidium hevea*[1], and certain salts of substituted dithiocarbamic acid which are at present under examination for the control of defoliation due to *Phytophthora palmivora*, or (*b*) extremely effective catalysts of the oxidative degradation of natural rubber, for example, copper compounds which have been examined in Ceylon[2] and elsewhere for the control of defoliation due to *Phytophthora palmivora*.

Clearly, the successful use of such fungicides in mature *Hevea brasiliensis* areas requires either the application of the dusting or spraying formulations under conditions where contamination of the product is physically impossible or the collection of data which show that the extent of contamination of the product by the technologically active ingredient is, or can be made, of negligible significance. It has been assumed that when sprays or dusts are used for controlling leaf diseases the major sources of contamination in the field will be (*a*) drifting at the time of application, (*b*) rain-borne contamination arising through water washing down the trunks and (*c*) wind-borne contamination arising through wind, usually with rain, blowing the particles from point to point after application. On the basis of these assumptions, the first criteria mentioned above, namely, application of the fungicide under conditions where contamination is physically impossible, can probably be met either by the employment of, say, voluminous mackintosh-type rainguards which protect appropriate areas of the tree, or by the application of the fungicide at periods when the areas to be treated are out of production. It is now known[3] that rainguards which probably minimize only contamination arising through rain washing down the trunks are not invariably sufficiently effective, and detailed information on mackintosh type rainguards is not yet available.

In the absence of protective devices which preclude the possibility of contamination by the technologically active ingredients of fungicides, the actual and permissible extent of contamination must be considered in detail for each fungicide. However, with the exception of a reference by Petch[4] to a brief experiment with Bordeaux mixture, this Institute is aware of very little published information on the actual extent of contamination found under commercial conditions with fungicides employed against leaf diseases of *Hevea brasiliensis*.

In the case of fungicides based upon copper the permissible extent of contamination must at present generally be regarded as defined by the type descriptions of the Rubber Manufacturers' Association of New York Inc., which contain a clause limiting the total copper content to 8 p.p.m. The corresponding figure for manganese is 10 p.p.m.

Clearly, detailed information on the extent of contamination of processed natural rubber samples by the technologically active ingredient of one type of fungicide is only of value as an indication of the extent of contamination with other fungicides if (*a*) reasonable allowance is made for factors such as the relative proportions of the technologically active ingredients and the presence or absence of sticking and wetting agents, etc., and if (*b*) the annual differences in the climatic conditions of the particular areas involved can be largely ignored. Subject to these and certain other provisos, the information published, or to be published, elsewhere[3,5,6] on the copper content of samples of processed natural rubbers collected over the period 1955–57 from small experimental areas and from areas on commercial plantations which have been dusted with formulations containing 0–6 per cent copper at the rate of 8–16 lb. per acre per round can be tentatively generalized as follows. First, under climatic conditions similar to those found during the Ceylon low country '*Phytophthora* season', fungicides containing an ingredient which becomes of adverse technological significance when present in natural rubber at a concentration of the order of 8–10 p.p.m. should apparently only be used, against leaf diseases of mature *Hevea brasiliensis* in tapping, with very strict care at all stages in the field and in the plantation's factory even when the dusting formulation contains preferably no more than 1 per cent of the technologically active ingredient. Dusts containing 4 per cent of the technologically active ingredient can probably be employed; but the probability that certain batches of the final product may have to be rejected or be submitted to special processes in the plantation's factory appears to be increased. Secondly, in a similar manner it may be reasonable to suggest that where the care which would be taken on the plantation to minimize contamination or the effects of contamination is of an appreciably lower order, 1 or 4 per cent dusting formulations would probably be practicable, provided the relevant ingredient is not of adverse technological significance when present in natural rubber at concentrations below about 25 p.p.m. Thirdly, where the care on the plantation is of a distinctly low order the relevant concentration figure at which significant adverse technological effects are noted should probably be not less than about 220 p.p.m. A further point at present of only local practical interest is that although this Institute at present suggests[2] copper for the control of defoliation due to *Phytophthora palmivora*, it would obviously prefer to use an alternative effective fungicide which does not have a significant undesirable technological effect below a concentration of about 220 p.p.m. in natural rubber and to use this fungicide with the care required for an '8 p.p.m. fungicide' or a '25 p.p.m. fungicide'. The application of the general principle, that considerable care may be needed over the choice and utilization of fungicides for plantation crops, to the control of panel diseases of *Hevea brasiliensis* is also under examination.

I wish to thank the Administration of this Institute for permission to publish this communication.

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Selection for an Invariant Character—'Vibrissa Number'—in the House Mouse

Waddington[1] has described selection experiments in *Drosophila* in which acquired characters were 'assimilated' by the genotype. This communication describes the initial results of a mouse experiment of similar design.

The character, 'vibrissa number', was scored by addition of the number of vibrissæ in the five minor groups found on the head and forelimbs of the mouse —a total of 19 'vibrissæ'[2]. Inbred lines *Aw*101 and *CBA* showed no variation in 'vibrissa number' and it was decided to use a parent stock based on these two lines in an attempt to break down the invariant vibrissa development. If this could be done it should be possible to breed mice with more or less than 19 vibrissæ.

Since it is possible for vibrissæ to fall out or be eaten, the best evidence of a real change must, at

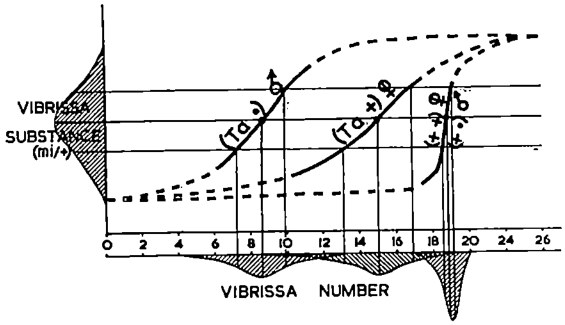

Fig. 1. Diagram illustrating the possible relationship between the genetic system determining the initiation of vibrissæ (*mi* − + genes); and the variation of vibrissa number in the (Ta − +) genotypes

least in the early stages, be looked for in the high selection line, that is, an increase of 'vibrissa number' is more convincing than a decrease. However, in an examination of 6,000 mice involving 14 strains, the post-orbital vibrissa was invariably present. Therefore, if there is loss of post-orbitals in the low line this can be taken as critical.

In order to produce phenotypic variance in 'vibrissa number', the sex-linked, semi-dominant gene Tabby (*Ta*) (Falconer, 1953) was crossed into the selection stock. Three frequency distributions are shown below the abscissa of Fig. 1. From right to left they refer to the 'vibrissa number' in (*a*) wild-type mice [(+ +) or (+ ·)], (*b*) (*T a* +) females and (*c*) (*Ta* ·) males. High and low lines were established by selecting within this uncovered variance.

Selection was applied both to (*Ta*+) females and (*Ta*·) males using consecutive matings of the form:

1. (+ +) female × (*Ta*·) male
2. (*Ta*+) female × (+ ·) male

The assumption was made that the same modifying genes influence both (*Ta*+) and (*Ta*·) scores. The changes in (*Ta*+) score support this as the two selection lines have been separated by three standard deviations in four generations.

Wild-type mice with low 'vibrissa number' became frequent in generations 5 and 6 of the low selection line and four of these mice had no post-orbital vibrissa. In generation 6, four mice with increased 'vibrissa number' appeared in the high line. Three of these mice had an extra supra-orbital vibrissa and one, 4 inter-ramal vibrissæ.

These results show, first, that there is genetic variation in vibrissa development which is not apparent in the absence of *Ta*. Using Waddington's terminology, vibrissa development is 'canalized'. Secondly, by selecting the variation which is apparent when *Ta* is present it has been possible to produce wild-type mice with both more and less than the standard number of vibrissæ. Although the genetic basis of these changes is unknown, it seems reasonable to suggest that the polygenic system controlling vibrissa development has been altered by selection.

It is possible to explain the absence of phenotypic variability in wild-type mice, despite the presence of genetic variability, by supposing a sigmoid relationship between the genetic actions and their phenotypic effects. If we assume a genetic system determining the form of this sigmoid relationship which is independent of the genetic system determining the initiation of vibrissæ, then it is possible to explain these results in terms of (*a*) the *Ta*/+ genes affecting the form of the sigmoid relationship and (*b*) a genetic system (*mi*/+) determining the initiation of vibrissæ. This is shown in Fig. 1, which demonstrates the parallel changes in 'vibrissa number' which occur when selection is applied within the Tabby genotype.

These results illustrate a function of major gene mutations in evolution, that is, to break down developmental homeostasis and so expose concealed genetic variation to natural selection.

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Chromosome Variation in the *Heleocharis palustris-uniglumis* Complex

The *Heleocharis* (*Eleocharis*) *palustris-uniglumis* complex shows a considerable variation in chromosome number, the following figures being recorded in the literature: $2n = 10, 16, 32, 36, 38, 46$, *c.* 69, 92[1]. The taxonomical implications of this variation is under discussion[2–4], but no definite conclusions have been reached. It was felt that more information about the chromosome variation was needed before definite conclusions as to the taxonomical status of the different chromosome types could be drawn.

Counts of 158 specimens, mainly collected in Denmark and Sweden, gave the chromosome numbers indicated in Table 1.

Table 1. Chromosome Numbers of 158 *Heleocharis* Plants

$2n$	16	38	39	40	42	44	46	47	48	49	51
No. of plants	2	66	21	4	8	1	42	2	9	2	1

The taxonomical investigation of this material by Prof. Th. Sørensen is now in progress. Most of the plants with $2n = 38$ correspond to *H. palustris* (L.) R. et S., whereas the 46-chromosome type corresponds to *H. uniglumis* (Link) Schult. Plants with 38–46 chromosomes and those with more than 46 are more or less intermediate between *H. palustris* and *H. uniglumis*. They are all fertile, though some of them have a reduced fertility. It should be emphasized that the plants counted do not represent random samples from natural populations because intermediate types were deliberately selected for chromosome counting. These results suggest that '*H. palustris*' and '*H. uniglumis*' represent two semi-isolated entities. Hybridization takes place in Nature, and where *H. uniglumis* and *H. palustris* grow together the populations comprise both the two pure types with 38 and 46 chromosomes respectively, F_1 hybrids with 42 chromosomes and various back-cross or F_2, F_3 . . . karyotypes. Hence the *H. palustris–uniglumis* complex represents another case of introgression in the sense of E. Anderson[5]. The 16-chromosome type which is rare in Scandinavia but is the only type found in Greenland[4] and which is also common in southern Europe is probably completely isolated from the 38- and 46-chromosome types and should most likely be considered a separate species. It is undoubtedly split up in a number of subspecies[4]. The final decision as to the taxonomical status of the 38-chromosome '*palustris*'-type and the 46-chromosome '*uniglumis*'-type must await further morphological, cytological, and genetical investigations. The 10-chromosome type of Russian origin probably belongs to a different species. The plants of British origin with 92 and 69 chromosomes respectively which are referred to *H. uniglumis*[6] have not been found in Scandinavia. They may represent natural tetraploids and triploids respectively of this species or they may belong to a separate species. There is a conspicuous difference in chromosome morphology between *Heleocharis* and *Scirpus* species (which is one argument against merging the two genera into one). *Heleocharis* species have rather long chromosomes whereas *Scirpus* species have very tiny ones. Several *Scirpus* species have very high chromosome numbers (100 or more) and it would be interesting to know the chromosome morphology of the British 92-chromosome *H. uniglumis* type which was counted by Hartshorne (unpublished, ref. 1).

This work was supported by a grant from the Carlsberg Foundation.

LISE H. SAUNTE

Institute of Genetics,
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Decision-making and the Communication of Information in an Industrial Setting

THIS communication is concerned with structural or organizational variables which may affect the transmission of information. It deals with a study which was made of variations in the communication patterns of four light engineering factories carrying out the same work. The communication structures in these factories were considered from the point of view of the individuals whose work required them to make decisions or estimates from production information available to them.

'Decision' in this context refers to daily operational judgments which are similar and recurrent, the effectiveness of which appears particularly dependent upon a knowledge of the outcome of previous judgments made earlier in the series. The particular decision discussed here concerns the estimate of delivery—the length of time which it is judged will be taken to complete a customer's order. Accurate delivery was especially important in the four firms studied since they were supplying components to customers who were also manufacturers with delivery dates to fulfil.

The way in which delivery time was estimated differed in the four factories. In *W* and *X* it was carried out by works estimators on the shop floor who were also responsible for maintaining their estimates. In *Y* and *Z* estimating was the function of office staff, physically isolated from the works. Fulfilment of the estimate was here the responsibility of works personnel, themselves isolated from the estimating process.

In order to assess whether variations existed in the ability of the four estimators to judge accurately, estimated and actual delivery times were compared in each of the four firms for all orders received during the same period of four weeks. In making the comparison error was measured in terms of the number of days by which fulfilment of an order exceeded or fell short of the estimated time. The range of error for each firm and a condensed distribution of items within this range are given in Table 1.

Table 1

	Estimates		Range of error	Percentage frequency of error (+ and −)				
	No.	Range		0–9 days	10–19 days	20–39 days	39+ days	
W	663	2–170	−214 to + 78	42	18	22	18	100
X	338	2–185	−197 to + 74	26	24	29	21	100
Y	540	3–205	−187 to +149	23	22	26	29	100
Z	461	3–256	−198 to +115	19	15	30	36	100

A more refined firm-by-firm comparison yielded the ranking *W*, *X*, *Y*, *Z* in order of accuracy of delivery estimating.

It is not sufficient to attribute this greater accuracy in *W* and *X* to the fact that estimators in these firms were responsible for their estimates and so 'allowed themselves longer', since their performance was superior whether the error taken into account was that of over- or under-estimation. A more reasonable explanation may be put forward in informational terms. Their position in the communication structure appeared to allow to estimators in *W* and *X* a direct, continuous and fairly immediate knowledge of the outcome of their estimates. Direct knowledge of results was available through their daily association with the manufacturing side of the business. In the case of *Y* and *Z*, any knowledge of results which existed appeared at best to be indirect, intermittent and retrospective.

This example illustrates one way in which the position of an estimator in a communication net may increase or reduce the likelihood of error in his estimates. It suggests that closer attention to structural variables and manipulation of the way in which a communication system is organized may help to reduce error commonly ascribed to unforseeable circumstances and uncontrollable factors.

The research to which this communication refers was sponsored by the Department of Scientific and Industrial Research and the Medical Research Council Joint Committee on Human Relations in Industry, and financed from Counterpart Funds derived from United States Economic Aid. A report has been submitted to the Committee. I am indebted to Mr. J. W. Whitfield under whose direction the work was carried out.

R. SERGEAN

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Industrial Psychology Research Group,
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Feb. 4.

FORTHCOMING EVENTS

Wednesday, April 9

Oliver Bird Trust and the Society for the Study of Fertility (in the Lecture Hall, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5 p.m.—Dr. Gregory Pincus: "Fertility Control with Oral Medication" (Second Oliver Bird Lecture).

Institution of Electrical Engineers, Radio and Telecommunication Section (at Savoy Place, London, W.C.2), at 5.30 p.m. —Informal Evening on "U.H.F. Test Transmissions".

Institution of Mechanical Engineers, Steam Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Combined Nuclear/Fossil Fuel Cycle".

Society of Chemical Industry, Food Group—Nutrition Panel (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Annual General Meeting, followed by the Fourth Meeting on "Some Nutritional and Allied Problems Confronting the Food Manufacturer". Dr. M. Ingram: "Technological Aspects of Chemical Preservatives"; Dr. J. M. Barnes: "Biochemical and Pharmacological Aspects of Chemical Preservatives".

Wednesday, April 9—Friday, April 11

Institute of Physics, Education Group (joint meeting with the UTH Western Branch, at the University, Bristol)—Conference "The Teaching of Science in Schools".

Thursday, April 10

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. A. Ratcliffe, O.B.E., F.R.S.: "Radio Observations on Artificial Satellites".

Société des Ingénieurs Civils de France, British Section (joint meeting with the Institute of Fuel, at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—M. André Blanchard: "Lacq: Its Problems and Potentialities".

Society of Chemical Industry, Microbiology Group (at Queen Elizabeth College, Campden Hill Road, London, W.8), at 6 p.m.—Annual General Meeting, followed by Dr. E. F. Gale, F.R.S.: "Nucleic Acids, What, Where, Why".

Royal Photographic Society (at 16 Princes Gate, London, S.W.7), at 7 p.m.—Mr. D. Causley: "Electronic Control in Photographic Printing".

Friday, April 11

British Psychological Society, Industrial Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. Robert H. Guest: "Behavioural Effects of Managerial Change".

Institution of Electrical Engineers, London Graduate and Student Section (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. R. Carruthers: "The Engineering Aspects of the British Controlled Thermonuclear Reaction Experiments".

Saturday, April 12

South-Eastern Union of Scientific Societies (at the House of the Zoological Society of London, Regent's Park, London, N.W.1), at 10 a.m.—Conference on "Conservation of Nature in South-East England".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer in Inorganic Chemistry; and a Lecturer in Organic Chemistry—The Registrar, Hatfield Technical College, Hatfield, Herts (April 10).

Senior Lecturer (with a good honours degree or higher degree in chemistry and experience in industry, teaching and/or research) in Chemistry—The Principal, Wigan and District Mining and Technical College, Wigan (April 11).

Assistant Lecturer in Philosophy—The Registrar, The University, Leicester (April 12).

Lecturer (with an honours degree in botany with subsidiary qualifications in zoology, and teaching experience) in Botany—The Principal, Derby and District College of Technology, Normanton Road, Derby (April 12).

Principal (with high academic qualifications, and good teaching and industrial experience)—The Clerk to the Governors, North Staffordshire Technical College, P.O. Box No. 23, Town Hall, Hanley, Stoke-on-Trent (April 12).

Senior Lecturer in Mathematics—The Secretary, Royal College of Science and Technology, Glasgow (April 14).

Lecturer in Aesthetic Philosophy—The Secretary of University Court, The University, Glasgow (April 15).

Assistant Lecturer in Mathematical Statistics—The Registrar, The University, Manchester 13 (April 18).

Imperial Chemical Industries Research Fellows in Biochemistry, Chemistry, Engineering, Pharmacology or Physics —The Secretary, The University, Aberdeen (April 18).

Assistant Lecturer (with special interests or training in experimental and statistical psychology) in Psychology—The Registrar, The University, Manchester 13 (April 19).

Deputy Librarian (with a good honours degree and experience in a university or similar academic library, and preferably professional library qualifications)—The Secretary, University College, Gower Street, London, W.C.1 (April 19).

Lecturer (with a special interest in plant biochemistry. microbiology or associate fields) in Botany—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 25).

Assistant in Mathematics—The Secretary of University Court, The University, Glasgow (April 26).

Research Fellow in Mathematics—The Secretary of University Court, The University, Glasgow (April 26).

Assistant Lecturer (with a special interest in some aspect of vertebrate zoology) in Zoology—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (April 30).

Forest Entomologist (with a postgraduate degree in entomology, and preferably experience in forest entomology) in the Department of Entomology, Waite Agricultural Research Institute (University of Adelaide)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

Junior Lecturer in Petrology; and a Junior Lecturer in Zoology—The Registrar, Trinity College, Dublin (April 30).

Lecturer (preferably with experience in electronics and instrumentation for automatic control) in Electrical Engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 30).

Lecturers (preferably with a special interest in thermodynamics) in Mechanical Engineering—The Secretary of University Court, The University, Glasgow (April 30).

English Electric Research Fellow in Aeronautics, for postgraduate research into the problems of vibration or stability and control of aircraft—The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks (May 1).

Lecturer in Chemistry—The Secretary, Durham Colleges in the University of Durham, 38 North Bailey, Durham (May 1).

Reader in Mechanical Engineering at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 1).

Reader in the History of Philosophy at the London School of Economics and Political Science—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 2).

Assistant Keeper in the Department of Geology—The Secretary, National Museum of Wales, Cardiff (May 14).

Assistant Lecturer (Demonstrator) in Anatomy, to undertake teaching and research—The Secretary, University College, Gower Street, London, W.C.1 (May 15).

Computer (preferably woman graduate) in the Mathematics Department—The Assistant Secretary, University College, Gower Street, London, W.C.1.

Electrical or Mechanical Engineer in the Department of Physics, to form part of a research team developing a linear accelerator for nuclear physics research—Prof. S. Devons, The University, Oxford Road, Manchester 13.

Fisheries Research Officer (with an honours degree in biology with emphasis on zoology; appropriate knowledge of chemistry and of statistical methods; and the ability to read French and possibly German) with the Federation of Nigeria, to undertake research into pond culture of local species of fish and into the chemistry and plankton populations of fish ponds to ensure the most profitable use of available nutrients, foodstuffs and fertilizers—The Director of Recruitment, Colonial Office, London, S.W.1, quoting Ref. BCD.65/14/01.

Head (graduate with good industrial and teaching experience) of the Department of Mechanical Engineering (Grade III)—The Principal, City of Bath Technical College, Lower Borough Walls, Bath.

Head of the Feeding and Metabolism Department—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 58/8.

Lecturer in Geography, and a Lecturer in Mathematics—The Warden, Goldsmiths' College (University of London), New Cross, London, S.E.14.

Lecturer or Assistant Lecturer in Inorganic Chemistry—Prof. G. Wilkinson, Imperial College, London, S.W.7.

Lecturer (preferably with teaching experience and a special interest in biochemistry) in Physiology—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

Lecturer (with a suitable degree and industrial research experience) in Metallurgy—The Deputy Registrar, The University, Birmingham 15.

Lecturer (with some industrial research experience, and preferably teaching experience) in Physics—The Principal, Royal Technical College, Salford 5.

Lecturers and Assistant Lecturers in Electrical Instruments, Telecommunications, Applied Electronics and General Electrical Engineering—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

Master (well qualified) to teach Chemistry—The Headmaster, School House, Berkhamsted, Herts.

Physicist (Scientific or Experimental Officer grade), to develop heavy particle detectors and undertake fundamental research as a member of a team studying charged particle reactions using a 50-MeV. proton linear accelerator—The Recruitment Officer (1047Y/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Plant Pathologists (with some postgraduate experience), to investigate diseases of cotton in Africa—The Secretary, Empire Cotton-Growing Corporation, 12 Chantrey House, Eccleston Street, London, S.W.1.

Senior Pathological Technician (male or female)—The Secretary, Wembley Hospital, Wembley, Middlesex.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Report of The Nature Conservancy for the year ended 30th September 1957. Pp. v+99+13 plates. (London: H.M. Stationery Office, 1957.) 5*s*. net. [71

Colonial Office. Colonial Research, 1956–1957: Reports of the Colonial Research Council; Committee for Colonial Agricultural, Animal Health, and Forestry Research; Colonial Economic Research Committee; Colonial Fisheries Advisory Committee; Colonial Medical Research Committee; Colonial Pesticides Research Committee; Colonial Products Council; Colonial Road Research Committee; Colonial Social Science Research Council; Tsetse Fly and Trypanosomiasis Committee; Director, Anti-Locust Research Centre; and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. Pp. 322. (Cmnd. 321.) (London: H.M. Stationery Office, 1957.) 11*s*. net. [71

Ministry of Labour and National Service. Report for the year 1956. Pp. vii+161+8 plates. (Cmnd. 242.) (London: H.M. Stationery Office, 1957.) 6*s*. net. [71

University of Hull. Third Report of Council and Report of Senate for the academic year 1st October 1956 to 30th September 1957, and Accounts for the year 1st August 1956 to 31st July 1957. Pp. 69. (Hull: The University, 1957.) [71

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IONS OF THE TRANSITION ELEMENTS

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The Discussion will be divided into two main sections:

I. Optical and Magnetic Properties.
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It is proposed to exclude rare earth and transuranium elements and to concentrate on those aspects where the physical and chemical aspects of the subject come together.

Anyone wishing to contribute a paper should write to the Secretary, enclosing a brief summary, as soon as possible.

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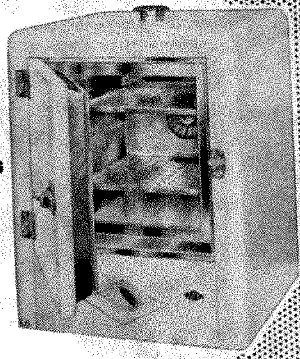

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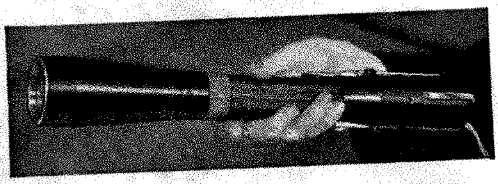

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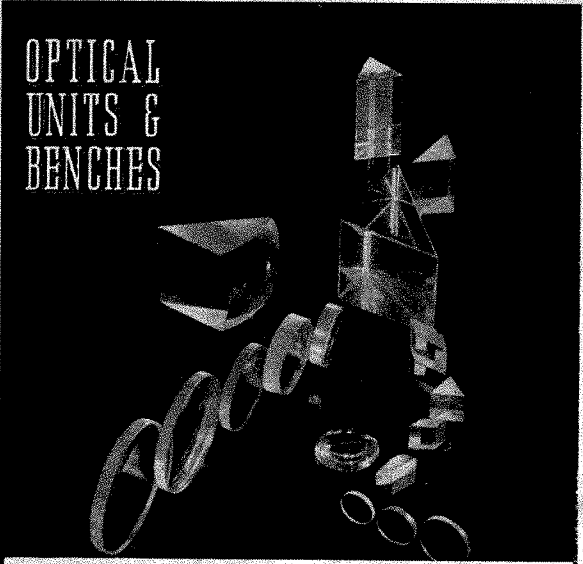

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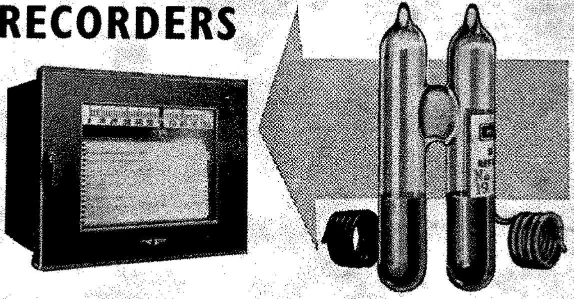

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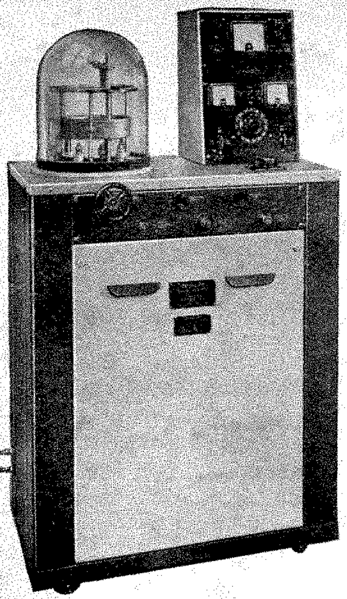

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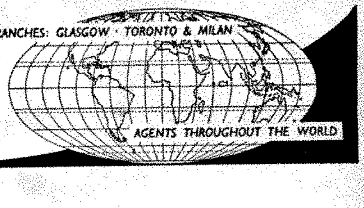
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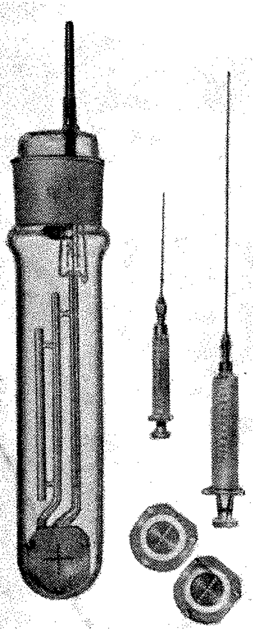

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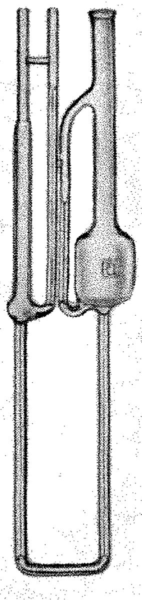

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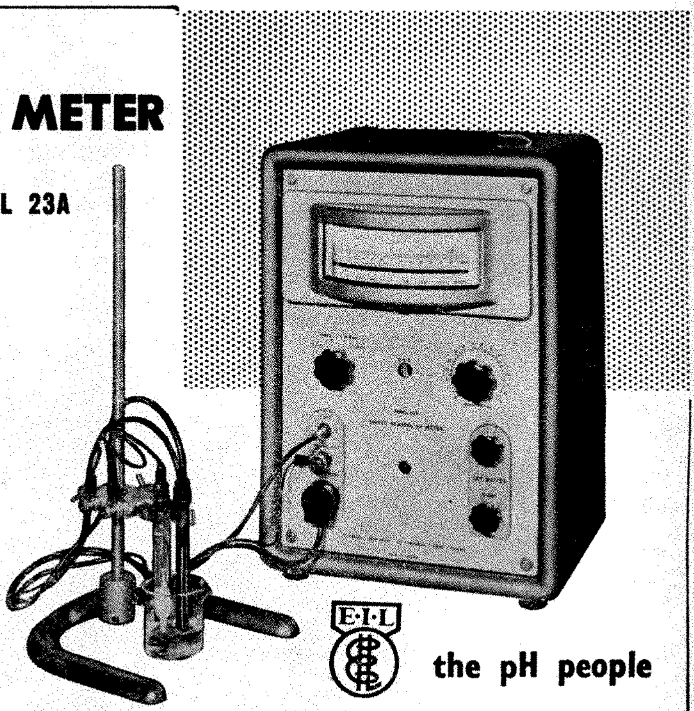

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INDUSTRIAL HEALTH PROBLEMS IN THE USE OF NUCLEAR ENERGY

THE second of the Committees of Inquiry set up under the chairmanship of Sir Alexander Fleck following the accident to Windscale Pile No. 1 on October 10, 1957, was "to review the organization within the Atomic Energy Authority as a whole for control of health and safety and to make recommendations"; a survey of the report appears on p. 1043 of this issue. The Committee appointed to examine the organization and staffing of parts of the Authority has already reported and attributed the accident primarily to an insufficiency of senior technical staff in the Operations Branch. The strengthening of this Branch was regarded as a first essential even if it involved some curtailment of developments elsewhere. Understaffing is also the primary trouble revealed by the examination of the Authority's organization for control of health and safety*. The Committee is satisfied there are no fundamental weaknesses, but is concerned to note that the acute shortage of expert health and safety staff means that the planned organization is seriously under strength in the higher posts. The health and safety organization is called upon to perform a wide variety of duties, both internally and externally, many of which require expert qualifications in more than one of the fields of medicine, radiology, health, physics, mathematics, nuclear physics or nuclear engineering. The review revealed an acute shortage of people possessing the requisite qualifications; throughout the Authority there were only about ninety people possessing honours degrees or equivalent qualifications who were engaged full-time on the control of health and safety.

Nor is it simply that these people are seriously over-burdened, with the result that the safety officers at Windscale had had little exact guidance about the amount of radioactivity that could safely be allowed to accumulate in the area. With the development of the nuclear power programme and the increasing use of radioactive materials in medicine, agriculture and many parts of industry, the demand for specialist health and safety staff will increase still further. That much is attested by the annual report† of the Chief Inspector of Factories for 1956 (see p. 1043 of this issue), which followed that of the Fleck Committee. Not only is the question of safety in nuclear power stations one of the four main topics which Sir George Barnett selects for discussion in this, his last, report, but also elsewhere in the report the use of ionizing radiations in industry is discussed at some length. What the Fleck Committee urges as to the desirability of making the field of health and safety provide an attractive career for those able to acquire the necessary expert knowledge, finds ample corroboration in Sir George Barnett's report.

For the Authority this would involve, the Committee points out, permitting greater flexibility in salaries, particularly for the specialist medical staff needed to head the integrated health and safety organizations in the works of the Industrial Group. More important still, the Fleck Committee considers that the Authority, as the vanguard of the nation's effort in nuclear energy, should assume responsibility for building up the supply of expert health and safety officers at all levels, from managers to the technicians who will be required in ever-increasing numbers by the electricity authorities and industry as well as by the Authority itself. The main instruction in the United Kingdom on the health and safety problems of nuclear energy has hitherto been given by the Authority as part of its courses in the Reactor and Isotope Schools at Harwell and the Reactor Operations School attached to Calder Hall. Factory inspectors are now taking short courses at Harwell to help them in inspecting industrial establishments where radioisotopes are in use.

This has covered only a small part of the field, and the Fleck Committee holds that more comprehensive instruction is needed. In view of the urgent need and the impact of the shortage on the Authority, the Committee recommends that the Authority should take the lead in this matter, by establishing a national training centre for health physics and nuclear safety staff (under the administration and general supervision of its Research Group) where courses should be graduated to suit all levels and cover not only problems of protection against radiation hazards, but also the health and safety aspects of the use of isotopes in medicine, agriculture and industry. In the medical field, the Authority should be prepared to recruit and to finance the specialized training of candidates who will be required for future management posts, and the Committee visualizes this specialized training as being worthy of recognition as a new professional qualification. Moreover, the Authority should also recruit and give training on the job to the medical staff required to provide the new type of medical service, as well as recruit and train a cadre of health physicists and nuclear safety experts commensurate with the future needs of the nation as a whole. It is recommended that Government departments should be directed to ensure that appropriate training in radiological problems is given to the public services and industries for which they are responsible

The Committee's specific recommendations regarding the Authority's internal responsibilities and organization are summarized elsewhere (see p. 1043 of this issue); but before considering the implications of the assumption by the Authority of such national responsibilities for leadership, the background against which these recommendations are made must be appreciated. The Committee was particularly conscious that the accident at Windscale brought to the surface the latent public anxiety about the hazards of nuclear energy. Now that the nation is committed to a large nuclear-power programme, the Committee holds, and rightly, that it is of the first importance that the hazards of nuclear energy should neither be exaggerated nor minimized in the public mind. The Authority has sought to err on the side of caution and, within the limits of existing knowledge, takes no chances. The Health and Safety Organization plays a major part in the Authority's affairs, and the Committee is satisfied that in general the Authority's policy has hitherto been governed by the considerations that operating procedures and codes of practice must not risk endangering workers or the public and, within the limits of human ingenuity, must be proof against human failure.

---

* Atomic Energy Office. Report of the Committee appointed by the Prime Minister to examine the Organisation for Control of Health and Safety in the United Kingdom Atomic Energy Authority. Pp. 28. (Cmnd. 342.) (London: H.M. Stationery Office, 1958.) 1s. 3d. net.

† Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories for the year 1956. Pp. 195. (Cmnd. 329.) (London: H.M. Stationery Office, 1958.) 9s. 6d. net.

Nevertheless, the Committee became aware that besides making good the deficiencies in the Authority's organization, there is urgent need to clarify the relations between the many Government departments concerned with health and safety in the field of nuclear energy and to strengthen the co-ordination between them. That is the reason for the recommendation that the Atomic Energy Authority should be built up to enable it to play the leading part and ensure that all necessary action is initiated in good time. Since the ultimate responsibility for assuring safety in relation to nuclear energy must be borne by the Government, it is of vital importance, the Committee urges, that this major improvement in organization should be made. Linked with it, of course, is the question of public confidence, and while the Committee endorses the arrangements for local liaison which the Authority has initiated, it recognizes that special care is required in public relations; and it therefore recommends that the Authority should review present procedures for publishing information about accidents, with the view of giving a prompt account of such occurrences in as much detail as may be appropriate. Moreover, apart from its bearing on health and safety, public confidence could be a decisive factor in the smooth implementation of the nuclear power programme.

The three most important implications of these recommendations are in respect of staff, of finance and of time, and all three are appropriately considered in the context of Sir George Barnett's valedictory report as chief inspector of factories. It will be recalled that even before the publication in October 1956 of the report on the staffing and organization of the factory inspectorate, the Minister of Labour had announced his decision to treble the size of the Engineering and Chemical Branch of the inspectorate, and to increase that of the general inspectorate by 26 posts. Nevertheless, at the end of 1956 Sir George Barnett reports that only 375 out of an authorized 439 posts were filled, and 25 inspectors were lost during the year, 17 by resignation. On February 5 the Minister of Labour, Mr. Iain MacLeod, said there were still 33 vacancies, though the number of inspectors had risen to 394 with 15 awaiting appointment, and there had been only 9 resignations in 1957. The present recruitment situation in the general inspectorate was not unsatisfactory, and it was hoped to fill the three vacancies in the Medical Branch from an open competition.

This position, as the White Paper on the Factory Inspectorate fully recognized, is related to the national shortage of scientists and technologists. Of this the Fleck Committee was no less cognisant; but none the less its argument that an adequate proportion of that scarce and limited man-power must be directed to this field, even at the cost of curtailment elsewhere, cannot be gainsaid. Moreover, in stressing the need for making the conditions and opportunities of service more attractive, it is again in harmony with the findings of the White Paper, and these steps could well further that greater esteem and understanding of the factory inspectorate's work which is so important for efficiency and recruitment. Taking a long view, that report was concerned not to advance unreasonable claims for expanding or even maintaining the factory inspectorate. On the contrary, it conceded the possibility, and even the probability, that with continuing improvements in the design and operation of factories and industrial processes, the cumulative effect of the work of the inspectorate would permit a substantial reduction in the resources of man-power devoted to factory inspection.

That almost certainly is the way in which the most efficient use of highly trained man-power is to be achieved and if, by emphasizing the opportunities for scientific work which careers in industrial health and safety offer, and ensuring that the conditions of service are appropriate, we can attract sufficient recruits of high ability, the purpose of industrial health and safety should itself be more effectively served than by reliance mainly or solely upon the inspectorate. For many years to come, the need for close co-operation will remain and there will be much, possibly even more than to-day, for the inspectorate to do; but it is in harmony with the whole trend of the Chief Inspector's report that such work should be done primarily and to the maximum degree from within industry.

That is only part of the picture. The Fleck Committee was not solely concerned with the supply of specialists of high qualifications and ability; it recognized the need for expert health and safety staff at all levels—from managers to technicians. There is a significant section in the chapter on accident prevention in Sir George Barnett's report which bears on this. In many sections of the Factories Acts and in some codes of special regulations made under the Acts, an employer is required to have certain duties carried out by a "competent person" or a "responsible person". These duties are very varied and include, among others, the detailed technical inspection, examination or testing of boilers and autoclaves, lifting machines and appliances, scaffolds, breathing apparatus and ventilating plant. This work plays a most important part in ensuring the safety and health of workers, but in general receives little public notice unless something goes wrong.

There are two points to be emphasized here. First, the adequacy and effectiveness of such work go far to determine both the effectiveness of the control exercised by the more highly qualified health and safety officers, and also the number of such officers required. In other words, it determines the most efficient and economical use of the most highly trained categories of scientists and technologists. Secondly, those carrying out such duties are themselves essentially specialists. Indeed, at one extreme they may require to be scientists or technologists possessing fundamental theoretical knowledge combined with sound practical experience of the kind of plant to be examined; and while other work may require less technical knowledge, good experience and sound judgment are invariably required.

We are thus once again touching an important facet of the problem of technical education, and it is obvious that if the full benefit of the recommendations of the Fleck Committee in the comparatively limited field of nuclear energy are to be realized, due attention must be given to the extension and improvement of technical education, as the Chief Inspector himself notes in a specific reference to the technical colleges. Where that reaches a sufficient standard, it is clear from the Chief Inspector's current report there is little cause of complaint, for example, in chemical works. Nevertheless, as the report insists, the work of the "competent person", however high his qualifications, must be integrated with that of the accident prevention organization as a whole; and meticulous care and close and harmonious relations between the different works departments concerned, the safety organization and the inspectorate are essential.

That, of course, means finance as well as manpower, and it is important to emphasize, at a time when the Government is pre-occupied with economy, that industrial health and safety involve expenditure. But wise investment in this way brings a return many times over in industrial efficiency, altogether apart from the elimination of human suffering and loss of life. A programme such as the Fleck Committee has outlined will involve the expenditure of considerable sums, which will have to be found, even at the cost of curtailing expenditure elsewhere.

Thirdly, there is the question of timing. The Fleck Committee rightly insists that action is urgently needed and cannot wisely or safely be postponed. The health and safety specialists, the safety organization and codes and the supporting technicians must be trained in advance, so that they are ready to take up their duties as soon as they are needed. Preparation cannot be deferred just because the new power stations are only being planned or under construction, still less because a time of national economy is inconvenient for incurring such expansion in expenditure. There could be no plainer warning to both major political parties to seek to agree on what sacrifices in non-essentials—even in the social services—it may be necessary to recommend to the country, to ensure that the health and safety of the workers concerned and of the nation as a whole are fully secured.

EVOLUTION AND ORGANIZATION

The Strategy of the Genes

A Discussion of Some Aspects of Theoretical Biology. By Prof. C. H. Waddington. With an Appendix by Dr. H. Kacser. Pp. ix+262. (London: George Allen and Unwin, Ltd., 1957.) 28*s.* net.

AMONG the more important of the advances that are at last really bringing us to grips with the relation between genetics and evolution is Waddington's experimental demonstration of the genetic assimilation of acquired characters, an apparently 'Lamarckian' phenomenon that needs no 'Lamarckian' explanation. In this book Waddington discusses the concepts that led to and arise from such experiments and considers some of their consequences. There is also a discussion by Kacser of models based on chemical kinetics that have relevant properties.

The most essential concept is that the processes of development are canalized so that the effects of disturbances are not random, but tend to be buffered or damped or otherwise compensated for by consequential effects that leave the resulting organisms 'organized'. From this basis, through a discussion of "the cybernetics of development" Waddington develops his model, the "epigenetic landscape", which pictures the probabilities that development will follow particular paths to given end-results. The contours of the landscape are determined by the genotype, and the process of development is represented by a ball rolling down the valleys.

This model provides a picture of the organization of developmental processes that aids discussion of the different properties of epigenetic systems and classification of selection "in relation to the type of effect which it produces". Canalized development may involve narrow valleys, or broad U-shaped valleys that permit minor modification by environmental or genetic variation. It may be flexible, alternative valleys being available into which the ball may be pushed, perhaps over a threshold, by environmental switches, and which lead the organism to different adapted forms; and it may be "noisy" in the sense that random sources of variation are inadequately buffered (represented by imperfections of the ball's surface). Selection in consequence may be not only progressive or directional, but also it may be stabilizing if it increases the canalization of the valleys (as opposed to normalizing if it reduces the variety of genotypes), and it may operate against "noise" so that homologous organs come to differ less. It may also be "disruptive" (Mather), though Waddington thinks, surely erroneously, that "this can be adequately regarded as a sub-type of the more usual unidirectional selection".

Such a model of developmental organization helps greatly the understanding of the effects we may expect different modes of selection to have. It is especially helpful in illustrating the way in which an environmental switch that pushes development over a threshold into an alternative path may aid selection of those genotypes which make the threshold lowest. Selection may thus produce a population in which the new path may be canalized by further selection until it becomes the norm even in the absence of the environmental switch. Waddington's discussions of these topics should interest all and stimulate many biologists.

But the model has its limitations. Waddington is aware of this; but nevertheless seems to push it too far in some respects. The model to some extent divorces genotype from environment and genes from other genes in a new way. Thus the landscape (Fig. 5) has its form determined by genotype, and an acquired character results if an environmental factor pushes the ball over a threshold into a valley not normally followed. "Organic selection" can then (Fig. 30) select a mutant allele that replaces the environmental switch, or "genetic assimilation" can change the landscape so that the threshold is removed. This seems to involve a distinction between landscape genes, ball-pushing genes and ball-smoothness genes (responsible for reducing developmental noise), though they are all landscape genes by definition. Thus noise genes "probably play relatively little part in evolution", though it seems impossible to see any difference in principle between them and canalizing genes which do.

It seems to be this tendency to push the model too far that leads Waddington to wonder speculatively at the origin of the ball-pushing mutants in his experiments, and he tentatively speculates whether the biochemical situation responsible for the landscape and altered by the environmental switch may not itself be responsible for the mutations. Here Waddington comes full circle and wonders whether the 'Lamarckian' phenomenon that he has demonstrated to need no 'Lamarckian' explanation does not need a 'Lamarckian' explanation after all. Now we must agree that mutation is often termed random very loosely, and that the class of viable mutations is clearly restricted to those to which the rest of the genotype is preadapted in the environment(s) in which the organisms must survive; and we must also keep an open mind concerning the possibility of genuine directed mutation. But it seems inappropriate to speculate whether directed mutation may be involved in particular experiments without first eliminating other more plausible hypotheses. Even if it were necessary to suppose that the mutant genes in Waddington's experimental populations have been produced by his experimental conditions, there is more than one plausible mechanism that does not involve directed mutation. In particular there is evidence that the stability of meiosis is easily disturbed, and therefore it is possible that selection may change the frequency and spectrum of recombination and thus increase the likelihood that particular recombinations with relevant effects may arise. Waddington admits that rare recombination and mutation may be hard to distinguish, but does not seem to see that this does not make the distinction any the less important.

This leads to the major criticism that must be made of this book. Throughout, the part played by linkage in maintaining the organization of development is belittled or ignored (as a consequence of which scant recognition is given to Mather's work). But in the face of evidence that genes of major effect are themselves linked complexes and that recombination can of itself give lethal effects, especially when the recombining chromosomes come from unrelated populations, it is impossible to believe that the organization of development does not involve the organization of genetic material into linked groups. To Waddington, the role of linkage is to be viewed in terms of the tactics of the genes; their strategy involves their part in the organization of development. But this is because he clearly regards the egg as the hen's means of making another hen, for he is discussing (preface) "biological organization and the developmental processes that *bring it into being*" (my italics). But "the hen is the egg's means of making another egg" is a re-statement of the same truth. More attention to the biological organization at the *beginning* of the developmental time-scale would improve this illuminating and stimulating discussion of the organized developmental processes that Waddington calls the epigenetic system. J. M. Thoday

THE WEALTH OF INDIA

The Wealth of India

A Dictionary of Indian Raw Materials and Industrial Products. Raw Materials, Vol. 4: F–G (with Index). Pp. xxviii+287+13 plates+viii. (New Delhi: Council of Scientific and Industrial Research, 1956.) n.p.

The fourth volume of "The Wealth of India" closely resembles its predecessors, that is to say, it is a scholarly production overflowing with up-to-date information. Unfortunately, much to the regret of the compilers, circumstances over which they have no control have resulted in an interval of nearly four years between the dates of issue of Vol. 3 and 4, and even now it has not been possible to include the obviously important article on "Fish and Fisheries". It is pleasing to note that those responsible are taking all possible steps to expedite the completion of the series.

It is difficult to compile information; it is still more difficult to decide what to leave out in order to satisfy the average reader who requires his information to be as concise as possible, especially when economic subjects are in question. The advisory board for the present publication realized this fully, and in 1943, before work was started, drew up a number of admirable directions for the editorial board. It is regrettable to find that many of these have now been ignored. The maximum length of a major contribution was not to exceed twenty-five pages of the book as now printed, and yet "Gossypium" covers eighty-two. This article, with its three beautiful coloured plates, 44 figures and 64 tables, occupies nearly one-third of the whole volume, and although difficult to compress, contains much which could be omitted with advantage. Photographs of 158 cotton samples distributed through 63 pages so that comparison is hindered seem unduly numerous; the table showing the properties of these fibres is much more informative. On the other hand, two excellent maps indicate so clearly the acreage and production of cotton and the spread of improved types that the corresponding tables appear unnecessary. Many of the tables are of interest only to specialists who might prefer to consult the original sources, reference to which is invariably given. Much space is taken up by detailed statistics for each main political division of India. This seems inappropriate in view of the almost complete absence of correlation between cotton growing and State boundaries. One table gives a number of analyses of black cotton soils differing widely in composition, but no indication of their value for growing cotton. The large amount of matter of secondary importance tends to obscure much that is interesting and informative, and it is suggested that in future all major articles should be preceded by a table of contents.

There is some tendency to give over-elaborate descriptions of products not well established in India although common in other countries. For example, the comprehensive article on soybean, admirably written, seems far more detailed than is required to show the importance of this commodity and the desirability of extending its cultivation in India. Many of the analyses given refer to material of foreign or unknown origin and are of little value, whereas comparative figures for Indian and foreign products, such as those given for fennel and tallow, often reveal striking and important differences. Production figures for cotton in tons, bales, maunds and candies do not conduce to clarity. Lastly, a few of the illustrations are of poor quality in marked contrast to the majority, and do nothing to elucidate the text.

The above remarks are not intended to disparage, but to convey a few impressions of an important and valuable book. To increase its value still more it is hoped that the practice of issuing provisional subject indexes will be continued and that they will be in even greater detail than that attached to Vol. 3.

H. E. WATSON

EAST AFRICAN MOUNTAIN FLORA

Afroalpine Vascular Plants

A Taxonomic Revision. By Olov Hedberg. (*Symbolae Botanicae Upsalienses* 15 : 1.) Pp. 411+12 plates. (Uppsala : A.-B. Lundequistska Bokhandeln, 1957.) 40 Kr.

SINCE the extraordinary vegetation of the African equatorial mountains was revealed during the latter part of last century, the problems of its relationships and the reasons for its occurrence have exercised the minds of botanists. In this region, where the chill of a rarified atmosphere tempers the heat of a tropical sun, and where there is little variation throughout the year in the length of day and night and in the range of temperature, the flora is of exceptional interest. Nowhere in the world are alpine landscapes so weirdly beautiful as on these mountains of East Africa. Each mountain group in its higher zones has an assemblage of species the nearest relatives of which do not occur at lower altitudes on the same mountain, but in the corresponding zones of neighbouring though totally isolated mountains. In the alpine regions there is some degree of endemism, but it is the vicarious species of genera such as *Lobelia*, *Senecio*, *Helichrysum* and *Alchemilla* that pose interesting problems in regard to common ancestry and comparatively rapid rates of evolutionary diversification on the various mountains. On the other hand, there are species which are common to some of these mountains and the north temperate region the isolation of which has not produced any significant morphological change.

The first attempt to consolidate and summarize knowledge on the flora of the tropical African mountains was Engler's work "Über die Hochgebirgsflora des tropischen Afrikas", which was published in 1892. Engler's material was very sparse and almost entirely confined to collections made on Kilimanjaro, the other mountain groups at that time being virtually unexplored botanically. In the present century there have been a number of well-organized expeditions to all the high mountains of East Africa and splendid collections have accumulated, especially at the British Museum, Kew and botanical institutions in Sweden. There was urgent need for a thorough taxonomic study of this unique dispersed flora and Dr. Hedberg's revision is a massive and authoritative *exposé* of the subject. His survey is rather arbitrarily confined to the species which occur in the alpine belt immediately above the heath forest. This has the merit of giving some definite topographical and ecological limits to the work and bringing the treatment of the material within manageable scope, though, with the exclusion of the ericaceous belt, and also the bamboo zone and the mountain forest, many of the most interesting elements in the flora are eliminated. The closeness of the links between the mountains is thus more obscure and the interesting intra-continental relationships with floras of West Africa, the Cape and the Mediterranean basin are unrecorded.

In his taxonomic analysis Dr. Hedberg has taken a tolerant and sensible view of the various taxa, particularly in his conclusions on the species which have a wide distribution in the north temperate zone. He has laid stress on resemblances rather than on differences and has thus resisted the modern tendency to recognize critical units.

The work is well produced with a judicious number of text figures and a supplement of habitat photographs of certain species. Altogether this account of the Afroalpine vegetation is one of the most significant and meritorious recent contributions to the study of the African flora.

G. TAYLOR

ECONOMIC THEORY

The Theory of General Static Equilibrium

By Prof. Eraldo Fossati. Edited by Prof. G. L. S. Shackle. Pp. xvi+247. (Oxford : Basil Blackwell, 1957.) 30*s.* net.

THE lectures on economics which Prof. E. Fossati gave when he was at the University of Trieste have been known at second hand by many economists in Britain, and by the few proficient in Italian in more detail through his "Elementi di economia razionale", first published in 1946. The volume now reviewed is an English version of the fourth edition (1954) of Prof. Fossati's text. It is not simply a translation, but rather a new edition by an outstanding English theoretical economist. Prof. G. L. S. Shackle explains in his foreword that he found the text in need of "re-expression in the forms of thought with which the English-speaking economist works". Consequently "this English version has been entirely written out in my own hand in phrases which are mostly of my own choosing".

The student of economic principles in Britain, brought up in the Marshallian tradition, tends to acquire a knack for improvization, to assume away the less immediately relevant interdependencies in his problem and to concentrate on those analyses which involve the view of the problem through time. He usually lacks the guidance which can be provided by Pareto's unifying concept of general static equilibrium. As Prof. Shackle points out, it is not generally possible to get him to read Pareto's "Manuel". The present version of a text by a brilliant successor and expositor of Pareto should redress the balance. It will certainly be welcomed by all teachers of courses in general economic principles and it should make a most valuable, if subsidiary, text to put in the hands of students.

The scope of the book is not quite as limited as the title might indicate. One of Prof. Fossati's contentions is that the theory of general static equilibrium is not only of importance in itself but also serves as "a powerful apparatus for dynamic analysis . . . by offering deep insight into the reaction of representative consumers and entrepreneurs to given situations . . . and through the process of model construction, it paves the way to econometric research" (author's preface, p. xii). There are chapters towards the end of the book, simple and even sketchy though they may be, which introduce the student to stability conditions, to money, risk and uncertainty, and to the stochastic approach in econometrics.

On the other hand, though Prof. Fossati has written with recent developments in economic theory in mind, the text remains a version of the scheme originally elaborated more than ten years ago. It cannot be expected, therefore, that the analysis is completely up to date, still less that it should emphasize those particular lines of thought most familiar to Anglo-American economists. Indeed, Keynes gets no more than one incidental mention and Leontief none at all; nor is the 'linear programming' school represented. In fact, following Pareto, the treatment is strictly confined to continuous analysis of the familiar marginal type, easily expressible in terms of the calculus.

The mathematics, it should be noted, are largely relegated to appendixes to the various chapters. The exposition is designed to be simple, clear and lucid, and it succeeds admirably. There are adequate lists of books and articles to assist the student in his further reading. R. G. D. Allen

LIPID BIOCHEMISTRY

The Lipids

Their Chemistry and Biochemistry. By Prof. Harry J. Deuel, Jr. Vol. 3: Biochemistry—Biosynthesis, Oxidation, Metabolism, and Nutritional Value. Pp. xxxvi+1065. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 25 dollars.

The late Prof. H. J. Deuel set himself to write a single treatise on the chemistry and biochemistry of lipids and with the appearance of this third volume his monumental task is complete. Volume 1 describes the chemistry of the lipids (*Nature*, **170**, 727; 1952) and Volume 2 deals with some aspects of their biochemistry: digestion, absorption, transport, and storage (*Nature*, **177**, 1050; 1956). The present volume covers other aspects of lipid biochemistry, in particular biosynthesis, oxidation, metabolism, and nutritional value.

After a brief introductory chapter, three chapters (266 pp.) are given to an account of the biosynthesis, oxidation, and metabolism of fatty acids, glycerol, and the triglycerides. Then come chapters on the oxidation and metabolism of phospholipids and their hydrolysis products (18 pp.), on the role of formic, acetic, and propionic acids in fat metabolism (38 pp.), and on the metabolism of branched-chain acids, hydroxy- and keto-acids, di- and tri-basic acids, acid amides, aldehydes, and hydrocarbons (70 pp.). There follows an account of the metabolism of cholesterol and related sterols (60 pp.), the carotenoids and vitamins A (200 pp.), vitamins D (62 pp.), vitamins E (68 pp.) and vitamins K (32 pp.), and the final chapters are devoted to the essential fatty acids (52 pp.) and the nutritional value of fats (99 pp.). The book has three indexes covering 130 pp. Each topic is covered in the same comprehensive and impartial manner which the author has displayed in earlier volumes. More than five thousand references are listed including several to publications in 1956, and only very few trivial errors have been noted in the text.

Prof. Deuel had prepared the text of this volume before his death in 1956, so that, although his colleagues and friends assisted in the later stages of publication, the book remains his. With its companion volumes it will long be a standard work in this field and a tribute to H. J. Deuel's zeal, industry, and enthusiasm. The text is prefaced by a biographical note about the author written by George R. Cowgill. F. D. Gunstone

ENGINEERING THERMODYNAMICS

Engineering Thermodynamics

Work and Heat Transfer. By G. F. C. Rogers and Y. R. Mayhew. Pp. x+619. (London: Longmans, Green and Co., Ltd., 1957.) 50*s*. net.

The authors have succeeded in providing the first English publication (rather than English republication of works by American authors) to give a rigorous treatment of fundamental and applied thermodynamics for the engineering student.

The first section discusses the principles of thermodynamics, and here the authors wisely follow the lines of Keenan's "Thermodynamics". They have amplified and added to Keenan's presentation. (For example, they discuss the statement of the second law for a control surface.) In general a simple lucid survey of basic thermodynamics is given, although in the discussion of the thermodynamic scale of temperature rigour has been sacrificed in the attempt to simplify the presentation.

A second section discusses "Application to Particular Fluids". Properties of fluids, non-flow and flow processes, power and refrigeration cycles, properties of mixtures and combustion processes are logically dealt with in a readable yet rigorous fashion. The section on feed heating is not as good as other parts of the book, the distinction between direct contact and surface heating not being adequately developed.

Components used in thermodynamic cycles are discussed in two sections on work and heat transfer. In their discussion of turbo-machinery, the authors point out the limitations of the so-called 'diagram efficiency' or utilization factor (in that the exhaust kinetic energy is used in most turbine stages). It is unfortunate that they do not develop definitions of turbine and compressor efficiency in terms of stagnation states, which are but briefly discussed in the section on isentropic flow.

It is pleasing to note that the heat transfer section is competently and thoroughly written.

If the division of the material into the four sections is somewhat artificial, if the book is a little too wordy and is slightly uneven (the omission of the subject of availability and the inclusion of detailed discussion of turbulent shear flows are examples of this), these are but very small criticisms in comparison with the fine overall achievement this book represents. The authors are to be congratulated on writing an excellent book, for student and teacher, and the publishers are to be congratulated on producing it at a reasonable price. J. H. Horlock

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Microdiffusion Analysis and Volumetric Error

By Prof. Edward J. Conway. Fourth revised edition. Pp. xviii+465. (London: Crosby Lockwood and Son, Ltd., 1957.) 42*s.* net.

ONE may speculate as to the extent to which microdiffusion analysis is practised, but there can be little doubt of the existence of a widespread interest in the subject. This fourth revised edition of Prof. Conway's book contains accounts of many new applications of microdiffusion analysis as well as enlarged and revised sections on the apparatus used and the principles involved. New methods described include determinations of blood ammonia, total nitrogen, using a mercury catalyst, glutamine, enzymes, including acetylcholinesterase, formaldehydogenic steroids, a group of volatile poisons, and organically bound halogens. A description is also given of the method of Burbridge, Hine and Schick (1950) for the determination of acetaldehyde in blood. It may be mentioned that recent work by Lundquist published since the appearance of the work under review throws doubt on the specificity of this method. Acetoacetate in the blood may, under the conditions of the analysis, give rise to amounts of acetone which interfere in the measurement.

Part 3 of the book, a section of about 100 pages, deals with volumetric error. An analysis of the errors of micro methods compared with macro volumetric methods reveals many of the reasons which make micro work a practical possibility.

The book is clearly written and well printed. It should be read not only by those who have an immediate interest in microdiffusion but also by all who use volumetric methods of any kind. Most of the text shows an intimate practical knowledge of the processes described and no analyst could fail to profit from a study of it. The author is not always orthodox in his opinions, but where controversial issues are raised, all the evidence and the opinions of others are clearly and fairly given. The book is well illustrated and has a good bibliography and index.

E. I. JOHNSON

Introduction to the Mechanics of Stellar Systems

By Rudolf Kurth. Pp. ix+174. (London and New York: Pergamon Press, 1957.) 55*s.* net.

THIS book is intended to serve as an introduction to the subject for advanced students. After a discussion of the observational data, chapters are devoted to the mechanics of systems of mass-points, stellar systems as assemblies of gravitating mass-points, stellar systems as gravitating continua, and statistical mechanics of stellar systems. The book as a whole is written from a refreshingly novel point of view, and there is relatively little overlap with other text-books on the subject. Especially noteworthy are the treatments of the recurrence theorem of Poincaré, the little-known theorems of Hopf, similarity transformations and Poisson's equation. Although a study of the book would be of considerable educational value to an advanced student, it would nevertheless give a very one-sided view of the subject without a supplementary study of its more practical aspects. The possibility that the observations of stellar motions in our own Galaxy should be interpreted not as properties of an almost stationary stellar system but as well-preserved evidence of initial conditions during the formation of the Galaxy suggests that much of the book may remain of academic interest only. The reviewer feels that the kinematical rather than the dynamical approach to the study of stellar systems may well prove to be more fertile for further development. Nevertheless, it is important to appreciate the achievements of the dynamical approach as well as its limitations, and this book serves as a useful aid to this end.

R. H. GARSTANG

Cytochemical Methods with Quantitative Aims

Biophysical and Biochemical Approaches. Proceedings of the Symposium held September 27–29, 1956, by the Institute for Medical Cell Research and Genetics, Karolinska Institutet, Stockholm, Sweden. Edited by Dr. B. Lindström and Dr. R. Brown. (Experimental Cell Research, Supplement 4.) Pp. viii+296. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 9.50 dollars.

THIS is a report of a conference held at the Karolinska Institute, Stockholm, in September 1956, which was sponsored by the Institute of Medical Cell Research and Genetics. It consists of twenty-seven papers on different aspects of quantitative cytochemical techniques, the majority of which are physical methods, based on optical, absorption and interference microscopy, and on X-ray techniques, which are taken to include quantitative autoradiography using radioactive tracers. These papers are a mine of information which will be invaluable to all workers in these fields. The chemical techniques are less exhaustively dealt with, but nevertheless some very useful discussions of the micro-determination of nucleic acids by a number of the workers in this field are included. These form a valuable addition to the information given in existing text-books. The supplement is quite reasonably priced and would form a useful addition to libraries which do not subscribe to the whole of *Experimental Cell Research.*

Introduction to Enzymology

By Alan H. Mehler. Pp. viii+425. (New York: Academic Press, Inc., 1957.) 10.80 dollars.

IN this book the author has provided an outline of the main metabolic pathways by a description of the individual enzymes and cofactors concerned. He has not attempted to provide a comprehensive review of each enzyme, with the result that rather arbitrary and sometimes inaccurate descriptions are given (for example, the section dealing with the general properties of flavins and flavoproteins ascribes a spurious ionization constant at *p*H 1·7 to flavins, and contains generalizations concerning the fluorescence, redox potentials and absorption spectra not justified by the experimental evidence available). As the book gives many references to recent publications, it is undoubtedly useful as a guide to current metabolic trends. It is difficult, however, to find any real justification for the title of "Introduction to Enzymology". Little or no discussion is devoted to the general properties and theoretical principles of enzymic catalysis; hence very few unifying hypotheses of the type valuable to a student are developed. To those people who have been awaiting publication of a book illustrating in detail the general principles of enzyme chemistry this work will therefore be disappointing. It can be recommended only as a reasonably up-to-date book on metabolism at the level of the individual enzymes. Contrary to its title, it should be of more use to the experienced investigator than to the beginner.

VINCENT MASSEY

THE BRITISH NORTH GREENLAND EXPEDITION, 1952–54

SCIENTIFIC RESULTS

By R. A. HAMILTON, O.B.E.

THE British North Greenland Expedition carried out a programme of research in Dronning Louise Land, north-east Greenland, and on the northern part of the inland ice. The scientific plans were outlined[1] before the departure of the expedition in July 1952 ; the purpose of this article is to summarize the scientific work which was carried out.

The expedition's bases were at Britannia Sø (77° 09′ N., 23° 36′ W., 229 m.) and at 'Northice' (78° 04′ N., 38° 29′ W., 2,343 m.) on the inland ice. Many journeys were made and one party made a traverse across the inland ice from Britannia Sø to the Thule district on the west coast. A general description[2] of the expedition by the leader, Commander C. J. W. Simpson, was given in a lecture to the Royal Geographical Society before Her Majesty the Queen, the expedition's patron.

Survey

An aerial survey of Dronning Louise Land had been carried out by the Geodetic Institute, Copenhagen, in 1950. Captain Hans Jensen, and after his death in an accident, Brooke[3], extended the triangulation of Germania Land which had been started by the *Danmark* Expedition and completely triangulated the whole of Dronning Louise Land. A map on the scale 1 to 250,000 is being produced by the Institute. A further aerial survey of north-east Dronning Louise Land was carried out by R.A.F. Coastal Command[4], and from this a more detailed map on the scale 1 to 50,000 has been constructed by Arnold[5].

During the traverse of the inland ice the altitude of the surface of the ice sheet was measured at intervals of about 4 km. by trigonometrical levelling[6]. Paterson and Slesser[7] have described the method of survey and estimated the standard error of the altitude of the higher stations to be 10 m.

Geology

The geologists Peacock and Wyllie made a geological reconnaissance of Dronning Louise Land and of southern Germania Land. Archæan gneisses unconformally overlain by what are believed to be representatives of the two Precambrian sedimentary groups of north and east Greenland were discovered in western Dronning Louise Land[8], separated by a structural break from Caledonian schists farther east[9]. Four metamorphic zones culminating in lower amphibolite facies have been tentatively outlined, including a broad zone of low-grade cataclastic metamorphism in the originally high-grade Archæan gneisses. In southern Germania Land, Wyllie discovered altogether higher-grade gneisses[10] which contain basic intercalations of considerable interest, and are intruded by granite in the eastern part of Saelsø. It is believed that Dronning Louise Land lies near or on the western boundary of the East Greenland Caledonian orogenic belt, and that much deeper Caledonian structures are exposed in southern Germania Land.

Meteorology

Meteorological observations were made by Hamilton and Rollitt at Britannia Sø and at 'Northice'. The 'Northice' observations have been published in full[11] and climatological summaries[12] have been made of the observations of both stations. The temperature gradient in the air one or two metres above the surface of the inland ice was determined both at 'Northice'[13] and on the traverse across the inland ice[14] by measurement of the optical index of refraction. By this method the errors caused by the diffusely reflected solar radiation on thermometers[15] are avoided.

A detailed study[16] of the synoptic meteorology of north Greenland in the midsummer period shows that the tendency for the glacial anticyclone to be established is disturbed by waves and depressions and their associated fronts which can be followed on the 700-mb. charts. A similar study of midwinter conditions is being made.

Measurements of humidity were made at Britannia Sø[17] by a lithium chloride hygrometer : the observations suggest that at low temperatures in calm weather in the dark winter, hoar frost is not deposited until the air is saturated with respect to water.

Visual observations of aurora were made at both stations, at the same time as the meteorological observations. The forms and brightness of the aurora were recorded, using the international classification ; the positions were also noted. The information was handed over to Mr. J. Paton, of the Department of Natural Philosophy, University of Edinburgh, and has been plotted on charts for each night covering the region bounded by geomagnetic latitudes 53° and 84° and geomagnetic longitudes 70° and 90° (English Channel to north Greenland). Brief analysis of these data indicates that the auroral frequency was greater than had been expected[18]. The data will be examined more fully when the collection of the information made during the solar cycle 1951–62 is complete.

Gravity

The value of gravity was determined at approximately three hundred points on the traverse of inland ice[19] with a standard error of less than 5 milligals. The results show that the Earth's crust, with its superimposed ice load, is approximately in a state of isostatic equilibrium. In the eastern part of the ice sheet, where direct determinations by seismic methods were not possible, ice thicknesses have been estimated from the values of gravity.

During the winter when the lake was frozen, Bull[20] developed a technique of measuring the depth of the lake by gravimetric methods and was able to construct a contour map of the lake bottom.

Glaciology

The expedition planned to measure the thickness of the ice sheet by seismic methods, but neither Cadd in the first year nor Bruce in the second year was able to detect reflexions from the ice – bedrock interface at any point between Dronning Louise Land and 'Northice', and it was not until shortly before the expedition was due to come back that an energy return was detected at a point farther west. Thereafter, strong reflexions were obtained west of a separating line[21] running approximately 330° through 77° N., 45° W., but no reflexions could be obtained east of it. In this region the bedrock is approximately 200 m. below sea-level. The seismograms indicate that the reflexion coefficient east of the separating line is less than one-hundredth of that at points west of it. Bull suggests that the phenomenon may be explained by assuming that the bottom of the ice is melting to the east of the separating line and that the thickness of ground moraine varies greatly across it. The altitudes of the seismic stations on the inland ice were computed[22] from the aneroid readings, by the use of meteorological upper-air charts, with an estimated error of 13 m.

In addition to measuring the altitudes of the stations on the gravity traverse, Paterson[6] also determined the surface slope of the ice sheet at a number of places. These enabled Bull[23] to calculate the shear stress on the bed from Nye's formula.. The values of shear stress in the east are lower than those in the west, and it is suggested that the difference may be due to bottom melting in the east.

At about thirty points on the gravity traverse the firn structure was examined. A Rammsonde was used for measuring the resistance to penetration which had been related to the density by a series of calibrating experiments[24] at 'Northice'. The soundings show that the mean annual accumulation for the period 1948–53 was about 13 gm./cm.^{2} and was almost constant along the gravity-traverse route, except near the coasts, where the accumulation is less, due, presumably, to increased abflation. Except near the coasts, the annual accumulation in the eastern part of the traverse for the period July 1953–July 1954 was approximately[25] 16 gm./cm.^{2}.

Beacons were erected on the inland ice and their positions, as well as the height of a mark above the snow surface, were accurately determined, so that if these are remeasured about twenty years later the mean movement of the ice sheet and the net accumulation during the period can be determined[26].

A pit dug to a depth of 14 m. at 'Northice' enabled the annual accumulation back to the year 1878 to be determined[27]. This decreased during the last part of the past century and continued to decrease to a minimum value in 1940, but has increased again in the past decade.

The regime of two glaciers in northern Dronning Louise Land was studied[27]. There was a net loss from their surfaces of less than 1 m. depth of water equivalent, most of which was compensated by flow from the inland ice. Measurements of the rate of flow indicate that it is 12–20 m. per year.

Lister and Taylor[28] studied the heat balance at the glacier surface. Of the total amount of heat which entered the glacier from above, the contributions due to radiation, condensation and eddy conductivity were 69, 2 and 29 per cent. The proportions of this total heat used in melting, evaporation and conduction into the ice were 54, 34 and 12 per cent. Similar micro-meteorological investigations were made by Lister at 'Northice', but the results have not yet been worked up.

As a result of his study of all the major glaciers of Dronning Louise Land, Wyllie[29] concludes that the decrease in the height of the inland ice and the consequent emergence of rock thresholds is the dominant factor in the final stages of glacial recession. Ice recession in the neighbourhood of Britannia Sø was studied in detail[30].

Physiology

Though the emphasis was on research in the geophysical sciences, a programme of physiological research had been drawn up by the Medical Research Council. A general account of the physiological and medical aspects of the expedition has been given by Lewis and Masterton[31]. Acclimatization to cold was the main line of research. Body-weights were measured weekly and have been compared[32] with comparable weights of intakes into the Regular Army. The annual increase of weight of the expedition members was greater than that of the soldiers and showed also a seasonal fluctuation with a maximum in the early spring. Measurements of fat thickness showed a close correlation with changes of body-weight[32]: the experiments indicated the need for simplification of the technique of measuring subcutaneous fat. The number of sites of the body was reduced from thirty-six to five[33], and subsequent work suggests that the subcutaneous fat at one site (namely, under the scapula) correlates extremely well with changes in body-weight[34].

The effect of seasonal light and darkness on the men's sleep was studied. It was found that although sleep was taken very irregularly, there was no seasonal variation in the number of hours slept in a month. The average sleep taken was just under 8 hr. per day, which may represent the natural biological demand[35].

The men's basal metabolic rate was measured fortnightly: the mean was almost identical with that given for men in Britain. The figures confirm that British means are substantially smaller than the American figures.

The physiological findings reflect the pattern of activity of the men rather than an effect of season *per se*; in any event, the body was shielded from the extremes of environment by clothes and shelter[36].

Measurements of the men's physical efficiency were made; but the results tend to be equivocal. Diurnal temperature measurements remained within normal limits and the blood cells were found to remain constant; there was no rise in the red cell count in men who were subjected to the 2,500 m. altitude of the inland ice. These findings indicate the great stability of many body systems in spite of great fluctuations in the external environment.

Research was also carried out in the nutritional field. By way of experiment, samples of biltong were taken for eating on journeys: its use stimulated a fuller investigation into its calorific value[37].

The observation that husky dogs eat human fæces prompted an investigation which revealed that the fæces did not contain excess fat[38]. This in turn suggested a full investigation of the calorie requirements of men sledging[39]. There were wide variations, from 4,000 to 5,500, with a mean of 4,800 calories a day. An estimate of energy expenditure tallies very closely with this figure, confirming that the food intake was just adequate.

This research has a two-fold significance. First, it has formed the nucleus of subsequent polar physiological programmes of Antarctic expeditions now in the field. The second feature is the fact that our figures show the sledging ration of 4,200 calories to be insufficient to maintain nutritional balance in the face of extremely hard work in the cold. The Medical Research Council reviewed the whole problem and advances in food technology packaging have been incorporated in prototypes now being tested in the polar regions[40].

On the biological side, the incidence of trichinosis in those dogs which were shot or died in the second year were studied. It was found that the infested dogs were among those which had been brought from west Greenland, where they have been accustomed to eating raw meat, while none of the puppies which had been born on the expedition were infested[41].

The insects which were collected in the Britannia Sø area and placed in the British Museum are all well-known members of the Arctic fauna of Greenland[42]. A botanical collection has been examined by Dr. A. Melderis at the European Herbarium of the British Museum, where the specimens are now lodged.

Small fish, an unusual variety of the Arctic char, *Salvelinus alpinus*, were taken from Britannia Sø and handed over to Mr. G. F. Friend, of the Department of Zoology, University of Edinburgh. These fish are undoubtedly descendants of migratory sea-char which once made their way up a river, into the lake, and established themselves there. Since then, they have been isolated for thousands of years perhaps, and have evolved their own peculiarities, some probably in response to their difficult life in high latitudes and sealed as they are for five-sixths of the year under thick ice. Their eyes, nostrils and lateral-line pores—all sense organs—are large for the size of such small fish. They have a starved and juvenile appearance, while their growth-rate is slower than that of any known race of char. A low, flattened cranial-roof and a 'turtle nose' are other striking features. These add much new material to the picture of the chars as a whole.

Except where stated above, the results of the research carried out in the field have now been worked up and the following list of publications may be regarded as the scientific results of the expedition.

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COLONIAL RESEARCH, 1956-57

FOLLOWING the pattern of the previous report, under the title "Colonial Research, 1956–57"[*], are collected the annual report of the Colonial Research Council, the twelfth annual reports of the Committee for Colonial Agricultural, Animal Health and Forestry Research and the Colonial Medical Research Committee, the tenth annual reports of the Colonial Economic Research Committee and the Colonial Pesticides Research Committee, the fourth annual report of the Colonial Products Council, the thirteenth annual report of the Colonial Social Science Research Council, the second annual report of the Colonial Road Research Committee, the annual reports of the Colonial Fisheries Advisory Committee on Fisheries Research, 1956–57, of the Tsetse Fly and Trypanosomiasis Committee, and of the director, Anti-Locust Research Centre. There is also a section on research matters not covered by the reports of the specialist advisory bodies, which deals with building and housing research, the Falkland Islands Dependencies

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[*] Colonial Office. Colonial Research, 1956–1957: Reports of the Colonial Research Council; Committee for Colonial Agricultural, Animal Health and Forestry Research; Colonial Economic Research Committee; Colonial Fisheries Advisory Committee; Colonial Medical Research Committee; Colonial Pesticides Research Committee; Colonial Products Council; Colonial Road Research Committee; Colonial Social Science Research Council; Tsetse Fly and Trypanosomiasis Committee; Director, Anti-Locust Research Centre; and Research Matters not covered by the above Reports of the Specialist Advisory Bodies. Pp. 322. (Cmnd. 321.) (London: H.M. Stationery Office, 1957.) 11*s*. net.

Survey (an outstanding feature of the work of which has been the air survey of 35,000 square miles conducted during the past two years by Huntings Aerosurveys), meteorology, industrial and engineering research, water-pollution research and geodetic, topographical and geological surveys. For the first time in many years, recruitment of surveyors and cartographical draughtsmen exceeded losses and the total staff on March 31, 1957, was 390, while the number of geologists, geophysicists and geochemists overseas, where geological surveys continued in twenty territories, rose to 211, although some vacancies remained unfilled.

Other than the fact that the work is concerned with problems arising in various overseas territories there is little in common between the several reports, nor is any general conspectus attempted even in that of the Colonial Research Council itself, other than the brief reference to Colonial Development and Welfare Schemes (a list of which is appended to the report). Expenditure on these schemes for the year ended March 31, 1957, was £1,538,412, compared with £1,374,323 in the previous year. A review of the whole field of Colonial research where Colonial Development and Welfare assistance is involved is being undertaken, and the Council will then consider the possible re-allocation of funds between the various fields to ensure that full use is made of remaining funds under the current Colonial Development and Welfare Act to fulfil the various programmes envisaged. Even this, however, gives no true measure of the effort in Colonial research which Britain is making. As the various reports demonstrate, this effort is interwoven with that made by the various overseas Governments themselves, and with that of British as well as Colonial universities, so that a complete assessment is difficult or impossible. Apart from the financial aspect, it represents an appreciable tax on British scientific and technical man-power which the universities and research institutions must be prepared to meet. During the year, thirty-four new appointments brought the complement of the Research Branch of the Overseas Civil Service in March 1957 to 189. In addition, two Research Fellows continued investigations on behalf of the Colonial territories, and fourteen research studentships were awarded.

The Committee for Colonial Agricultural, Animal Health and Forestry Research, which recommended grants totalling £925,921 during the year, still finds difficulty in securing suitable officers for senior posts, although recruitment of scientific staff for overseas duties was a little easier. To ensure closer co-ordination of work on control of pests and diseases, a special sub-committee, the Crop Protection Sub-Committee, was set up jointly with the Colonial Pesticides Research Committee. Under the Technical Aid Agreement, the Food and Agriculture Organization gave expert assistance for surveys of the Rufiji Basin in Tanganyika and the Accra Plain in Ghana, assisted Cyprus in controlling an outbreak of sheep-pox, and provided an expert for a survey of swamp soils in Sarawak. Acknowledgment is again made of the help received from research organizations and universities in the United Kingdom.

Much of the work of the Commonwealth Institute of Entomology is concerned with Colonial problems and 42 per cent of the Institute's identifications during the year were concerned with Colonial inquiries, notable help being given to a survey of forest pests in East Africa and to the investigation of premature nutfall of coconuts in the British Solomon Islands Protectorate. Very satisfactory progress has been achieved in Jamaica with soil surveys, the results of which are being utilized in land rehabilitation schemes in overcrowded areas, while studies on soil fertility are receiving very close attention in nearly all Colonial territories. There is good prospect of remedying the deficiency of major and minor plant nutrients which prevent good growth of crops over large areas of Africa south of the Sahara. The Herbarium of the Commonwealth Mycological Institute is collaborating with the West African Maize Research Unit in a statistical analysis of spore sizes in collections from different parts of the world, and a serious outbreak of leaf-curl disease in flue-cured tobacco in Nigeria led to a recommendation for an immediate preliminary survey of economic-crop diseases. An electronic computer was used in a theoretical investigation for the Tsetse Fly and Trypanosomiasis Committee into the effect of introducing sterilized males into a natural tsetse fly population.

It appears that research results are increasingly being applied in tropical agriculture. Extension of soil conservation measures with the concomitant practice of moisture conservation in areas of low or erratic rainfall has greatly improved farm conditions in Kenya, Swaziland, Uganda, Granada and Somaliland. The soil nutrient status has also become clearer with discoveries of deficiencies of major and trace elements in many parts of Africa, particularly of phosphorus, nitrogen, sulphur, boron and molybdenum. Maize breeding in Africa, particularly with strains from Mexico, has produced a series of high-yielding varieties highly resistant to tropical maize rust, while cocoa hybridization in the West Indies and West Africa has given new material of exceptional yield and early bearing. Organic weed-killers also figure prominently in research programmes: thus, in West Africa a programme to spray 700,000 acres against capsid has been approved, of which about 100,000 acres have been treated with power-sprayers, and about 20,000 hand-sprayers have already been sold to cocoa farmers. Considerable advances have been made in the control of pests and diseases of cotton, and practical and economic measures developed for controlling major insect pests of sorghum and other cereals. Much attention is being given to the prevention of damage by storage pests and valuable advances are being made in control or prevention, particularly with rice, cocoa and groundnuts.

The large regional research organizations have advanced fundamental knowledge of the role and importance of organic matter in tropical soils, the nitrogen and sulphur cycles and phosphate fixation. Advances in banana breeding are recorded in the West Indies and the examination and description of flora continued in East Africa, the Zambezi Basin, Cyprus, Malaya, Tropical West Africa, Jamaica and Trinidad. Particular attention was given to the co-ordination of research and the prompt exchange of information between workers in allied fields. In forestry the cultivation in plantations of the valuable African timber tree, mvule (*Chlorophora excelsa*), was specially examined in collaboration with the Imperial Forestry Institute. Work on hormonal arboricides has established their use in eliminating weed trees when making improvement fellings, and notable success has attended species trials on tropical pines in Central Africa and the Caribbean, and work on ambrosia beetles in West Africa has led to the adoption of practical measures of control. While attention to animal breeding led to no spectacular results, stock of better quality is continually becoming available and progress in vaccine production and other biological products has permitted a high degree of control of rinderpest and pleuropneumonia of cattle and Newcastle disease of poultry, and much progress was made in fundamental work on protozoal diseases of animals in East Africa. The detailed accounts of the work of the regional organizations include lists of publications. The Committee's report now occupies some 111 pages out of a total of 322.

The tenth annual report of the Colonial Economic Research Committee records the completion of Prof. A. T. Peacock's inquiry on the national income of Tanganyika, and of Mr. D. T. Edwards's analysis, in association with the Jamaican Department of Agriculture, of the economics of small farms in Jamaica. A large-scale study of the economics of farming systems in Africa was commenced and also an investigation of the agricultural economy of Malta. Among new projects priority was given to a study of the economics of road development in Uganda; an economic survey of the Seychelles; a survey of farm production in British Honduras; studies of the Fijian community as an economic unit; and of the effects of diamond mining in Sierra Leone on a predominantly subsistence economy.

The annual report on Fisheries Research, 1956–57, which comprises the reports of the individual Colonial fisheries research stations, records the failure of a special mission to impress on local opinion in Ghana and Nigeria the continuing need for fishery research in West African waters and the consequent winding-up of the West African Fishery Research Institute, Sierra Leone, as an interterritorial body, though plans have been laid to safeguard the results already obtained by establishing, in consultation with the Sierra Leone Government, a small territorial unit based on the Institute's premises. Both the Federation of Malaya and the Singapore Government have withdrawn from the work of the Regional Fisheries Research Station at Singapore, and this station is also to be wound up. Efforts are being made to place the scientific staff of both stations in other parts of the Oversea Research Service.

Results obtained at the Jinja laboratory of the East Africa Inland Fisheries Research Organization have been used in advising the East African Governments on the probable consequences of proposed changes in legislation for the protection of fish stocks in Lake Victoria. Experimental evidence has now shown that organic sulphur deposited on the lake bed as plant debris has little chance of being converted into available sulphates. Interest in snails as intermediate hosts has led to the observation that the ability of snails living in small streams and pools to survive the dry period depends on their degree of infestation by parasitic nematodes. The effects of DDT on insectivorous fishes have been studied, and work on the food and feeding habits of insect-eating and fish-eating species of fish in Lake Victoria is nearly complete. Steady progress is reported by the East African Marine Fisheries Research Organization, which has correlated the seasonal appearance of the dolphin-fish, *Coryphaena hippuris*, with plankton and hydrographic data.

The Northern Rhodesian–Nyasaland Joint Fisheries Research Organization gave priority to basic research on fish ecology in Lake Bangweulu, the Bangweulu swamps (where the importance of *Vossia* grass is being studied) and the Zambesi and Ianyeti rivers in the area to be covered by the Kariba Dam. From the Fisheries Research Unit, University of Hong Kong, a hydrographic survey of the sea around Hong Kong has now continued for two years and the possibility of developing an edible-oyster industry in Tolo Harbour has been investigated. The West African Fisheries Research Institute had fifteen scientific papers published or in preparation, including a complete scientific survey of the Sierra Leone estuary and an extensive survey of the bottom fauna on the continental shelf off Freetown, correlating this fauna with the nature of the sea-bed and with the food of fish.

The twelfth annual report of the Colonial Medical Research Committee refers to the termination of research on the physiology of hot climates which, in Nigeria and adjacent territories over the past eight years, has been very productive. With this exception, the various fields of research have remained unchanged, although research on trachoma in Jordan had to be suspended. The Research Unit on Tuberculosis in Ghana is now well established and has maintained effective contact with workers in Nigeria and Sierra Leone, while the formation of the Leprosy Sub-Committee has greatly stimulated interest and co-ordination; pilot control measures based on data secured in filariasis research, whether loiasis or bancroftiasis, are increasingly applied or planned. On the recommendation of the Committee, modest block grants have been placed at the disposal of each of the three regional organizations for medical research, in East and West Africa, and the British Caribbean, from which each could make small immediate grants annually to provide some additional research facility required by an individual research worker.

Research on loiasis and onchocerciasis in the Cameroons and Nigeria indicated that use of DDT and dieldrin granules in high concentrations (say, 5 per cent) to spray the mud of breeding-sites of *Chrysops* and *Tabanus* killed all larvæ, a process which, while very costly, may be economical in the rain-forest where the breeding-sites, though scattered and inaccessible, are small in total area. Investigations into the effects of 'Antrypol' and dimercaptosuccinate on the concentration of microfilariæ in onchocerciasis gave promising results. Encouraging results were also obtained in East Africa in the control of filariasis in rural areas by treatment with 5 mgm./kgm. 'Hetrazan' once a week for six weeks and by spraying houses with dieldrin at 100 mgm./ft.^{2} every six months. A pilot control scheme of bilharzia among schoolchildren is to be undertaken in the Mwanza area. Investigations on guinea-worm at University College, Ibadan, point to the value of 'Hetrazan' as a prophylactic for travellers journeying through endemic areas of dracontiasis, while in Tanganyika granulated dieldrin has proved a highly effective larvicide.

No definite evidence of a relation between the frequency of the sickle-cell trait and the parasite-rate or parasite-density was obtained in investigations in Nigeria and Southern Cameroons on malaria and the sickle-cell trait. At the West African Council for Medical Research Laboratories, Lagos, studies in hepatic pathology showed that monkeys hyperimmunized against Zika virus were more tolerant to the yellow fever virus than the normal controls, while at the Trinidad Regional Virus Laboratory, Port of Spain, research has centred around epidemiological investigations of Ilheus virus infections. Investigations on the yellow fever hazard at the Institute for Medical Research, Kuala Lumpur, have been mainly concerned with whether local mosquitoes and animals can transmit and maintain the disease, whether the presence of other viruses in Malaya would affect its establishment, and methods of vaccination and mosquito-control. The United States Army Medical Research Unit (Malaya), in collaboration with the Institute, the nearby British Military Hospital and the Walter Reed Army Institute of Research, Washington, has made clinical and laboratory studies of children with pyrexias of unknown origin in the General Hospital, Kuala Lumpur, of encephalitis in Singapore and the Federation, and of the ecology of potential vectors of viral diseases in Malaya.

Much progress has been made in building up facilities for nutrition research at the East African Medical Survey and Research Institute, Mwanza, and at Kampala the Infantile Malnutrition Research Unit continued to explore the use of various diets in treating kwashiorkor. The Tropical Metabolism Research Unit, Jamaica, continued work on the composition of tissues in malnutrition, especially of muscle, and some progress was made in the measurement of Krebs cycle oxidations. In a controlled pilot trial in Nigeria, which has now lasted twenty-five months, diphenylthiourea has proved an effective treatment for all types of leprosy in a dosage of 1·0–3·0 gm. daily. It is at least as active as diaminodiphenylsulphone. With an isoniazid it combines effectively, is remarkably free from toxic action, and no evidence of drug resistance has appeared. Diaminodiphenyl sulphoxide also continues to show considerable promise. In studies at Makerere College on the enzymes of *Mycobacteria*, particularly the use of tetrazolium salts to detect dehydrogenases, satisfactory micro-methods have been developed which give consistent results with cultural organisms. At the National Institute of Medical Research studies have been made on the evolution of infection with *Mycobacterium lepramurium* in experimental animals, while at the Medical Research Council Laboratories in The Gambia, observations on the long-term therapeutic effects of 'Hetrazan' in *Wuchereria bancrofti* infections indicate that the maximal effect of non-toxic dosage-levels is not discernible until two years after treatment. In research on the biology of sandflies in East Africa, work with *Phlebotomus guggisbergi* may provide clues as to the real vector of kala-azar.

The tenth annual report of the Colonial Pesticides Research Committee refers to further studies of the Colonial Insecticides Research Unit, Porton, on the sorption of insecticides by soils, which have shown that repeated sprayings do not affect the sorption-rate, whereas increase of temperature increases the sorption of DDT and dieldrin, and that loss of insecticide by chemical decomposition is not a significant factor. A preliminary investigation has been made of the properties of residual DDT and dieldrin on some surfaces used in house construction, and the relative toxicities of the organic phosphorus insecticides, diazinon, chlorthion and malathion, to houseflies and some species of mosquitoes have been determined. Promising new variations in olfactometric technique have been developed at the Imperial College Field Station, Silwood Park, while at Long Ashton Research Station a technique has been evolved for controlling leaf-spot disease of Lacertan bananas. At Urambo, Tanganyika, the Colonial Pesticides Research Unit successfully controlled heavy infestations of bollworm (*Heliothis armigera*) and stainers (*Calidea*) on cotton by weekly sprayings of DDT at 1 lb./acre, with BHC for aphid control when required. Control of bean fly, *Agromyza* (*Melanagromyza*) *phaseoli*, has been obtained with seed dressings of emulsifiable concentrates of aldrin, endrin and dieldrin. The Biting Fly Research Unit, Uganda, extended its facilities for entomological research and has established a laboratory colony of *Stomoxys calcitrans*. In filariasis research in Fiji residual sprays of DDT and dieldrin gave satisfactory control of mosquitoes resting in houses, and in transmission experiments high infection-rates were obtained with *A. polynesiensis* Marks in feeding experiments. In the Western Sokoto Malaria Control Pilot Project an improved technique for sampling insecticide deposits on mud surfaces was evolved, and on the 100-acre experimental plot at Kidichi Mdo, Zanzibar, effective economical control of *Pseudotheraptus wayi* on coconuts was obtained using 10 per cent DDT with 1 per cent coumarone indene resin dissolved in a mixed aromatic petroleum solvent.

Stress is also laid on research being done in the Colonies without the assistance of the Committee: for example, the preliminary survey at Aden of the relative importance of various pests of cotton; the promising results obtained in control of various weeds in Bermuda; the control of olive leaf spot (*Cycloconium oleaginum*) in Cyprus with 10 : 1 : 100 Bordeaux mixture; of scale insects on *Hibiscus* sp. in Malaya with dieldrin and 'Nicotox'; and of white copper borer, *Anthores leuconotus* Pasc., with 0·5 per cent dieldrin in Tanganyika.

Almost half the fourth annual report of the Colonial Products Council and Laboratory is concerned with work conducted outside the Laboratory but under the direction or with the assistance of the Council. The 745 inquiries handled by the Laboratory during the year, of which sixty-two were still in hand, included such varied subjects as cedarwood oil, coconut products, the development of *Crambe abyssinica* as an oilseed crop, the relative nutritional value of *Oryza glaberrima* and *O. sativa*, the packing and transport of fresh mangoes, nutritional biscuits from local ingredients for school-children in Uganda, and the extraction of vitamin C from the West Indian cherry. Among the ninety-five investigations completed by the Laboratory during the period were those relating to oil of *Leptospermum citratum*, oil from the bark of *C. pedatinervium* as a source of safrole, Illipe butter, sugar cane wax, sisal wax, starches from arrowroot and sago, and animal feeding stuffs from waste materials. Other work included the separation, by chromatographic and counter-current techniques, of the constituents of pyrethrum, work on the seaweed *Corallopsis opuntia*, which has good jellying properties, the comparative properties of abaca fibre from Borneo, Sumatra and the Philippines, and pulping trials of *Ricinodendron rautanenii* timber from Northern Rhodesia and of British Honduras slash pine, *P. caribaea*.

Further work on the curing of the cacao bean and on the structure of the cacao leucocyanidin compounds was carried out at the Colonial Microbiological Research Institute, Trinidad, where a 3 : 4-diol structure has been indicated for peltogynol in place of the accepted structure, and the isolation of the intermediate oxidation products of substituted catechols is in progress. The Sugar Technological Laboratory, Trinidad, carried out much work on the fundamental physico-chemical aspects of clarification and also further work on the removal of evaporator scale and the chemistry of constituents of ammoniated molasses, but pilot-plant work indicates that the production of lævulinic acid from molasses is unlikely to be economical. At Makerere College, besides investigations on the natural products of East African plants, the methane fermentation of vegetable wastes has been studied up to pilot-plant scale; and studies at the Forest Products Research Laboratory, Princes Risborough, on the production of fibreboard from secondary Colonial timbers indicated that after treatment with steam alone in the 'defibrator', pulp from all the species tested required further refining to give boards of adequate strength. Work on sugar derivatives continued at the University of Birmingham, where the series of oligosaccharides produced by acid reversion of N-acetyl-D-glucosamine has been fractionated and two disaccharides isolated, and a unit has been established for studying the pharmacological activity of extractives from plants and other materials of interest to Colonial territories. The study of medicinal plants which might contain hepatoxic agents by the Medical Research Council's Toxicology Research Unit continued and also work on the constitution of the alkaloid dioscorine at University College, Cardiff, chemical investigations on the leaves of *Anona senegalensis* and the structure of the pectic compounds of *Agave sisalana* flesh at the University of Edinburgh. Further investigation at the Institute of Animal Physiology, Cambridge, of extracts of the seeds of *Dichapetalum toxicarium* indicates that a major part of the active fraction behaves mainly as a C_{18}-fatty acid with one double bond and one fluorine atom.

In its second annual report the Committee on Colonial Road Research notes a slow but steady build-up of the Colonial Section of the Road Research Laboratory, which, at the end of March 1957, was short of its complement by two scientific officers, five experimental officers and five assistants (scientific) and emphasizes the adverse effect of the restrictions and delays in new buildings. Federal Nigeria proposes to establish its own central Road Research Laboratory, and Western Nigeria and Northern Nigeria are building up their Materials Testing Laboratories. Research teams have been recruited to study road-making materials available in Colonial territories and pavement design, and a survey has been made of published information on corrugations, theories advanced to explain their formation, and on methods of alleviating or preventing them by selection and treatment of road-making materials.

The bearing capacity of representative soils from Uganda, Northern Rhodesia and The Gambia over a range of densities and moisture contents has been determined using the California bearing ratio test. Road construction problems with fine-grained cohesionless sands occurring in coastal and desert areas have been investigated in connexion with the proposed Ado–Badagry road in Western Nigeria and the Georgetown–Rosignol road in British Guiana. A range of full-scale experiments on the use of rubber in surface dressing, bitumen macadam and rolled asphalt is in progress, and examination of the economics of roads and road transport in under-developed territories has begun. This work has included a review of methods of road accidents with the view of helping territories to adopt methods within their capacities and suited to their needs, and ensuring that the data are so presented that they provide a reliable measure of the pattern of road accidents and their economic importance.

To the thirteenth annual report of the Colonial Social Science Research Council are appended the customary reports for 1956–57 of the East African Institute of Social Research, the West African Institute of Social and Economic Research, the Institute of Social and Economic Research, University College of the West Indies and the Rhodes–Livingstone Institute. Work was commenced on the project initiated at University College, Ibadan, for a history of Benim, to be financed jointly by the Carnegie Corporation and the Governments of Nigeria, and a study of family attitudes in Jamaica. The fourth volume, "Bantu Languages of Africa", of the Handbook of African Languages is in the press, and forty volumes of the Ethnographic Survey of Africa have now been published, while further sections on peoples of East Africa and of Nigeria are in preparation. A new relation between the East African Institute of Social Research and the Social Studies Department of Makerere College is being inaugurated which will establish a closer link between teaching and research, while maintaining the Institute as an autonomous organization within the College. The Institute of Social and Economic Research, University College of the West Indies, is studying West Indian agriculture and agricultural development, the labour market, the analysis and supplementation of West Indian national accounts and the role of investment in economic development. At the Rhodes–Livingstone Institute for Social Research, studies are in progress of European communities in the Copperbelt and in Southern Rhodesia; of the economics of peasant farms and of African education; and of urban sociology and the sociology of industry as well as two tribal studies.

The major field of activity of the Tsetse Fly and Trypanosomiasis Committee was in chemotherapy, and at a conference at the Colonial Office agreement was reached on procedures for the fullest co-ordination of full trials of promising new trypanocidal drugs and the prompt dissemination of such results. The new procedures have already been implemented, and the suramin complexes developed at the West African Institute for Trypanosomiasis Research appear to offer a considerable increase in the period of protection obtainable. In human trypanosomiasis the Institute has closely studied changes occurring in the saliva of tsetse infected with the *brucei* group of trypanosomes, and its clinical trials indicate that 'Malarsen' is a valuable alternative for treating *T. gambiense* infection under field conditions, especially in late or relapsed cases. Research on the forest species of tsetse continued at the Field Station and a comparative experiment on 'man–fly contact' was started near Kaduna during the rains. The study, by the East African Trypanosomiasis Research Organization, of the resting-places of the tsetse flies *Glossina swynnertoni*, *pallidipes* and *morsitans* is likely to lead to new ideas on the use of insecticides. An investigation of the mechanism of water control in the pupa of *Glossina* is contributing to an understanding of the success and failure of some current methods of reclamation.

At the Sukulu Laboratory a small hospital was opened for the reception of patients from the lakeshore fly-belts, and a joint investigation with the Kenya Medical Department has shown that in that area *G. pallidipes* is a carrier of *T. rhodesiense*. The epidemiology of *palpalis*-borne sleeping sickness in Uganda is also being investigated. In Northern Rhodesia trypanosomiasis research has been limited to drug trials and prophylaxis. The Veterinary Department of the Northern Region of Nigeria is pursuing a vigorous programme of research into cattle trypanosomiasis, while the Department of Veterinary Services, Tanganyika, has compared the protection given by prothidium, ethidium–suramin complex and *RD*290 suramin complex with that given by 'Antrycide' prosalt. Prothidium was also the outstanding new prophylactic tested by the Department of Veterinary Services, Kenya.

The report of the director of the Anti-Locust Research Centre for 1956–57—in which the Centre received 984 reports of the desert locust situation from thirty-two territories, including reports on low-density locust populations from survey officers in the Somali Peninsula, Ethiopia and parts of Arabia—notes that the desert locust situation improved somewhat in Eastern Africa, Iran, Pakistan and India, although heavy breeding occurred in the Sudan, the French Chad territory and the Niger Colony. A panel of international experts which met at the Anti-Locust Research Centre in April 1956 recommended that permanent surveys of the whole of the distribution area should be established by all governments concerned, and that all information on the state of desert locust populations and relevant weather phenomena should be centralized.

The International Red Locust Control Service continued studies on red locust populations in relation to vegetation dynamics and on control methods, and the International African Migratory Locust Organization became a permanent international body in 1956, when a research service was established. The Anti-Locust Research Centre continued to work on phase variation and its inheritance; maturation and fecundity in the red locust; weight and water-content of the desert locust in relation to flight and the life-cycle of *Eyprepocnensis plorans*, *Acrida bicolor* and *Gastrinargus africanus*. Annual and seasonal frequency maps of the incidence of desert locust swarms and hoppers were completed and maps of the major seasonal swarm movements were prepared.

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OBITUARIES

Dr Willis R. Whitney

With the death on January 9 of Dr. Willis Rodney Whitney, at the age of eighty-nine, there ended a very remarkable career.

Although Dr. Whitney was a first-class scientist in his own right, his great contribution was the organization and successful direction, for thirty-two years, of the Research Laboratory of the General Electric Co., Schenectady, New York. It is hard to understand now what a truly pioneer task this was, for in 1900 there were no organized industrial research laboratories in the United States. He had to prove that industrial research could be made to pay. When he did this, other industries quickly followed General Electric's example. To-day, a research laboratory is considered essential for industrial success.

Born in Jamestown, New York, on August 22, 1868, Dr. Whitney's interest in science began with the acquisition of a microscope when he was in high school. After graduating from the Massachusetts Institute of Technology in 1890, he first spent four years as instructor in chemistry there, then went to the University of Leipzig, where he received his Ph.D. degree in 1896. After six months at the Sorbonne, he returned to the Massachusetts Institute of Technology as assistant professor and later full professor.

It was at this point that E. W. Rice, vice-president of the General Electric Co., visited him and proposed that he should start a research laboratory—a thing new to industry. The fact that it was an experiment appealed to Whitney—he loved an experiment. But he also believed in proceeding cautiously and slowly, feeling one's way. So he agreed to try it on a part-time basis, spending three days a week in Schenectady and the other three at the Massachusetts Institute.

His first laboratory was a barn in the rear of Dr. Steinmetz's house, and the laboratory staff consisted of Whitney and half the time of an assistant shared with Dr. Steinmetz. When the barn burned down in the following year, he moved to a building in the Schenectady works, and gradually began to add more employees, being very careful to preserve the atmosphere of friendly co-operation.

This atmosphere he himself generated by personal example. As long as the size of the laboratory permitted, he made a practice of visiting every member of the staff every day. His usual greeting on these visits was, "Are you having any fun ?". To him, research was fun, "the finest of sports", as he once expressed it. Frequently, on his visits, he brought some new project or experiment, suggested by company activities or scientific progress, which he literally peddled from room to room, but seldom assigned.

It was one of his key principles that members of his staff were given freedom, in proportion to their proved ability, to choose their own research problems, and to publish important results promptly in their own names. He was a pioneer in the championing of such publication.

Optimism, enthusiasm and sound judgment were conspicuous qualities of Dr. Whitney, but above all was his devotion to science. It was literally true of him that science was his religion. He often talked about religion, but always concluded that the "search for truth" was the best kind of religion.

Scientific curiosity, which he once defined as the greatest asset of a research man, was his most conspicuous quality. If you visited him on a Saturday afternoon, you were likely to find him in a field near his home, putting a small piece of iron wire in the stem of a golden-rod and surrounding it by a high-frequency coil, to find out whether it was the heat of the bug inside that caused the swelling called a gall to grow. Or you might find him sitting on a log in the woods, counting the mosquitoes that alighted on him and on a quarter of beef beside him, to find out how they knew what to bite.

Dr. Whitney retired as director in 1932, becoming an honorary vice-president of the General Electric Co. But he still came to the laboratory every day, at first devoting his time to personal experiment, his first love, which he had missed during his directorship; and later to visiting the research workers, with interest and encouragement.

Dr. Whitney's success as a pioneer of industrial research is a lasting contribution. The secret of that success was a combination of remarkable personal qualities—friendliness, mental vigour, breadth of interest and knowledge, stimulating originality, delightful flashes of humour, modesty, courage, directness and simplicity. A. W. HULL

Dr. K. H. Barker

DR. K. H. BARKER, who died suddenly in London on March 3, was born in Manchester in 1925 and educated in the Department of Physics at the University of Manchester, graduating in 1948. His university education was interrupted between 1945 and 1947 when he worked on the Tube Alloys Project in the Department of Physics at the University of Liverpool.

In 1948 Barker started research work in cosmic-ray physics at Manchester, under the direction of Prof. P. M. S. Blackett. At the beginning of his research career he joined my group, then engaged in studying high-energy nuclear collisions using a cloud chamber equipped with an electromagnet. This collaboration lasted until his death, a period of almost ten years without a break. His death is a very great loss to the group and to the subject of high-energy nuclear physics in which he had achieved a world-wide reputation.

The Manchester electromagnet was moved to the Observatory on the Pic-du-Midi in the French Pyrenees in the autumn of 1949. Barker was responsible for installing the magnet and cloud chamber in the mountain laboratory at an altitude of 9,500 ft. Altogether, he spent between two and three years of his life working with the apparatus. In the early years he often climbed to the mountain top during the winter months; but a cable railway has now been installed. Barker was a first-class experimental physicist able to operate and maintain efficiently a complicated piece of equipment in very difficult circumstances.

In 1950 Barker obtained a very valuable set of photographs showing many decays of V^0-particles. From the analysis of these pictures the group demonstrated, for the first time, that the V^0-particles, discovered by Rochester and myself in 1947, consisted of two kinds: neutral Λ-hyperons which are heavier than the proton and heavy mesons, with mass intermediate between the π-meson and the proton. Barker played a leading part in obtaining and interpreting these photographs. He also observed, in 1950, the first decay of a Ξ^--hyperon.

In 1953 Prof. Blackett and a number of his staff moved from Manchester to the Imperial College of Science and Technology, London. Barker was at once appointed a lecturer in physics at the Imperial College and continued to spend part of his time at the Pic-du-Midi working on the same general research programme. During the past year or so the group has been studying the properties of nucleon–nucleon collisions with energies of 50 GeV. and upwards. In this work Barker collaborated very successfully and fruitfully with French physicists from Prof. Leprince-Ringuet's Laboratory at the École Polytechnique in Paris. At the time of his death he was enthusiastically planning new experiments in high-energy nuclear physics using an accelerator, instead of the cosmic-rays, as a source of particles.

Barker was a good teacher, both of undergraduates and research students, and, as a friendly and helpful colleague, will be sadly missed by the staff of the Department of Physics at the Imperial College.

C. C. BUTLER

NEWS and VIEWS

Mastership of Clare College, Cambridge :

Sir Henry Thirkill, C.B.E.

SIR HENRY THIRKILL retires from the mastership of Clare College, Cambridge, on September 30 next. Apart from the war years 1914–19, Sir Henry has been in residence since he entered the College as an undergraduate in 1905. He sat for the Natural Sciences Tripos, Part I, in 1907, and for Part II in the following year. He was elected a Fellow of Clare in 1910, having embarked on research at the Cavendish Laboratory under J. J. Thomson, being later one of his demonstrators in the somewhat precarious days when the professor was personally responsible for his assistant's stipends. During the First World War, Thirkill served in the Royal Engineers, being O.C. Wireless in East Africa, 1915–18, and receiving the Military Cross. On returning to Cambridge, he was appointed College lecturer and a University lecturer in experimental physics. It is, however, as tutor of Clare College from 1920 that he will best be remembered by many generations of Clare men—not only for his gentle if determined guidance but also for his hospitality at breakfast or Sunday evening music and, for the more energetic, on the tennis or squash court. Though made president of the College in 1930, he retained the tutorship until he was elected master in 1939.

Always a great worker, Thirkill found time from an early date to serve the University as well as his College. He was elected a member of the Council of the Senate so far back as 1927, serving continuously for thirty years. This was only a beginning; for many years he was also a member of the General Board of the Faculties, of the Financial Board and of many other committees. It would be difficult to find a man in any age who has given longer or more devoted service in the sometimes thankless task of university administration. Thirkill was vice-chancellor in the particularly busy years 1945–47 when plans for post-war developments were being prepared on every hand. It fell to him to entertain the many war leaders on whom honorary degrees were conferred. His brilliant speeches at the luncheons following the degree congregations will long be remembered. It will be difficult for old Clare men to think of the College without Thirkill as master or tutor, but they may be comforted by the knowledge that he will continue in residence on his retirement.

Sir Eric Ashby

THE Fellows of Clare College have announced their intention of electing Sir Eric Ashby into the mastership of the College on the retirement of Sir Henry Thirkill. Sir Eric, who has been vice-chancellor of The Queen's University, Belfast, since 1950, was elected on March 13 into a Fellowship of the College. From the City of London School, Ashby went to the Imperial College of Science and Technology, where he later became a demonstrator in botany and, after two years in America as a Commonwealth Fellow, a lecturer during 1931–35. His next post was reader in the University of Bristol until 1938, when he was appointed professor of botany in the University of Sydney. The sea-trip to Australia with a young family was so turbulent that Ashby swore never to return. Fortunately for the cause of education in Britain, the busy years that followed made him forget his resolve. Scarcely was he settled in Sydney when the Second World War made heavy demands upon him. He was chairman of the Australian National Research Council, 1940–42, and director of the Scientific Liaison Bureau, 1942–43, having conducted an inquiry for the Prime Minister into the enlistment of scientific resources in 1942. In 1945 he went to Moscow as Counsellor and chargé d'affaires at the Australian legation. His experiences there are recounted in the Penguin book, "Scientist in Russia". In 1946 he left Australia to become Harrison professor of botany and director of the Botanical Laboratories in the University of Manchester, where he remained until he went to Belfast as vice-chancellor. While continuing his interest in botany, Ashby has found time for many other activities, including the administration of research, having been a member of the Advisory Council on Scientific Policy (1950–53), of the Advisory Council on Scientific and Industrial Research since 1954 and chairman of the Scientific Grants Committee since 1955. Above all, he is well known as a writer, and thinker, on educational problems.

Research at Imperial Chemical Industries :

Mr. R. M. Winter

MR. R. M. WINTER, who is retiring from the post of research controller of Imperial Chemical Industries, Ltd., after thirty years service with the Company, was born in Scotland in 1896, and emigrated in early childhood to New Zealand, where he received most of his formal education. On graduating B.Sc. in 1916, he volunteered for military service and served with the New Zealand Division in France, where he was wounded. At the end of the War he worked for a time at the Royal College of Science as a research student under Prof. H. Brereton Baker, and on his return to New Zealand was awarded an 1851 Exhibition science research scholarship. After a year's research at the Rothamsted Experimental Station, he joined the staff of the Explosives Research Department at Woolwich Arsenal, where he remained until the end of 1927. He joined Synthetic Ammonia and Nitrates, Ltd. (now the Billingham Division of Imperial Chemical Industries), early in 1928 and was transferred to the General Chemical Division as research manager in 1931. In 1937 he moved to Head Office as chief assistant to Dr. R. E. Slade, who was then research general manager, and was appointed research controller in 1946.

Dr. M. A. T. Rogers

DR. M. A. T. ROGERS, head of the Academic Relations Department of Imperial Chemical Industries, has been appointed research controller in succession to Mr. R. M. Winter. Dr. Rogers was born at Mill Hill in 1911, and received both the B.Sc. and Ph.D. degrees from University College, London, where he was a Tuffnell Research Scholar and the Ramsey Memorial Medallist for 1933. Dr. Rogers joined the Dyestuffs Division of Imperial Chemical Industries as a chemist in 1934, and served in the Azo Section until 1936, the Textile Auxiliary Section until 1939 and the Exploratory Research Section until 1942. In that year, Dr. Rogers joined the Royal Artillery, and when he returned from his military service he became engaged in research on penicillin with Sir Robert Robinson at the Dyson Perrins Laboratory, Oxford. In 1946, Dr. Rogers joined the Medicinal Research Division, and in 1949 he became head of the Academic Relations Department of the Dyestuffs Division of Imperial Chemical Industries.

Atomic Energy Insurance

THE second international Atomic Energy Insurance Conference, held in London during February 26–28, under the chairmanship of Mr. H. T. Silversides, issued in a widespread agreement by representatives from fifteen European countries on the broad approach to the insurance of risks arising out of the use of nuclear energy reactor installations. Essential features of pool management agreements were discussed, and it was decided that the material damage risks to be pooled should be the insurance of damage to nuclear installations (defined as nuclear reactors, nuclear power stations, and plant and facilities for producing nuclear energy), including contamination by radioactivity. Third party liability for damage and loss of life or injury arising out of the use of nuclear installations is also to be pooled, and each reactor and third party liability must be comprehensively covered. All the participants in the Conference endorsed the principle that a single insurance policy should be effected by the owner or operator of the reactor, who should also accept all responsibility for radiation liabilities for contractors and suppliers of parts, and undertake to indemnify the contractors and suppliers from any legal liability for radiation risks. The Government of the United Kingdom has already agreed to this approach in fixing an absolute liability at law and requiring insurance to a sum of £5 million or proof of equivalent liquid assets. A special committee of representatives of Belgium, France, Germany, Holland, Italy, Sweden, Switzerland and the United Kingdom is meeting in April to consider hazards, evaluations and surveys ; the basis of premium rating ; and the policy cover to be offered ; while legislative aspects of nuclear insurance will continue to be handled by the Organization for European Economic Co-operation and the European Committee for Insurance.

Industry and Atomic Power

AN illustrated brochure entitled "Atomic Power Achievements" (chairman's address at the Fifty-seventh Annual General Meeting, London, September

5, 1957. Pp. 36. London: General Electric Co., Ltd., 1957) describes the part to be played by the General Electric Company, Ltd., in the implementation of the British nuclear power programme. The Company is building at Hunterson on the Ayrshire coast one of the world's largest full-scale commercial nuclear power stations, for use by the South of Scotland Electricity Board. Photographs of models of the station and details of its capacity are given in the brochure. The generating capacity will be 360,000 kW., of which 320,000 kW. will be fed into the National Grid system, the remainder being consumed in the station. The two reactors will be loaded initially with 500 tons of uranium. The graphite core of each reactor will consist of about 115,000 graphite blocks and will be enclosed by a spherical steel pressure-shell 70 ft. in diameter. In addition to the reactors and the turbine hall, housing six turbo-generator sets with feed water and condensing plant, administration and laboratory blocks and a number of ancillary structures will be built. Between the two reactor structures a pond for the storage of irradiated or spent fuel elements from the reactors, prior to their removal to the processing plant, will be constructed. The first reactor and three turbo-generator sets are scheduled for commissioning in 1961 and the whole station will be fully operational in 1962.

Milford Haven Conservancy Bill

On March 25, during the committee stage in the House of Commons of the Milford Haven Conservancy Bill (see *Nature*, April 5, p. 937), the amendments moved by Lords Silkin and Ogmore and others were negatived, although Lord Brecon, for the Government, promised to consider further before the report stage the desirability of placing the provision for amenities in a separate section. Some disturbing disclosures were made during the debate. Lord Ogmore revealed that the Chairman of the Pembrokeshire County Council had opposed the suggestion that the whole scheme for development should first be explained to the nation in a White Paper, and appeared to be concerned solely with local benefits. The Minister of Housing and Local Government had taken a wider view, and had refused the Esso Company permission to develop 1,000 acres, and permission to develop 350 acres had been given only under very stringent conditions. Lord Ogmore pointed out that there were eight developments proposed in the area; besides this proposal for a £20 million refinery on the north shore, there was the landing stage for the harbour at Popton Point capable of taking the largest tankers afloat; a £9 million project for two dry docks, five wet-berths and a discharging pier; a deep-water unloading berth for iron ore; the iron ore stocking ground at Angle or near by; another refinery on or near the Haven; a group of chemical and kindred factories; and a ship-repairing project at Pembroke Dock.

These developments, which it was estimated would bring a further 50,000 people into the area, were likely to have a profound effect on the whole of west Wales and, apart from the effect on the National Park area itself, Lord Ogmore and other speakers were concerned that any essential development should not be allowed to create industrial slums in the way that some nineteenth-century developments had done. His contention that due regard should be had to cultural and social development was strongly supported by Lord Lloyd and by Lord Hurcomb, who welcomed the writing into the Bill of the powers which the Minister of Power agreed to write into the Electricity Bill. Lord Hurcomb was concerned that planning authorities should not be allowed to give free play at the expense of all other considerations to any profitable industrial or commercial development, and referred to the probable deleterious effect of the proposed dredging on the marine biological station at Dale Fort. As regards oil pollution, he thought that much of the evil could be avoided if the responsible authorities were vigilant and exercised their great powers. The oil companies in Britain had always taken an enlightened attitude.

Lord Brecon, in replying to the debate, said that the Government had very carefully considered the amenity question, and thought that the Bill, as it stood, provided all the care for amenity that will be required in the development of Milford Haven. The Minister of Housing and Local Government and for Welsh Affairs had taken great personal interest in the question, and could call in all the planning applications for consideration by his Department. The National Parks Commission would be represented on the Board, which would have greater responsibilities for amenities than any other harbour board in Britain. The Government, he said, is really keen to see that full consideration is given to amenity, and that as little despoliation as possible occurs in the area; but matters of cultural and social development are the responsibility of the local county council, the committee for further education, youth clubs and other organizations.

Entomologia Experimentalis et Applicata

Within a year of the first appearance of the new *Journal of Insect Physiology*, yet another scientific journal dealing with entomology has made its debut. *Entomologia Experimentalis et Applicata* (1, No. 1; February 1958. Pp. 72. Published quarterly. Annual subscription (for a volume of at least 320 pages): 32 Dutch guilders; 63*s.*; 8.50 dollars. Amsterdam: North-Holland Publishing Co., 1958) has a distinguished board of editors drawn from the Netherlands, France, Germany and Great Britain. The first number contains nine papers which formed part of a symposium on "Insect and Foodplant" held at Wageningen in 1957. These interesting papers cover a wide range of topics in insect physiology and biochemistry, ecology, behaviour and plant breeding; but they cannot be regarded as typical of the kind of papers the new journal will carry in the future. The intention is to provide a meeting-ground between experimental and applied entomology. Such problems as the resistance of crop plants to insects, diapause, phenology, biological control and resistance to insecticides are among those which may be expected to figure in future numbers. This journal will certainly serve a most useful purpose. It is well printed and produced on a rather small page measuring 6 in. by 9¼ in.

Worthing Museum

In 1956 work commenced on a complete re-presentation of the collections in the Worthing Museum. During its fifty years history, the Museum's collections have undergone a shift of emphasis from natural history and folk material to archæology, a process which has increased rapidly in momentum in the past decade. This might well have been foreseen, since the South Downs near Worthing have been occupied during every prehistoric period with the exception of the Palæolithic, and the activity of archæologists and archæological societies has brought an increasing yield of displayable material from which a connected and absorbing story can be told. Latterly, too, the Museum staff has undertaken excavations which have made valuable contributions to the prehistory of Worthing. The theme of the new displays, therefore, is the habitation of the South Downs and coastal plain of West Sussex. Small models and diagrams were prepared to assist in the presentation of an easily assimilated visual story, and three more ambitious models and reconstructions were designed to focus attention and hold the interest of the casual visitor. The first of these is a copy of the geological relief map of the Weald in the Geological Museum, South Kensington—the first copy to have been attempted. The second is a large-scale model of a room in the Roman villa at Bignor, originally made for the Festival of Britain Exhibition, and the third is a reconstruction of a Roman cist burial from Avisford, complete with grave furniture. On March 1, Dr. W. E. Swinton, of the British Museum (Natural History), opened the sections already completed, containing material of the periods from Palæolithic to Mediæval times. Cases have already been provided for a new geology bay, and work will commence shortly on a series of period rooms which will continue the sequence down to the nineteenth century.

Gas Chromatography Discussion Group

The Gas Chromatography Discussion Group was formed in association with the Hydrocarbon Research Group of the Institute of Petroleum following the Symposium on Gas Chromatography in London, May 1956, and has the following objects: to promote interest in gas chromatography; to organize meetings devoted to gas chromatography; to compile and distribute gas chromatographic data. The expanding interest shown in the activities of the Group over the past year has necessitated some changes in the present organization. It is proposed to invite interested workers in the field to become members of the Group and to contribute to the planning and execution of its work in the future. The annual subscription will be 1 guinea, which will entitle members to vote at general meetings, attend the informal symposia organized twice yearly and receive such compilations of data or other information as may become available from time to time. The first annual general meeting will be held in London in the autumn of 1958 in conjunction with the next informal symposium. Further information can be obtained from the secretary, D. H. Desty, British Petroleum Co., Ltd., Sunbury-on-Thames, Middlesex.

Geological Society of Australia

The following officers of the Geological Society of Australia have been elected for the year 1957–58: *Vice-President*, Prof. A. R. Alderman (Adelaide); *Vice-President*, Prof. R. T. Prider (Western Australia); *Hon. Secretary*, Dr. N. H. Ludbrook (Department of Mines, Adelaide); *Hon. Treasurer*, Dr. O. A. Jones (Queensland); *Hon. Editor*, Dr. M. F. Glaessner (Adelaide).

The Geological Society of Australia was formally constituted in 1952. Developing originally from informal groups of geologists, it has attained in its sixth year about 470 members and 130 associates. The Society is organized on a Federal and State basis with seven State Divisions. Plenary meetings of the Federal body are held with the meetings of the Australian and New Zealand Association for the Advancement of Science. Until permanent headquarters are established, the headquarters of the Society move after each meeting to the place of the next plenary meeting. The *Journal of the Geological Society of Australia* has been published annually since 1953; Vol. 4, part 2, and two parts of Vol. 5 are due early in 1958. Inquiries regarding subscriptions to the *Journal* should be addressed to the Hon. Treasurer, Dr. O. A. Jones, Department of Geology, University of Queensland, St. Lucia, Brisbane.

A Cytotaxonomic Study of *Carex*

Áskell and Doris Löve and Marcel Raymond have given a cytotaxonomic account of the *Capillares* section of *Carex* (*Canadian J. Bot.*, 35, 715; 1957). This section comprises nine distinct species, one of which (*C. boecheriana*) is raised to specific status in this paper. Three species include two distinct subspecies each; two varieties and three formæ are accepted for two species, respectively. The chromosome numbers of the taxa involved are $2n = 18$, 36, 38, 40, 54, 56 and 58. The authors point out that the chromosomes of *Carex* have a polycentric or diffuse kinetochore and that this explains the aneuploid variations in number known to be typical of the genus. Karyotypic analysis of the chromosome complements of the section *Capillares* revealed that in the basic diploid set of $2n = 18$ chromosomes, four units are long, ten are medium and about half the length of the long ones, while four are small and about half the length of the medium ones. This frequency of size classes is also met with in the plants with $2n = 36$ and 54 chromosomes. Those taxa with $2n = 38$, 40, 56 and 58 chromosomes show, however, such a deviation in the frequency of the size classes that it seems logical that these numbers have been produced by a secondary fragmentation of the chromosomes. On the basis of karyotypic analysis of this section and other groups of the genus, it is concluded that the primary basic number for the genus *Carex* in particular, and the family Cyperaceae in general, must have been $x = 5$, all other numbers having been derived mainly by fragmentation of chromosomes with a polycentric or diffuse kinetochore. This phenomenon of partial agmatoploidy is widespread in Cyperaceae, whereas complete agmatoploidy is typical of the closely related Juncaceae.

Spectrophotometric Study of Stars with High Velocities

Madeleine Chopinet has a paper with the title "Étude spectrophotométrique de quelques étoiles à grande vitesse", in *Publications de l'observatoire de Haute Provence* (3, No. 42; 1957), which analyses a number of spectra of stars taken with the 120-cm. Newtonian telescope at Haute Provence. The dispersion of this spectrograph with a flint prism was, unfortunately, rather low—about 50 A./mm. towards 3900 A. and 80 A./mm. towards 4400 A. All the photographs contained certain stars which were to be studied, together with several comparison stars. The deductions confirm the results of several other investigators, particularly of Keenan and Keller (*Astrophys. J.*, 117, 241; 1953). In the opinion of the author, however, they are not sufficiently characteristic to serve as criteria for stars with high velocities. She has searched the records of high-velocity stars the trigonometrical parallaxes of which are known; about 2,200 are given in Miczaika's list (*Astro. Nach.*, 270, 249; 1940) and fifty others elsewhere. The Russell diagram for these stars is compared to the diagram for about 650 normal stars in the vicinity of the Sun, for spectral types between $F0$ and $M5$. It appears that the branch corresponding to the main sequence for stars of high velocity is nearly 0·5 magnitude below that of the normal stars. The number of giants of both categories is too small to draw any conclusions about them.

1958 Waverley Gold Medal Essay Competition

The Waverley Gold Medal and £100 will be awarded for the best essay of about 3,000 words based on some recent scientific research or new development (whether the author's work or not), giving some indication of the scientific background, the experimental results and its potential application in industry. The essay should be written in a form that is clearly intelligible to a scientist engaged in another field or a director of an industrial firm. The essays will be judged for technical content by specialists in that field, for clarity of presentation and style. A second prize of £50 will also be awarded, and an additional prize, also of £50, for the best entry from a competitor under thirty years of age on July 31, 1958. The competition is open only to persons at present engaged in scientific work. Further information can be obtained from the Editor, *Research*, 4/5 Bell Yard, London, W.C.2. All entries must be received on or before July 31.

"Natural Gas in Scotland"

Referring to the article under this title in *Nature* of December 28, p. 1444, Mr. T. S. Ricketts writes: "The British Petroleum Co., Ltd., has pointed out that the Cousland anticline was not discovered by the D'Arcy Exploration Co., Ltd., but is a well-known feature of the geological maps published by H.M. Geological Survey and has been known for a very long time. It was first tested shortly after the First World War, when a small amount of gas was proved. Most of the present sub-surface knowledge of the Cousland anticline was obtained by test drillings by the D'Arcy Exploration Co. and the Anglo-American Oil Co. during the period 1937–39. It was at this time that the gas accumulation now being used by the Scottish Gas Board was discovered by the D'Arcy Exploration Co. The local crest maximum with the natural gas in it may have an east-to-west long axis, but the anticline runs north and south and not east and west".

University News: Belfast

The following appointments to supernumerary lectureships have recently been made in The Queen's University of Belfast: R. H. Buchanan (geography); J. F. Gracey and W. A. M. Gordon (veterinary science); J. Patton (agricultural bacteriology); Dr. C. E. Wright (plant genetics and plant breeding); Dr. A. M. Raven (agricultural chemistry); and Dr. A. G. Smith (botany). Dr. J. L. Douce has been appointed lecturer in electrical engineering.

London

Dr. Leslie Crombie, lecturer in organic chemistry at the Imperial College of Science and Technology, has been appointed to the University readership in organic chemistry tenable at King's College.

Announcements

The National Institute of Industrial Psychology has appointed Mr. J. D. Handyside to the post of controller of research, with effect from April 1.

Dr. Ethelwynn Trewavas has been appointed a deputy keeper in the Department of Zoology, British Museum (Natural History). She has been a member of the scientific staff of the Museum since 1935 and is a leading taxonomic ichthyologist, her special study being freshwater fishes.

Mr. J. D. Alston, a well-known Norfolk farmer, has been appointed a member of the Agricultural Research Council, to fill a vacancy on the Council. Mr. David Lowe, a member of the Council since 1954, has been appointed deputy chairman in succession to Prof. S. J. Watson; Prof. Watson will continue to serve as a member of the Council and as chairman of the Council's Standing Committee on Research affecting Plants and Soils.

The Physical Society is holding a conference on "Spectroscopy of Solids" at the Royal Radar Establishment, Malvern, on May 28 and 29. Further information can be obtained from the Secretary, Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

The eleventh Brookhaven symposium in biology will be on "The Photochemical Apparatus: its Structure and Function". It is sponsored by the Biology Department, Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York, and will be held during June 16–18. Further information can be obtained from Dr. R. C. Fuller at the above address.

The seventeenth meeting of the European Federation of Chemical Engineering will be a joint symposium on "The Organization of Chemical Engineering Projects". It will be held at Olympia, London, during June 24–26. Further information can be obtained from the Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

A symposium on "Continuous Cultivation of Micro-organisms", sponsored by the Institute of Biology of the Czechoslovak Academy of Sciences, will be held during June 23–28 in Prague. The symposium will deal with some theoretical aspects of continuous cultivation and the possibilities of the practical applications of this method. Further information can be obtained from Academician I. Málek, Institute of Biology, Czechoslovak Academy of Sciences, Na cvičišti 2, Praha 6, Czechoslovakia.

Dundee Technical College offers two one-week special summer programmes to bring information on electronic data processing methods and developments to those who are or may be involved in selecting, programming, operating or managing electronic computers. These are "Electronic Computers and Business Problems", to be held during June 23–27, and "Developments in Electronic Data Processing for Business", to be held during June 30–July 4. Both programmes will be directly supervised by Dr. Robert H. Gregory, professor of accounting, Massachusetts Institute of Technology, assisted by Dr. Stanley Gill, head of the Computing Research Group, Ferranti, Ltd., England. Further information can be obtained from the Head of the Department of Management Studies, Dundee Technical College, 40 Bell Street, Dundee.

University College of Science PHYSICS Dept. 92, Upper Circular Rd., Calcutta.

HEALTH AND SAFETY IN THE ATOMIC ENERGY AUTHORITY

THE report of the Committee appointed under the chairmanship of Sir Alexander Fleck to review the organization of the Atomic Energy Authority as a whole for the control of health and safety[*] begins by describing the measures which the Committee considers essential. Safe technological practice, it believes, involves: (*a*) formulating codes of practice for design and operation based on experimental facts and experience; the special problems of nuclear energy require that preparation of the codes should be the responsibility of specialist health and safety staff; (*b*) designing plant using these codes of practice; this is the responsibility of design engineers; (*c*) operating and maintaining the plant to these codes; the executive responsibility for this rests with the works general manager and his operating staff; (*d*) overall monitoring of both design and operations by the safety staff, whose duty it is to direct the attention of the executive authority to any lapse from the prescribed codes.

The report next considers the functions of Government departments in this field and, after defining the Authority's role in relation to health and safety measures, the Authority's organization against this background. The national implications of the acute shortage of specialist health and safety staff in the field of nuclear energy to which the report directs attention, and the recommendations of the Committee in this connexion, and in regard to the Authority's external relations and responsibilities, are discussed elsewhere (p. 1023 of this issue). The internal recommendations are summarized below.

The Fleck Committee endorses the Authority's decision to establish a committee of the Atomic Energy Executive to be responsible for the overall supervision of all matters of health and safety, but recommends some minor changes in the terms of reference. It considers that the new committee structure established under the Executive Committee on Health and Safety provides an effective means of controlling health and safety throughout the Authority. Recommended terms of reference for the subordinate Weapons Safety Executive Committee, Safety Executive Committee and Health Executive Committee are suggested. It also recommends that the management of health and safety in the factories of the Industrial Group should be fully integrated into a single section responsible directly to the works general manager and endorses the new health and safety organization at Risley and the concept of an Authority Safety Branch which it contains. This organization, it is suggested, should be brought up to strength as a matter of urgency, and detailed terms of reference for the Industrial Group Health and Safety Branch are suggested covering the preparation of codes of practice, and provision of a medical service, radiological safety service and industrial safety service at each site, and provision of an independent inspection service.

The Committee recommends that there should be one senior member of the scientific staff at the Radiochemical Centre, whose principal duty would be functional responsibility to the manager for all safety matters. Existing members of the staff should be given this duty on a rota basis, and a first task of the new safety officer should be to investigate storage arrangements for radioactive materials. It is also recommended that the Authority should bring the site emergency procedures in each of its establishments to a uniformly high standard. The procedures should be co-ordinated to ensure that the maximum technical resources of the whole Authority may be deployed to counter an emergency in any single establishment. Finally, there should be closer collaboration between the Authority's three Groups on the problems concerned with the control of criticality, and each Group should have a nominated officer to bear functional responsibility for criticality problems.

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[*] Atomic Energy Office. Report of the Committee appointed by the Prime Minister to examine the Organisation for Control of Health and Safety in the United Kingdom Atomic Energy Authority. Pp. 28. (Cmnd. 342.) (London: H.M. Stationery Office, 1958.) 1*s*. 3*d*. net.

INDUSTRIAL HEALTH IN GREAT BRITAIN

THE annual report[*] of the Chief Inspector of Factories for 1956 records a reduction of 2 per cent in the number of accidents, from 163,332 in 1955 to 160,116, although the estimated number employed in factories increased by 0·4 per cent. The downward trend in the accident rate per thousand employed continued, as did the fatality rate per million employed (54), the number of fatal accidents in factories being 426; and of 184,785 accidents notified during the year from all premises subject to the Factories Acts, 687 were fatal. The Chief Inspector observes that probably greater efforts have never been made than during the past year to reduce the risk of accidents due to fire; and these efforts, which are part of a continuing campaign carried out by the inspectorate, other Ministries, local authorities, fire services and various organizations, have been intensified, and co-operation between the authorities and services has been strengthened and extended.

The cardinal importance of the contribution of the scientist and technologist to health and safety in industry is again apparent from this report. Thus, reviewing progress on safety, the report stresses four aspects, in all of which that contribution is decisive. First, the need to design for safety. Secondly, the tendency for electrical and electronic apparatus to be included where formerly reliance was placed only on a mechanical system of control. Thirdly, and in consequence, greater reliability is required of such apparatus to ensure the safety of operators, since failure may lead to unexpected and dangerous movement. Accordingly, extensive studies are being undertaken of the reliability of complex electrical and electronic equipment, and there is every expectation that, in future, fault-finding will be made to some extent automatic, so that the production process may be kept going with a minimum of costly interruption. Fourthly, the problems of safety in the nuclear power stations are briefly reviewed (see p. 1023 of this issue).

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[*] Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories for the year 1956. Pp. 195. (Cmnd. 329.) (London: H.M. Stationery Office, 1958.) 9*s*. 6*d*. net.

There has been steady improvement in all fields of safety, and the Chief Inspector believes that accident prevention is gaining momentum, but that we need to set our sights a good deal higher. In referring to training in safety, he expresses the hope that the technical colleges will take greater interest, and that in the expanded programmes a place will be found for spreading the fundamental principles of safe working. The Clean Air Act, where it reduces the pollution of the atmosphere, has immediate repercussions on standards of cleanliness and lighting, and the Food Hygiene Regulations, 1955, have stimulated both food-products factories and factory canteens to further effort in cleanliness, both general and personal. Work continued on the surveys initiated by the Industrial Health Advisory Committee into conditions affecting health, and that on the Halifax Survey was practically completed during the year.

At the end of 1956, some 362 factories, including five receiving depleted uranium oxide from the Industrial Group of the Atomic Energy Authority at Risley, were receiving radioisotopes from Harwell and the Radiochemical Centre, Amersham, compared with 300 at the end of 1955, the most extensive use being for γ-radiography of castings, welds, etc., chiefly with iridium-192 and cobalt-60, though cæsium-137 continues to gain in favour. A draft code of regulations for the use of radioactive materials (other than for luminizing) was examined by an expert committee, and as a result draft regulations in respect of sealed sources were nearly complete by the end of the year and have since been published. The Radiological Protection Service made a concerted drive, with the Factory Inspectorate, to improve still further the protection of radium luminizers. The use of radioactive material for the elimination of static electrical charges continues to increase slowly.

SCIENTIFIC AND TECHNICAL TRANSLATION

A CONFERENCE on "Scientific and Technical Translation", organized by Aslib, was held at the Connaught Rooms, London, W.C.2, on March 5. Dr. J. E. Holmstrom of Unesco and Mr. E. B. Uvarov were chairmen for the morning and afternoon sessions respectively and about two hundred visitors attended. Mr. L. Wilson (director of Aslib) and Dr. Holmstrom introduced the subject, indicating that it had been examined in a report by Unesco* and was of increasing importance in facilitating scientific communication. Even if the problem were restricted to that experienced by those speaking English, it was found that about half of the world literature was unintelligible without translation. For those with other mother tongues the difficulties were far worse. The Unesco report contains the bulk of the factual information now available on translating methods, services, costs and indexes.

Three papers were presented: "The Organization and Availability of Technical Translation", by Dr. A. L. Mackay (Birkbeck College, London); "The Economics of Translation", by Mr. Felix Liebesny (Mond Nickel Company); and "Training for Translating Work", by Mr. A. G. Readett (National Coal Board, vice-chairman of the Institute of Linguists).

Dr. Mackay surveyed possible and actual methods of organizing the extraction of information from foreign-language literature, translation being regarded as an unproductive activity to be avoided if possible. The inefficiency of making a translation for one person who found only a fraction of it informative could be mitigated by circulating translations widely, regular cover-to-cover translations of major periodicals being the most systematic way of sharing expenses. Indexes of individual translations were thought to be only marginally useful. Persons properly qualified for scientific translation work would be better employed as full members of research and development groups working with linguistic and library rather than, say, chemical techniques. Material for translation should be selected for its value, reviews, digests and books being preferred; and an estimate of the premium to be placed on rapid processing could be made by attaching half-lives to various categories of literature. Training students in languages and maintaining scientific representatives abroad could reduce the volume of translation necessary.

Mr. Liebesny examined the actual costs, to an organization using translations, of various methods of preparation. He found that, where a complete text was required, the cost of translating a 1,000-word article from Russian to English was about 50*s.* to 120*s.*, depending on particular techniques (use of recorder, typist, etc.) and salary rates. If the translator worked through the paper orally with the inquirer, translating only part, the cost could be reduced to 17*s.* to 28*s.* Mechanical translation, according to the most optimistic forecasts, might cost 2*s.* per thousand words. Under various co-operative schemes, such as that run by the Department of Scientific and Industrial Research, where the costs are shared, the charges might vary from 8*s.* to 30*s.* For cover-to-cover translations of periodicals the cost would be only 4*d.* to 6*d.*, so that even assuming that only 2½ per cent of the papers which had to be bought were actually required and worth translating, the cost per thousand words would still be only 13*s.* to 20*s.* For such co-operative translations the choice of material is not wholly under the inquirer's control and certain papers would still have to be dealt with individually.

Mr. Readett described how translators at the London office of the National Coal Board were trained to prepare abstracts, to make full translations and to provide interpreter services. Only professional linguists of honours degree standard were recruited and they were familiarized with the technology of the subject. The close and harmonious relations maintained with the Board's technicians were especially emphasized. Visits, lectures and films, such as instructional films on new machinery, were used in addition to background reading material to ensure that translators were familiar with the subjects of the papers they had to translate. Only the highest quality of written translation was produced but, for speed, when only one inquirer wished for a translation, the paper could be very satisfactorily examined orally by the translator and the subject specialist. The concept of a 'rough translation' as something cheaper and easier to make than proper translation was based on a misunderstanding of the translation process which was to understand first, and then to re-express in English. Many papers could be clearer in a well-expressed translation, but those papers which were obscure, because they were ill-written and ambiguous even to a specialist, imposed an intolerable burden on the translator.

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* "Scientific and Technical Translating and Other Aspects of the Language Problem", Unesco, 1957; second edition, 1958. (H.M. Stationery Office.) 20*s.*

In discussion, Dr. D. J. Urquhart (Department of Scientific and Industrial Research) supported an organized system of cover-to-cover translation as the only real answer to the situation, together with the widest possible use of English by scientific journals. There was general agreement with this and with the proposition that students should be trained in foreign languages, particularly Russian, if only to employ translators more effectively. It was recommended that those translating papers should notify the Aslib index when they begin a translation so that duplication might be avoided. Many enthusiasts spoke on various aspects of translation without expressing views which diverged seriously from those of the main speakers, except that many preferred that scientists should be trained in languages rather than that linguists should be taught technology.

It was resolved, on the initiative of Dr. Urquhart, that Aslib should be recommended to convene a further conference "to see what measures can be taken to make Russian scientific and technical literature available in English". The meeting also passed a resolution from Dr. Clason (Philips, Eindhoven) that the whole question of translation required fuller consideration by a three-day conference. Discussion was terminated with a resolution that the Unesco Report proposals, circulated with the conference documents, should be sent out to participants as a questionnaire, so that the opportunity of obtaining the opinions of those attending the conference should not be lost through lack of time. The papers and discussion will be published later in "Aslib Proceedings".

A. L. MACKAY

HIGH POLYMERS

THE Kelvin Lecture, delivered on February 6 to the Institution of Electrical Engineers by Sir Harry Melville, dealt with the chemical structure and physical behaviour of high polymers. After giving an account of the underlying principles, Sir Harry dealt with natural and artificial rubber, polyethylene, synthetic fibres and ion-exchange fibres. The lecture brought out very well the co-ordination of chemistry, physics and engineering in the field of high polymers, and showed to what a large extent materials of this kind are finding all kinds of uses, and how their properties may to some extent be controlled on the basis of theory.

The fundamental property of a high polymeric material is its high molecular weight, which may increase from upwards of 10,000 to values of the order of a million for linear molecules and indefinitely large values for non-linear systems. The molecules should consist of long chains of atoms to which side-chains are attached. The groups in these side-chains may be able to rotate freely or may be joined by cross-links. If the main chain contains double bonds, its members will be hindered from rotation. If the number of molecules in the chain is not very large, the chain may coil into a spherical shape, and rubber is normally in this form. In stretching the rubber, the chains uncoil under moderate tension. Unvulcanized rubber behaves differently and tends to crystallize on extension. Vulcanization puts in cross-links, which are not extensive enough to prevent uncoiling. In synthetic rubbers the aim is to produce chains not long enough to form crystallites, and a recent discovery by the British Rubber Producers Research Association consists in modifying the chemical composition so that the chains cannot form such crystallites.

Silicones have chains of silicon and oxygen atoms in repeating units with various groups attached to the silicon atoms. They vary from mobile liquids, the viscosity of which is only very little affected by temperature, to rubber-like solids.

Polyethylene is a linear chain of carbon atoms with hydrogen atoms attached when the polymerization is carried out at room temperature. At higher temperatures and high pressures the molecules have many branches attached to the linear chain, and this has an important effect on the properties. By exposure to high-energy radiation such as gamma-radiation, hydrogen atoms are removed from the chains, leaving free radicals, which join to give cross-links, forming a three-dimensional structure which at high enough temperatures decomposes rather than melts.

Synthetic fibres must have a high tensile strength. It is curious that among the strongest natural and synthetic fibres the tensile strength does not vary much. The strength is much less than that calculated for breaking the chemical bonds, and it is less than the calculated value for other plausible structures, so that no explanation is yet known. The modulus of elasticity is close to the calculated value. The lecture dealt with the changes produced by altering the chemical composition. Fibres and rubber are closely related and relatively small changes in chemical structure influence their properties quite markedly.

Ion-exchange fibres are made by mixing high-polymer molecules containing carboxyl or acid groups and hydroxyl or alcohol groups, and heat treatment. They are in effect solid acids. In an acid liquid the fibre swells. If the acid is replaced by an alkali the molecules stretch, but if the fibre is put into acid its original state is restored. Theoretically, mechanical energy could be derived from such a system, but at present the efficiency is very low.

NEW INSTALLATIONS FOR B.B.C. TELEVISION

SINCE June 1955 a series of Engineering Monographs* has been published by the B.B.C., dealing with technical subjects within the field of television and sound broadcasting. Each Monograph describes work carried out by the Engineering Division of the Corporation and includes, where appropriate, a survey of earlier work on the same subject. About six Monographs are produced each year.

Monograph No. 12 is entitled "An Improved 'Roving Eye'", by T. Worswick and G. W. H. Larkby, and it describes the new design of mobile television camera which, with its associated equipment and short-range radio-link transmitter, permits pictures and their sound accompaniment to be broadcast while the vehicle is in motion and unimpeded by any connecting cables. The vehicle is equipped with two cameras, one of which gets a direct view forward through the windscreen or at right-angles to take kerbside interview shots. The second camera is mounted on a machine-gun ring and can be elevated with its operator to a position well clear of the roof. With this arrangement the camera can be swung to look all around the vehicle; and it can also be tilted on the mounting to take steep downward shots, for example to look on the pavement or in shop windows. The sound and vision signals are transmitted to the broadcasting network by a radio link on a frequency of about 660 Mc./s. When the vehicle is 'roving', a short aerial a few feet high is used to enable the van to pass under bridges; and in this case the maximum distance from the receiving base is some two or three miles. The vehicle is, however, also provided with a 45-ft. pneumatically operated telescopic mast, which can be used from a fixed position to send the signals over a distance of ten to fifteen miles from the receiving base. The normal crew of the vehicle comprises a driver, two cameramen, two operators, a commentator and producer; and the equipment is complete with an engine-driven alternator for the power required by the cameras, control units and the radio transmitter.

The two succeeding Monographs describe the premises at Hammersmith which the B.B.C. has recently converted into a self-contained television studio centre. No. 13 is entitled: "The B.B.C. Riverside Television Studios: The Architectural Aspects", by E. A. Fowler. It describes in some detail, with appropriate drawings and photographs, the planning and construction of the two studios, occupying 6,000 and 4,200 sq. ft., respectively, together with all the necessary equipment and facilities for the staging and production of television programmes. The incorporation of many new features on the engineering side, particularly in the fields of lighting control and co-ordination of the production and engineering staffs, has been made possible by the careful planning and layout of the studios and their auxiliary areas.

The technical accommodation and equipment are described in more detail in Monograph No. 14, entitled: "The B.B.C. Riverside Television Studios: Some Aspects of Technical Planning and Equipment", by H. C. Nickels and D. M. B. Grubb. As in the former case this number is well illustrated with plans, diagrams, photographs showing the studios, control rooms and associated lighting, camera and telecine equipment. The Riverside Studios represent the latest and most modern practice in the equipment of television studios in Britain: while they include certain novel features, they are essentially the outcome of experience gained over a considerable number of years.

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* Obtainable from B.B.C. Publications, 35 Marylebone High Street, London, W.1. 5s. each, 20s. per year.

THE PHYSICAL SOCIETY DURING 1957

THE 1957 Year Book of the Physical Society (pp. iv+132. London: The Physical Society, 1957. 12s. 6d.) is the third in the annual series and contains the report of the Council of the Society for 1956; the proceedings of the meetings of the Society; obituary notices of five fellows, including Sir Francis Simon and Sir John Townsend; and the texts of the presidential address and of the special lectures and discourses delivered to the Society during the year.

The presidential address, entitled "The Physics and Chemistry of Metals", was delivered by Prof. N. F. Mott on June 4, following the annual general meeting of the Society (see *Nature*, **180**, 272; 1957). The forty-first Guthrie Lecture, given by Prof. H. C. Urey on April 9 during the spring meeting of the Society at the University of Nottingham, was originally entitled "Some Chemical Limitations on Theories for the Origin of the Solar System". However, Prof. Urey has since been able to study the interesting observations of E. K. Gerling and L. K. Levskii made in 1956 in the U.S.S.R. and he has consequently modified and added many points and details to his lecture, with the result that the revised text appears under the title "Meteorites and the Origin of the Solar System". Prof. Urey points out that though meteorites have been investigated by chemists and mineralogists for more than a century, since the Second World War new and modern techniques have been applied to the problem, and he proceeds to review both the older and more recent data, and to outline possible series of events which may have led to the formation of meteorites. Recent work on radioactive dating methods, it is stated, shows conclusively that a most involved series of chemical and physical processes took place some 4·5 aeons ago (an aeon is 10^9 years) during the period in which the solar system originated.

In the nineteenth Thomas Young Oration which he delivered on May 15, Dr. J. Guild, of the National Physical Laboratory, describes observations on the behaviour of diffraction gratings, dealing particularly with those properties which affect image formation. Following a description of the test-bench employed at the Laboratory for the examination of the gratings, a number of examples are given of the peculiarities of behaviour of typical diffraction gratings of various origins as revealed by the tests. The examples show that the best gratings, regarded as optical instruments, are of poor quality by the standards normally applied to plane or concave reflectors, thus leaving considerable room for improvement in the technique of their production.

The magnetic refrigerator for temperatures below 1° K. was the subject of the thirty-third Duddell Medal address given by Prof. J. G. Daunt. A shortened version of the address (for the full text see *Proc. Phys. Soc.*, B, **70**, 641 ; 1957) is included in the Year Book, together with the thirty-fourth Duddell Medal address on the scale-of-two counter by Dr. C. E. Wynn-Williams ; the twelfth Charles Vernon Boys Prize address on "Hyperons and *K*-mesons : a Survey of the Results of the First Decade" by Prof. G. D. Rochester and Dr. C. C. Butler ; the thirteenth Charles Vernon Boys Prize address by Dr. L. Essen on the measurement of the velocity of light ; and the three evening discourses delivered at the forty-first Physical Society exhibition of scientific instruments and apparatus during March 25–28.

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PUBLIC HEALTH TRAINING OF GENERAL PRACTITIONERS

In many countries, general practitioners are required, in addition to their private practice, to devote part of their time to public health activities. They are thus called upon to play an important part in the protection of public health—a role for which they have not always received adequate training. A conference* to discuss this problem was organized by the World Health Organization in October and ovember 1956.

NThe main tasks of the conference were to examine the reasons for the frequent indifference of general practitioners to public health questions, to seek a means of arousing their interest in them, and to establish certain general principles for the guidance of those responsible for the organization of the public health training of general practitioners.

It was agreed that the first cause of indifference is in the present university and post-university curricula, which lay the main emphasis on diagnostic and therapeutic aspects. This is a gap which has to be bridged if the general practitioner is to be able to fulfil his public health role efficiently. Another reason for the lack of interest is that the young medical graduate finds the prestige and material compensations of private practice more attractive than public health work.

If the general practitioner's interest in public health work is to be aroused, the health authorities have to keep him informed of their plans for collective activities, and—whenever possible—invite his participation. For his part, the practitioner should realize that, even from the point of view of individual therapeutic care, there are advantages in having a modern public health service at his disposal.

There are various ways of maintaining effective liaison between the health administration and general practitioners, including periodic health bulletins, personal contacts and organization of meetings. Courses and seminars in which general practitioners are invited to participate are particularly helpful, and in several countries excellent results have been obtained by international teaching teams which have organized lectures and discussions in hospital centres on public health.

The report examines in detail the organization of courses for part-time public health medical officers and the various related problems, including time and place of courses, selection of teachers, content and arrangement of syllabuses. If physicians are to become familiar with the nature and aims of public health activities, if they are to take as much interest in these as in other aspects of their profession, and if they are to acquire the necessary technical competence, training programmes should cover, among others, the following subjects : role of the physician in society ; role of the public health administration ; reciprocal collaboration ; epidemiological methods ; environmental sanitation ; importance of external services (social services) ; and the interrelationship of curative and preventive medicine.

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* World Health Organization. Technical Report Series, No. 140. Pp. 21. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 1 Swiss franc; 1*s*. 9*d*.; 0.30 dollars.

SENSORY DEPRIVATION AND THE CAT'S OPTIC NERVOUS SYSTEM

By Dr. LAWRENCE WEISKRANTZ
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That rearing in darkness of rabbits[1], cats[2] and chimpanzees[3] can produce severe behavioural impairment in visual tasks is now well established. Less certain is whether this impairment can be attributed to peripheral neural changes, to the lack of opportunity to learn how to see—reflected, presumably, in neural changes limited to more central loci—or to both these factors.

The present investigation was undertaken to examine carefully the visual system of cats reared in darkness. The rearing was intentionally designed to conform to the schedule of an earlier study by Riesen, Kurke and Mellinger[2]. The five experimental animals were put into a dark room from the age of 7 days (before their eyes were opened) until they were 17 weeks old. From their fourteenth to seventeenth weeks, they were given a daily ½-hr. run in a normally illuminated room. During this period, the left eye of each animal received only diffuse illumination. This was achieved by fitting the animal with a mask with a semi-translucent insert in front of the left eye. The right eye received normal unobstructed stimulation. Riesen, Kurke and Mellinger found that cats reared in this manner not only had difficulty in

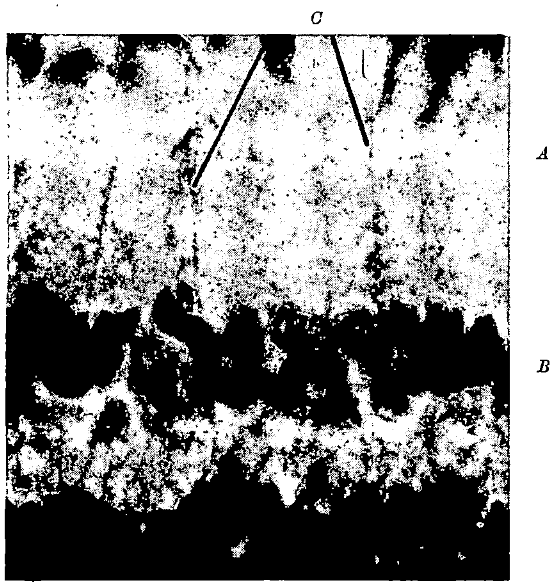

Fig. 1. Photomicrograph of the retina of a cat. *A*, inner plexiform layer; *B*, inner nuclear layer; *C*, Müller fibres. (× *c*. 450)

learning pattern discriminations with either eye, but had a deficit in transferring habits learned with one eye to the other eye. I observed, similarly, that the cats were severely impaired in discriminating objects and depth during their runs, although since my animals were killed at the end of the 17-week period there was not time to carry out the extended behavioural procedures which would be required for a complete replication of the earlier study, particularly those aspects concerned with interocular transfer.

The five experimental kittens were litter mates. As it was not practically possible to have matched or litter-mate controls, an attempt was made to obtain a fairly wide range of ages of control animals. At the time of death these ages were 10, 13, 18, 18 and 75 weeks (the last being the mother of the experimental kittens). The control cats were kept in well-lit laboratory rooms in cages identical to those of the experimental animals. The experimental kittens were 17 weeks old at the time of death.

All animals were killed with coal gas, and the eyes and optic nerves fixed in Bouin's solution. The brains were fixed in formol. The eyes and nerves were eventually embedded in 'Celloidin', the brains in paraffin. A variety of staining procedures were employed.

In microscopic examination of the retinas, no differences between controls and experimental animals were immediately obvious. After considerable examination, however, the impression was gained that there were some differences of a statistical or relative nature rather than all-or-none. In particular, experimental retinas seemed to have fewer clearly stained fibres transversing the inner plexiform layer, particularly Müller fibres. In addition, the inner plexiform layer appeared to be relatively thinner in the experimental retinas. Measures of these two features, therefore, were obtained. Molybdic acid hæmatoxylin was found to be the most suitable stain for both purposes. The sections were 10μ thick.

Before measuring the thickness of the inner plexiform layer, the slides were coded by an assistant so that it was not evident which was control and which experimental. Four specified points on each of two slides for each of the twenty eyes were used. The slides were chosen at random, the only restriction being that the sections had to be cut through the blind spot. The thickness of the over-all retina, the inner plexiform layer, and the inner nuclear layer was measured under high-power oil immersion (Fig. 1). Upon decoding and averaging, the distribution shown in Fig. 2 was obtained. The inner plexiform layers in the experimental eyes were thinner than those in controls. This was true both in absolute terms and in terms of the thickness relative to the over-all retina. The latter was about a 15 per cent difference, on the average, and was significant at the 1 per cent level by the Mann–Whitney non-parametric test[4]. There was some tendency for the retinas of control animals to be thicker over-all than those of experimental animals (Fig. 3); but this was not marked nor statistically significant. There was no suggestion of a difference in the relative thickness of the inner nuclear layer (Fig. 4). These measurements were repeated by another member of the laboratory, with comparable results.

Müller fibres were counted in two sections of each retina, the only condition being, again, that the sections had to include the blind spot. Under oil immersion, every recognizable fibre which travelled at least half the distance from the ganglionic layer through the inner plexiform layer was counted. The sections were not coded. The fibre counts were converted into density measures (fibres per unit length) since there was considerable variation in the actual retinal perimeters. The results are shown in Fig. 5. The experimental retinas are about 20 per cent less dense in the populations of Müller fibres than the controls. This difference is also significant at the 1 per cent level by the Mann–Whitney test. (Actually, 'Müller fibres' is certainly too broad a designation, since the count included a variety of fibre types. However, Müller fibres—so far as it is possible to identify them on the basis of the usual descriptions of them—certainly dominated.)

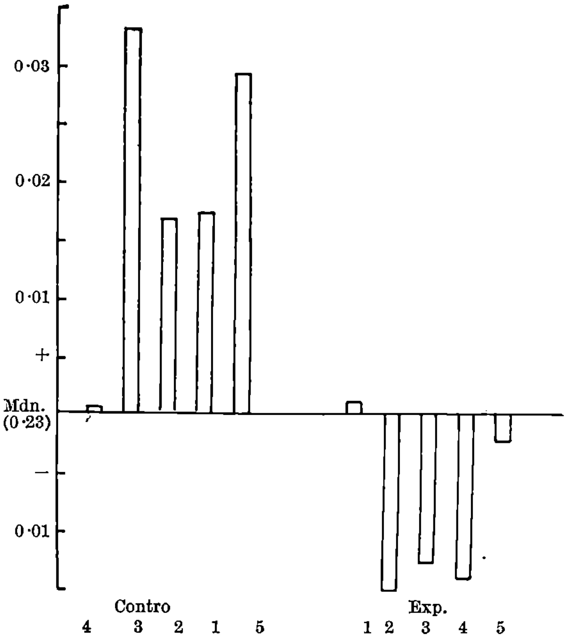

Fig. 2. Relative thickness of inner plexiform layer

No significant difference between the right and left retinas of the experimental animals could be found in the above measures. No differences in the size or distribution of ganglion cells appeared between groups or between left and right experimental eyes.

Finally, density measurements were obtained of fibres in the optic tract. Glees silver stain was used, with control and experimental brains embedded in the same block, sectioned and stained together. This was done as control, for variation is often characteristic of silver stain. Each tract on each side of each brain was sampled at twelve designated positions and fibres crossing a particular grid line under high-power magnification were counted. Experimental tracts were compared only with the corresponding control tracts on the same section. Out of nine such comparisons (one comparison was impossible to make because of poor staining), control tracts were more dense than experimentals in eight cases. Such a difference is significant at the 5 per cent level by simple binomial analysis. The amount of the difference was small, averaging about 6 per cent.

Chow, Riesen and Newell[5] have recently published a study of retinal changes produced by rearing chimpanzees in the dark. They found almost complete disappearance of ganglion cells in the case of two animals kept in darkness for $1\frac{1}{4}$ and $2\frac{1}{2}$ years. A 'normal' retina was found for a third chimpanzee reared in the dark for 7 months, with limited daily experience of non-patterned stimulation, and which was afterwards brought out into the light for two years. But these investigators do not report any control material, and give no basis for assuming that this third retina was in fact entirely normal. Nor is it known, of course, whether it was not more obviously abnormal when the animal was first brought out into the light.

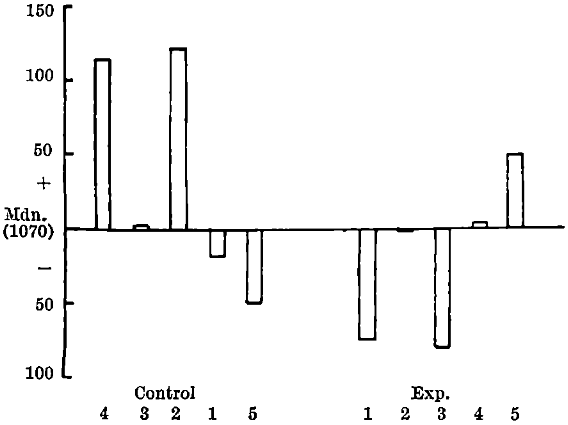

Fig. 3. Relative thickness of retina

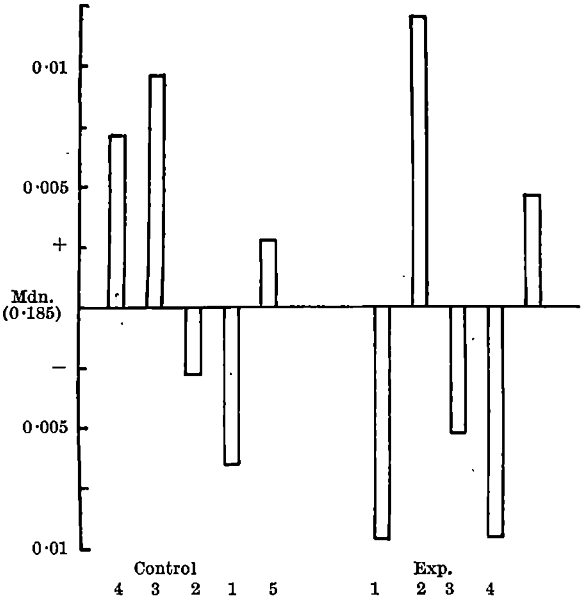

Fig. 4. Relative thickness of inner nuclear layer

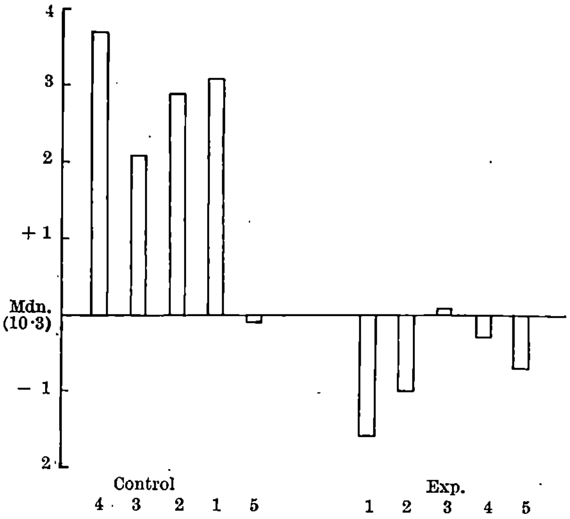

Fig. 5. Density of Müller fibres

Brattgård[6] has reported an elegant study of the pentose nucleoprotein fraction of retinal ganglion cells of rabbits reared in darkness. It was found that 10 weeks of darkness from birth yielded a pentose nucleoprotein fraction of zero. Animals afterwards brought out into the light did not develop pentose nucleoprotein as rapidly as did controls. To quote his conclusion, "The cell is dependent on adequate stimulation for the continued development of the nucleoprotein fraction. If it is deprived of this stimulation, the production is reduced or inhibited" (p. 67).

Thus, there seems little doubt that retinal ganglion cells are implicated; but the questions of the time-course and the sequence of events remain to be settled. Chow, Riesen and Newell have considered abnormal only the instance of rather complete disappearance of ganglion cells—a somewhat advanced state. Brattgård found ganglion cells well developed in terms of conventional histological examination, but altered in cell chemistry, in rabbits reared in darkness for 10 weeks. My cats, after 17 weeks of darkness, showed normal ganglion cell bodies, by conventional histological examination, but altered cell processes. That is, the inner plexiform layer, which includes the dendrites of the ganglion cells, was thinner, and the optic tract, which includes the axons of the ganglion cells, was less dense. The significance of the difference in Müller fibre density may be related to Brattgård's results, since one of the functions ascribed to the Müller fibres by some authorities (for example, Polyak[7]) is a metabolic one.

Attempts have been made to avoid the suspected peripheral atrophic reactions by rearing animals in diffuse, non-patterned light. In many such mammalian studies, however, animals were first kept in total darkness for some period prior to such experience, presumably for practical reasons. We have tried to duplicate this period in one such study by Riesen *et al.* Hence, by the time diffuse experience is permitted, the eye may already be retarded in its development, although perhaps not irrevocably if the period was not too long. Even where such a consideration does not apply, it is reasonable to assume that diffuse illumination may involve disuse of peripheral mechanisms, since 'on' and 'off' receptors would operate less frequently. Whether, in fact, rearing from birth under conditions of diffuse stimulation results in peripheral alteration awaits systematic study. In the present experiment, no histological difference could be found between the eye given diffuse stimulation and the eye given normal stimulation; but it should be remembered that this experience was necessarily very limited.

There are a few reports in the literature failing to find neural changes after rearing in darkness. Thus, Goodman[1] kept rabbits in the dark for 6 months, producing a clear behavioural deficit for vision. Unfortunately, data are not presented for the thickness of the inner plexiform layer of the retina, but only for the combined thickness of the optic fibre, ganglion cell, and internal plexiform layers, taken together. Nevertheless, this combined figure is smaller in experimental than control retinas. No counts of the optic tract are reported. But the density of cells in the superior colliculi of experimental brains was slightly greater than in control brains, as was, also, the density of pyramidal cells in the striate cortex. Both findings are consistent with a general notion of reduction of fibre field density. Interestingly enough, the lamina molecularis of the striate cortex, which is almost exclusively a fibre layer, was slightly thicker in controls than in experimental animals. All these differences are admittedly slight; but, since only group averages are reported, it is impossible to apply statistical treatment. The direction of the differences would, in general, support my findings.

Chow[8] kept two monkeys in total darkness for 8 months. The only retinal measure reported, however, was the density of ganglion cells, which did not differ from the control figures. There was no change in cell density in the lateral geniculate. Fibre counts are not reported.

It should be made clear that my findings do not rule out the hypothesis that sensory learning may occur as a necessary part of development. They merely cast doubt on the use of total sensory deprivation as a method of testing the hypothesis. While it might be convenient for psychological theory for sensory deprivation to produce changes limited to central neural structures, it is not convenient, perhaps, for the nervous system itself to make such a distinction.

This work was begun in the University Laboratory of Physiology, Oxford. My thanks are due to Prof. E. G. T. Liddell for the use of facilities and animals, to Messrs. Leach and Chesterman for invaluable advice and help in histological processing of the retinas, and to Mr. R. Hutchison for assistance throughout the entire experiment.

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CELL-WALL SYNTHESIS BY *STAPHYLOCOCCUS AUREUS* IN THE PRESENCE OF CHLORAMPHENICOL

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During investigations of the effect of chloramphenicol on the level of free amino-acids within growing cells of *Staphylococcus aureus* (strain Duncan)[1] it was necessary to measure the rate at which synthesis of cell material in the presence of the antibiotic was responsible for removal of amino-acids from the internal pool. Since chloramphenicol at the concentration used (50 μgm./ml.) causes complete inhibition of protein synthesis (measured by increase in 5 per cent trichloracetic acid-insoluble L-glutamic acid) in *S. aureus*[2], it was surprising to find that the increase in hot-trichloracetic acid-insoluble nitrogen in the culture was only inhibited to the extent of 70 per cent (measured over a period of 1 hr.). It seemed possible that this increase in the presence of chloramphenicol represented synthesis of the hexosamine-peptide polymer which in many Gram-positive bacteria is the predominant component of the cell wall; in *S. aureus* this polymer contains two hexosamines, glycine, D- and L-alanine, L-lysine and D-glutamic acid[3,4]. Accordingly, in the experiment described in Table 1, cells grown for 60 min. in the presence of chloramphenicol (50 μgm./ml.) were analysed for hot-trichloracetic acid-insoluble nitrogen before and after solubilization of the cell wall by complete digestion with the enzyme lysopeptidase, which specifically degrades the cell wall of *S. aureus* and is without detectable proteolytic activity[5]. It can be seen that all the increase in hot-trichloracetic acid-precipitable nitrogen in the presence of chloramphenicol can be ascribed to an increase in lysopeptidase-sensitive

Table 1

Time (min.)	Optical density of culture at 700 mμ	Hot-trichloracetic acid-insoluble nitrogen (μgm./ml. culture)	
		Control	Treated with lysopeptidase
0	0·35	46	34
60	0·41	63	35
60*	0·69*		

* Culture without chloramphenicol

Chloramphenicol (50 μgm./ml.) was added at time 0 to a culture of *S. aureus* (strain Duncan) growing exponentially in 2 per cent peptone–2 per cent glucose medium. Cells were harvested at time 0, and after 60 min., washed and an aliquot treated with lysopeptidase (50 μgm./ml.) for 15 hr. Hot-trichloracetic acid–insoluble nitrogen was determined on treated and control samples.

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* National Science Foundation Senior Post-Doctoral Fellow.

Table 2

Carbon-14 amino-acid	Total		Protein		Cell wall	
	Control (counts/min.)	Inhibition (per cent) + chloramphenicol	Control (counts/min.)	Inhibition (per cent) + chloramphenicol	Control (counts/min.)	Inhibition (per cent) + chloramphenicol
L-Leucine (2,900)*	5,135	92	4,917	98	234	95
L-Proline (6,650)	4,230	95	4,200	97	14	90
L-Phenylalanine (9,560)	7,170	94	7,050	94	58	92
Glycine (3,750)	24,400	37	8,700	90	15,700	8
L-Lysine (7,180)	31,400	71	21,050	96	10,850	6
L-Alanine (1,410)	8,700	54	4,320	85	4,300	5
L-Glutamic acid (8,100)	25,950	82	20,100	97	5,850	4
Increase in hexosamine (µmoles)	1·3	0	0	0	1·3	0

* Final specific activity, counts/min./µmole.

An equal quantity of an amino-acid uniformly labelled with carbon-14 was added to each of a pair of cultures of *S. aureus* (strain Duncan) growing exponentially in synthetic medium (ref. 1); chloramphenicol (50 µgm./ml.) was added to one flask. After 45 min. at 37° C., cells were harvested and fractionated as described. Samples were taken for radioactivity determinations using 'infinitely thin' samples, and hexosamine was determined by the procedure of Boas (ref. 6).

material, suggesting that under these conditions synthesis of cell-wall material continues although protein synthesis is completely inhibited.

Confirmation of this finding was sought using amino-acids labelled with carbon-14. A method developed in this laboratory was used for preparation of cell-wall fractions which allows rapid sampling, quantitative recovery and avoids the possibility of autolytic degradation during preparation. This procedure will be described in detail elsewhere; it entails extraction of cells with 5 per cent trichloracetic acid at 100° C. for 15 min. and digestion of the residue at 37° with trypsin (500 µgm./ml.) in 0·01 *M* ammonium bicarbonate (*p*H 8·0) until the optical density at 700 mµ ceases to drop; the residue is washed in ammonium bicarbonate and in 1 *N* ammonia. From the following evidence it appears that this fraction consists of all the cell-wall material contaminated with not more than about 5 per cent of cytoplasmic protein:

(*a*) After hydrolysis and separation of the amino-acids by paper chromatography, more than 90 per cent of the ninhydrin-reacting material is accounted for by alanine, glycine, lysine and glutamic acid, the characteristic amino-acids of *S. aureus* cell walls[3]. All the hexosamine of the cell, estimated by the procedure of Boas[6] after hydrolysis in 6 *N* hydrochloric acid for 5 hr. at 105°, is present in this fraction (Table 2).

(*b*) Less than 5 per cent of the radioactivity incorporated into growing cells from labelled non-wall amino-acids appears in this fraction, but between 22 per cent (glutamic acid) and 65 per cent (glycine) from wall amino-acids (Table 2).

(*c*) On treatment with lysopeptidase the turbidity of such preparations falls by 90 per cent, and from preparations containing carbon-14 in all the wall amino-acids 96 per cent of the radioactivity becomes non-sedimentable (3,000*g* for 30 min.) and 31 per cent becomes dialysable. It was considered that the ease of quantitative recovery and the small amount of contamination with cytoplasmic protein made such preparations suitable for studies of cell-wall synthesis.

The incorporation of amino-acids labelled with carbon-14 into the cell wall and protein of *S. aureus* (strain Duncan) during 45 min. growth in synthetic medium[1], together with the effect of 50 µgm./ml. chloramphenicol, is presented in Table 2. Considering the fraction insoluble in hot trichloracetic acid as a whole, the chloramphenicol-sensitive incorporation appears to be exclusively into the protein; incorporation into the cell wall is insensitive to chloramphenicol at this concentration (incorporation of alanine into the cell wall is unaffected by chloramphenicol at concentrations up to 500 µgm./ml.). Over longer periods some inhibition of wall synthesis is observed; this is probably because chloramphenicol prevents the

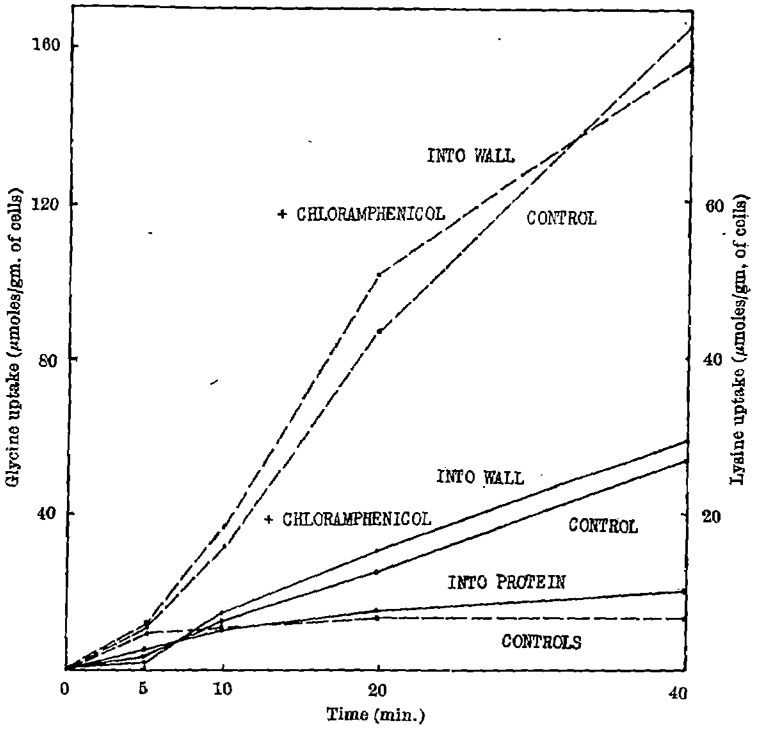

Fig. 1. Rate of incorporation of lysine (——) and glycine (– – –) into *S. aureus H.* Cells were harvested from nutrient broth when the cell population reached 0·5 mgm. dry weight/ml., washed, resuspended at a concentration of 1 mgm./ml., and shaken at 37° C. in the following medium which contained, per ml.: L-lysine, 0·5 µmole; glycine, 0·5 µmole; L-glutamic acid, 2 µmoles; DL-alanine, 2 µmoles; uracil, 20 µgm.; glucose, 4 mgm.; phosphate buffer, *p*H 7·0, 80 µmoles; magnesium sulphate, 1 µmole; manganese chloride, 0·1 µmole; thiamin, 2 µgm.; nicotinic acid, 1 µgm. Uniformly-labelled amino-acid (0·1 µc./ml.) was used and the cells were fractionated as described in the text

formation of the wall-synthesizing system so that wall synthesis is linear, compared with an exponential control. Moreover, the wall synthesized in the presence of chloramphenicol appears to be normal in at least two respects: the ratios of increases in glutamic acid : glycine : alanine : lysine : hexosamine were 1 : 5·8 : 4·2 : 2·0 : 1·8, compared with ratios of 1 : 6·3 : 2·8 : 1·9 : 1·8 in the wall present initially, and the extent of digestion by lysopeptidase (which is probably the result of a highly specific structure in view of the limited specificity of the enzyme[5]) was the same in wall synthesized in the presence and in the absence of chloramphenicol.

It has been found that *S. aureus* (strain *H*) will synthesize cell-wall material under conditions in which amino-acid incorporation into the protein fraction is severely reduced by the absence of essential amino-acids. As shown in Fig. 1, in the presence of L-lysine, alanine, glutamic acid, glycine, uracil and glucose, *S. aureus* (strain *H*) will almost double its wall in 40 min. as measured by the incorporation of lysine or glycine. The rate of synthesis of new wall material is linear, and chloramphenicol (20 μgm./ml.) has no significant effect on this synthesis.

Hence, in both growing cells and cells in which the synthetic activity is directed predominantly towards wall synthesis, chloramphenicol has no inhibitory effect on this synthesis. It is clear from these results that the fraction of bacterial cells insoluble in hot trichloracetic acid cannot be regarded as homogeneous with respect to the incorporation of labelled amino-acids, particularly in the case of the Gram-positive bacteria, where the hexosamine-peptide polymer may account for 30 per cent or more of the material insoluble in hot trichloracetic acid (Park, J. T., unpublished work). It is probable that hexosamine-peptide structural elements similar to those occurring in the Gram-positive cell wall are present also in the wall of Gram-negative bacteria, for example, *Escherichia coli*[7], but in smaller quantity; hence in all bacteria it is advisable to distinguish between amino-acid incorporation into the protein and that into cell-wall structures other than protein.

We are indebted to Dr. M. R. J. Salton for a preparation of lysopeptidase; this work was carried out during the tenure by one of us (R. H.) of a Medical Research Council Scholarship.

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A NOVEL TYPE OF AROMATICITY

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THE two ideas of aromatic character and the aromatic sextet are closely bound up together in aromatic hydrocarbon theory, but their association is not invariable, either in theory or, we believe, in practice. We present an outline of the theory of a second type of aromaticity and illustrate its application by reference to the monocyclic phosphonitrilic chlorides $(NPCl_2)_n$, which, certainly for $n = 3$ and 4 and possibly higher, display aromatic character without special preference for a group of six electrons.

Take a ring of $2n$ atoms, n of one species A and, alternating with them, n of a second species B. Let their Coulomb parameters be α_A and α_B, and their resonance integral be β, with non-neighbour interactions neglected. Each A and B has an orbital of the π-type to use in conjugation. If A and B are both carbon, or are carbon and nitrogen, or boron and nitrogen, both orbitals are $p\pi$. If A is carbon or nitrogen and B is phosphorus it is possible that one is $p\pi$ and the other $d\pi$.

The atoms A being numbered $k = 1, 2 \ldots n$ cyclically, the atoms B can be given the numbers $k + 1/2 = 3/2, \ldots n + 1/2$. Using molecular orbital theory of the simplest type, we begin with combinations of the sets A and B with irreducible symmetry:

$$A_l = n^{-1/2} \sum_{k=1}^{n} \exp(2\pi i l k/n)\, \varphi_k$$

$$B_l = n^{-1/2} \sum_{k=1}^{n} \exp\{2\pi i l\,(k + 1/2)/n\}\, \psi_{k+1/2}$$

φ_k denotes the π orbital at the kth centre, and $\psi_{k+1/2}$ that at the $k + 1/2$. l is the ring quantum number with allowed values $0, \pm 1, \ldots n/2$ or $\pm (n - 1)/2$ for n even or odd. Pairs of the same l have now to be combined to form molecular orbitals for the system. This leads in the usual way to a set of second-degree secular equations, one for each l value, of the form:

$$\begin{vmatrix} \alpha_A - \varepsilon & \chi \\ \chi^* & \alpha_B - \varepsilon \end{vmatrix} = 0$$

where

$$\chi = n^{-1} \sum_k \exp(-2\pi i l/2n) \int \varphi_k \mathbf{H} \psi_{k+1/2}\, d\tau$$

$$+ n^{-1} \sum_k \exp(2\pi i l/2n) \int \varphi_k \mathbf{H} \psi_{k-1/2}\, d\tau$$

H being the hamiltonian. Two cases only can occur: one is that of the aromatic hydrocarbons, and the other is distinct but not, so far as we are aware, hitherto recognized as such. They are illustrated in Fig. 1.

For convenience in fixing signs each member of the A set is generated by successive n-fold rotations from the first, and likewise in the B set. Then in case (1) every atom interacts with both its neighbours in the same way, that is,

$$\int \varphi_k \mathbf{H} \psi_{k+1/2}\, d\tau = \int \varphi_k \mathbf{H} \psi_{k-1/2}\, d\tau$$

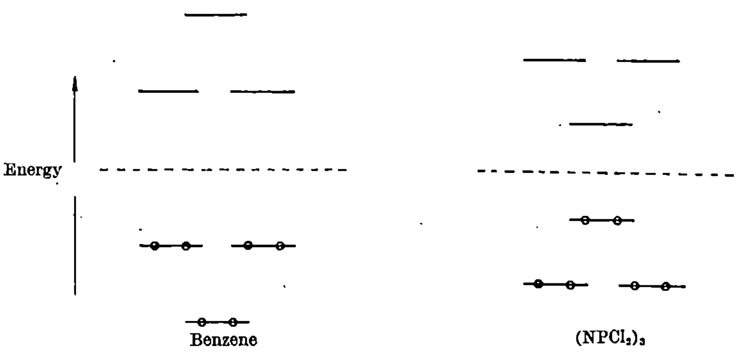

Fig. 2

This holds when A and B use the same species of atomic orbitals, both $p\pi$, or both $d\pi$, and also under somewhat wider conditions, as, for example, when A and B use orbitals which have in common both π-character and character for a reflexion σ_v. In case (2) the interaction of an atom with one neighbour is the negative of that with the other,

$$\int \varphi_k \mathrm{H} \psi_{k+1/2} \mathrm{d}\tau = -\int \varphi_k \mathrm{H} \psi_{k-1/2} \mathrm{d}\tau$$

as illustrated for $p\pi - d\pi$ interactions in the diagram. This case only occurs when A and B use different species of atomic orbitals and not always then. The orbitals must differ in character under σ_v.

Returning to the secular equation, for case (1) we find $\chi = \pm 2\beta \cos(\pi l/n)$, the sign depending on how the set of A orbitals is oriented, by initial choice, relative to the set of B. For benzene ($n = 3$, $\alpha_A = \alpha_B = \alpha$) this leads to the usual results for molecular orbital energies: $\varepsilon_0 = \alpha \pm 2\beta$, $\varepsilon_{\pm 1} = \alpha \pm \beta$ (both twice). In case (2) $\chi = \pm 2i\beta \sin(\pi l/n)$ leading to the energy expression

$$\varepsilon_l = (\alpha_A + \alpha_B)/2 \pm \{(\alpha_A - \alpha_B)^2 + 16\beta^2 \sin^2(l\pi/n)\}^{1/2}/2$$

For $n = 3$, $\alpha_A = \alpha_B = \alpha$, $\varepsilon_0 = \alpha$ (twice) $\varepsilon_{\pm 1} = \alpha \pm \sqrt{3}\beta$ (both twice). This example shows that the lowest energy is associated with ε_0 in case (1), with $\varepsilon_{\pm 1}$ in case (2); to be realistic we should allow α for the $2p\pi$ orbitals (for example, nitrogen) to be more negative than the $3d\pi$ (for example, phosphorus), and putting $\alpha_N = \alpha_P + \beta$ for purposes of illustration leads to the results shown in Fig. 2. The dotted line is placed at α_C for the benzene calculation and at $(\alpha_N + \alpha_P)/2$ for $(NPCl_2)_3$.

The differences between cases (1) and (2) run deep, but we wish now only to emphasize the matter of the aromatic sextet. The states $l = 0$ always lie at the extremes of the energy band in case (1), so that the top occupied orbital is always doubly degenerate in hydrocarbons. Closed shells associated with typically aromatic inertness therefore contain $4n+2$ electrons; $4n$ electron systems leave a half-filled orbital and are not aromatic. This is, of course, Hückel's rule, and the particular example of the stability of six compared with four and eight electrons supports the notion of the sextet. In case (2) the two states $l = 0$ have different symmetries and always (any n) lie adjacent to one another half-way up the energy band. Since except for exact equality in the electronegativity parameters of A and B these states are non-degenerate, a closed shell is obtained for any even number of electrons, both $4n$ and $4n + 2$. In the planar system in case (2) there is no preference for six over four or eight electrons, therefore no special stability is expected for a sextet. On the contrary, the energy per π-electron rises slowly but monotonically with the number of electrons to a limiting value, so that for planar molecules eight electrons are more stable than six. Fully in harmony with this is the fact that both the trimeric and tetrameric ($n = 3$ and 4) phosphonitrilic chlorides show unexpected stability and equal bond-lengths, both roughly speaking displaying equally well-developed aromaticity, in contrast to benzene and *cyclo*-octatetraene.

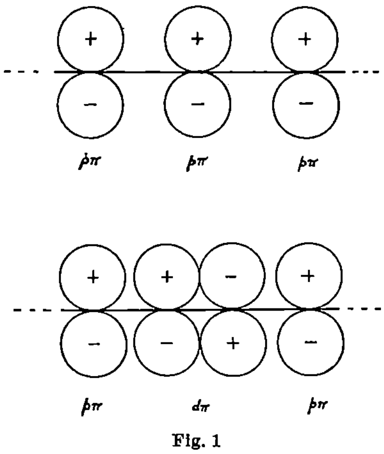

Fig. 1

In the phosphonitrilic halides there is the further consideration that the $p\pi - d\pi$ system is less affected by puckering than is the $p\pi - p\pi$ system, so that the probable non-planarity of the tetramer is not a serious hindrance to maintenance of aromatic interactions and need not affect arguments based on plane structures.

Conventional calculations of π-electron energies made for the case $\alpha_N = \alpha_P + \delta$, where δ is now used for the P–N resonance integral, are compared with the hydrocarbons in Table 1. Values are given per π-electron. We emphasize that the choice of α-values is an arbitrary one, and merely serves to indicate the pattern of the problem.

Table 1. CALCULATED ENERGIES PER ELECTRON

No. of electrons	4	6	8	10	12
Aromatic hydrocarbons $\alpha_C +$	$1{\cdot}0\beta$	$1{\cdot}33\beta$	$2{\cdot}20\beta$	$1{\cdot}30\beta$	$1{\cdot}24\beta$
$(NPCl_2)_n$ $\alpha_P +$	$1{\cdot}78\delta$	$1{\cdot}87\delta$	$1{\cdot}89\delta$	$1{\cdot}90\delta$	$1{\cdot}90\delta$

The alternation of values shown by the hydrocarbons, corresponding to the $4n + 2$ *versus* $4n$ rule, is not shown by the phosphonitrilic halides. Both series approach limiting energies per π-electron with increasing size; but in the hydrocarbons successive members fall above ($4n + 2$ electrons) and below ($4n$), while in the second case the approach to the limit is always from below, showing that if π-electrons were the only consideration, bigger molecules would be favoured over smaller ones. These quantitative results are, however, secondary to the main point, which is the distinction between the two types of aromaticity; this distinction depends on symmetry and is independent of the more disputable quantitative features of π-electron theories.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Variation in the Speed of Rotation of the Earth since June 1955

Time and frequency comparisons have been made since June 1955 between the National Physical Laboratory, Teddington, and the U.S. Naval Observatory, Washington, with the ultimate purpose of establishing the value of the transition frequency of cæsium, (4,0) $\rightleftharpoons$ (3,0), in terms of the second of Ephemeris Time based on the orbital motion of the Moon[1,2]. The second of Ephemeris Time is being determined at the Naval Observatory from photographic observations of the Moon, and will be reported on later.

As an intermediate step, the frequency of cæsium is currently being determined with respect to the second of Universal Time, called UT2, which is based on the rotation of the Earth. This frequency is denoted ν_U. The intervals between time signals from *WWV* (Washington, D.C., U.S.A.) and *GBR* (Rugby, U.K.) are measured at the National Physical Laboratory in terms of the cæsium standard, and at the Naval Observatory in terms of UT2. By using signals near the first of each month, the average frequency for the intervening month is intercompared with a probable error of 3 parts in 10^{10}.

If it is assumed that the time occupied by a specified number of vibrations of the National Physical Laboratory standard is constant, we may use it to determine changes in the speed of rotation of the Earth. Such changes would be indicated by changes in ν_U. The precision of the cæsium standard is so high that the accuracy with which the changes in speed of rotation can be determined depends almost entirely on the accuracy with which Universal Time can be determined. The results given here are based on observations made with the photographic zenith tubes at Washington, D.C., and Richmond, Florida, which are known to be instruments of high accuracy.

In order to interpret changes in ν_U, it is necessary to describe the types of variation in speed of rotation and how UT2 is computed.

There are three types of variation in speed: secular, irregular and periodic. The first, due to tidal friction, is too small to be significant here. Irregular variation refers to departures from the average speed of rotation which continue for the order of 5 or 10 years. This effect has been surmised but not previously exhibited. Periodic terms have been found with periods of 1 year, 0·5 year, 27·6 days and 13·6 days[3]. The first two of these terms comprise what is known as the seasonal variation.

By international agreement, an empirical correction for seasonal variation has been applied since January 1, 1956, in obtaining the time called UT2. The formula adopted by the Bureau International de l'Heure is:

$$\Delta SV = 0{\cdot}022^s \sin 2\pi t - 0{\cdot}017^s \cos 2\pi t - 0{\cdot}007^s \sin 4\pi t + 0{\cdot}006^s \cos 4\pi t$$

where t is the fraction of a year.

The terms of period 27·6 days and 13·6 days are eliminated by the smoothing process used in obtaining the adopted UT2 published in the *Time Service Bulletins* of the U.S. Naval Observatory. Hence, UT2 represents, in effect, the speed of rotation of the Earth when freed of periodic terms.

The values of ν_U since June 1955 are shown in Fig. 1. In addition to month-to-month variations which are of an accidental nature, there is seen to be a systematic trend. The length of the day was a minimum about September 1955 (speed of rotation at maximum) and has been increasing at a practically constant rate since then (speed of rotation decreasing).

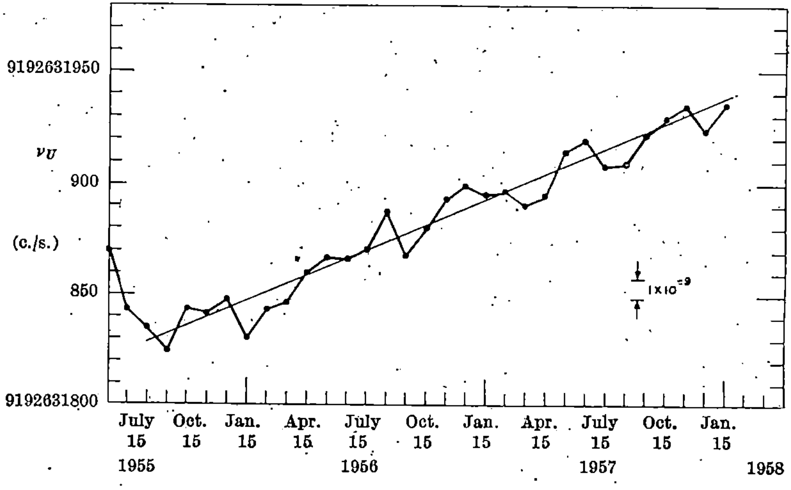

Fig. 1. Frequency of the cæsium resonance in terms of UT2

ν_U can be well represented since September 1955 by a straight line. This means that the seasonal variation for the past two years as determined with the aid of the cæsium standard is practically the same as determined with the aid of quartz-crystal clocks for several years previous to 1955.

Fig. 1 represents the non-periodic portion of the variation in the speed of rotation of the Earth. Since September 1955, this has been a constant deceleration of 5 parts in 10^9 per year, equivalent to an increase in the period of rotation of 0·43 msec. a year. This deceleration is about fifty times as large as that attributed to tidal friction. It is probable that it represents the irregular variation, but further observations are needed to confirm this.

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Effect of the Earth's Equatorial Bulge on the Life-time of Artificial Satellites and its use in determining Atmospheric Scale-Heights

PREVIOUS correspondents[1-3] have discussed the derivation of a simple formula for the life-time T of an Earth satellite. The formula concerned is:

$$T = \frac{3}{4}Pe\left(1 + \frac{7}{6}e + \frac{1}{2}kae\right)\Big/\left(-\frac{dP}{dt}\right) \qquad (1)$$

where P is the period, dP/dt the rate of change of period with time, e the eccentricity, a the semi-major axis and $1/k$ the atmospheric scale-height. This formula is valid provided e is both sufficiently small and sufficiently large, and the last two terms on the right-hand side (given here for the first time) indicate the limitations on e.

From various sets of available orbit data, I find that the descent dates predicted by (1) vary with the epoch of the data, more recent data leading to earlier descent dates. For the Sputnik 1 sphere ($1957\alpha_2$), data of October 15 give January 30 (± 4), whereas data of November 9 give January 18 (± 2). The actual descent date was about January 2. For Sputnik 2 (1957β), data of November 9 give June 24 (± 10), whereas data of February 4 give April 30 (± 1). Although these dates refer strictly to the time when the orbit becomes nearly circular, they should be only a few days short of the descent dates.

This shortening of the life-time is attributed to the fact that the perigee points of both satellites have been rotating slowly towards the equator and hence, on account of the equatorial bulge, into denser air. The perigee of sphere $1957\alpha_2$ moved from 42° N. to 5° N. during its life-time; whereas for 1957β, the perigee was initially at about 53° N., and will reach the equator by March 19. An equatorial radius is in excess of a radius at latitude 45° by 11 km., and so the bulge is equivalent to an air-density change of about 60 per cent in the 200-km. altitude region. Formula 1 should therefore not be applied without considering the latitude variation of perigee. The neglect of this effect in Scott's[2] estimates happened to compensate for the omission of the last two terms in (1), so leading to surprisingly good predictions.

My attention was first directed to the effect of the equatorial bulge on perigee air-density ρ by the values in Table 1, which were derived from the formula:

$$\rho = \frac{1}{3\varkappa}\frac{(1-e^2)^{1/2}}{(1+e)^2}\left(\frac{2ke}{\pi a}\right)^{1/2}\left(-\frac{dP}{dt}\right) \qquad (2)$$

where $\varkappa = SC_D/m$, S being the effective cross-sectional area and m the mass of the satellite, and C_D the drag coefficient. (This formula is valid so long at e is not too small; and, in all cases considered, the contributions from higher-order forms and the effect of the Earth's oblateness amount to only of the order of a per cent.)

Perigee air-density values cannot be guaranteed to better than about 30 per cent on account of uncertainties in k and $\varkappa$. Density ratios relating to the same satellite object are, however, independent of k and $\varkappa$ and should be accurate to a few per cent. Thus the perigee air-density for 1957β increased between November 9 and February 3 by a factor of 1·51(±0·06). The change in perigee distance between two epochs can be shown to correspond to a change of density of approximately

Table 1. VALUES OF AIR DENSITY IN THE REGION OF 200-KM. ALTITUDE

Object	Sphere, $1957\alpha_2$*	Sphere, $1957\alpha_2$*	$1957\alpha_1$†	Rocket, 1957β‡	1957β‡
Epoch of data	October 15	November 9 (approx.)		February 3	
Perigree latitude	37° N.	26° N.	26° N.	49° N.	19° N
Perigree height (km.)	206 (±7)	201 (±4)	202 (±4)	211 (±4)	197 (±1)
Perigree air density (gm./c.c.)§	$5·4\times10^{-13}$	$6·7\times10^{-13}$	$7·3\times10^{-13}$	$4·6\times10^{-13}$	$7·0\times10^{-13}$

* C_D taken equal to 2.

† $\varkappa$ taken equal to 1·8 times that of sphere $1957\alpha_2$ (as derived from the ratio of their initial rates of change of period with time).

‡ $\varkappa$ taken equal to 5–6 times that of rocket $1957\alpha_1$ on account of its greater mass.

§ Scale-height $1/k$ taken to be 25 km. Equation 2 shows that ρ varies inversely as the square root of the scale-height.

$$\rho/\rho_0 = (ae_0/a_0e)^{1/2} \qquad (3)$$

and this amounts to only 1·17 (± 0·01) for 1957β between November 9 and February 3. The discrepancy between these two factors, amounting to 1·29 (± 0·05), can be satisfactorily accounted for by the increase of 9·8 km. in the Earth's radius between 49° N. and 19° N. The value obtained for the atmospheric scale-height is then 39 (± 6) km. The data for perigee-height for 1957β in Table 1 enables the scale-height to be determined as 34 (± 11) km.

For sphere $1957\alpha_2$ the height data above are not sufficiently accurate for the scale-height to be found; but use can be made of the fact that 3·7 km. of the change arises from the equatorial bulge. Of the observed increase in air density by a factor 1·24 (± 0·05), a factor 1·08 (± 0·02) of this arises from the decrease in perigee distance as calculated from equation 3, so leaving a factor of 1·15 (± 0·06) attributable to the 3·7-km. change in height. This leads to a value of 26 (± 9) km. for the scale-height.

More accurate orbital data, particularly on the rate of change of period, are needed to take full advantage of the above method. It may then be possible to study the variations of scale-height with latitude.

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Application of the Kurie Plot to the Standardization of Pure Beta-Emitters

THE standardization of pure β-emitting nuclides becomes increasingly difficult as the energy of the radiation decreases, because of absorption and scattering effects which occur at the low-energy end of the β-spectrum. It may be possible to circumvent these effects by a technique employed by Waggoner, Moon and Roberts in connexion with a magnetic β-ray spectrometer[1]. This method consists of extrapolating to zero the straight Kurie plot which should be obtained for a single allowed β-ray transition. It is the purpose of this communication to show the relation between the slope of the Kurie plot and the absolute disintegration-rate of a radioactive source, and to describe the proposed method of application to 4π-counting.

The notation adopted is that used by M. E. Rose[2]. For the sake of clarity, simplified equations are used which refer to allowed β-spectra only. The β-spectrum can be represented by a simplified form of the well-known Fermi equation:

$$N(W)\mathrm{d}W = K^2(W_0 - W)^2 pWF(Z,W)\mathrm{d}W \qquad (1)$$

where $N(W)\mathrm{d}W$ is the probability per unit time that an atom will emit a β-particle in the energy range W to $W + \mathrm{d}W$; p is the momentum of the β-particle and W is its total energy; W_0 is the energy released in the nuclear transition; $F(Z, W)$ is the Coulomb field factor (Z referring to the daughter nucleus) and K^2 is a constant independent of W. The Coulomb field factor is also known as the Fermi function, and has been well tabulated for a range of Z and W values[2,3]. A measurement of the spectrum $N(W)\mathrm{d}W$ is made by means of a β-ray spectrometer the transmission factor of which is T. T is defined as the fraction of the particles emitted in a given energy-range detected by the spectrometer counter. If the number of atoms in the source is n, then the number of particles detected per unit time by the counter in the energy interval W to $W + \mathrm{d}W$ is

$$N_\beta(W)\mathrm{d}W = nTN(W)\mathrm{d}W \qquad (2)$$

where $N_\beta(W)\mathrm{d}W$ has been corrected for background and dead-time.

Equations 1 and 2 can be rearranged to give

$$\left(\frac{N_\beta(W)}{pWF(Z,W)}\right)^{1/2} = (nTK^2)^{1/2}(W_0 - W) \qquad (3)$$

which is the equation used for obtaining the Kurie plot. The left-hand side of (3) is plotted against W, as shown in Fig. 1. The graph is linear until the low-energy region is reached, and then deviates from a straight line because in this region the transmission T varies with the energy W. The variation is caused by the absorption and scattering of the low-energy β-particles. Over that portion of the Kurie plot which is linear, T is constant, and the square of the slope gives nTK^2, that is:

$$\tan^2\theta = nTK^2 \qquad (4)$$

By definition

$$\lambda = \int_1^{W_0} N(W)\mathrm{d}W \qquad (5)$$

where λ, the decay constant, is the probability of decay per unit time, and from (1):

$$\int_1^{W_0} N(W)\mathrm{d}W = K^2 \mathrm{f}(Z,W_0) \qquad (6)$$

where

$$\mathrm{f}(Z,W_0) = \int_1^{W_0} (W_0 - W)^2 pWF(Z,W)\mathrm{d}W \qquad (7)$$

Also, the law of radioactive decay can be expressed in magnitude as:

$$N_0 = \lambda n \qquad (8)$$

where N_0 is the number of atoms disintegrating in unit time.

Therefore, by rearranging (5), (6) and (8):

$$N_0 = nK^2\mathrm{f}(Z,W_0) \qquad (9)$$

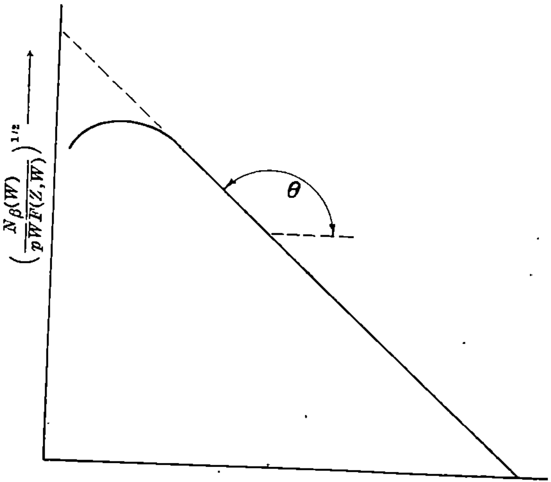

Fig. 1. Kurie plot of a pure β-emitter, according to equation (3); $\tan^2\theta = nTK^2$

and combining (4) and (9)

$$N_0 = \frac{\mathrm{f}(Z,W_0)}{T} \cdot \tan^2\theta \qquad (10)$$

Numerical values of $\mathrm{f}(Z,W_0)$ have been extensively tabulated[4]. If T is also known, then the absolute disintegration-rate of a radioactive source can be derived directly from the slope of the Kurie plot by using (10).

A β-spectrometer for this work need not possess high resolution, but it is necessary that its transmission be accurately known, and that its response either be linear or also accurately known. It would seem that 4π-counters are ideally suited in this first respect, because their transmission factor over the linear portion of the Kurie plot is unity. It is also possible to construct gas proportional counters the response of which is linear, by taking care to keep the gas gain constant[5]. Thirdly, it is necessary, over the energy-range which is of interest, that the β-particle shall expend its entire energy in the sensitive volume of the counter. This can be arranged by operating the counter at a suitable high pressure[6]. The design of a suitable high-pressure proportional counter is therefore being investigated and the accuracy of this method, compared with integral $4\pi\beta$ counting, is being assessed.

This work forms part of the research programme of the National Physical Laboratory, and is published by permission of the Director.

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Photoelectric Response of Selenium-type Photovoltaic Cells to X-Rays

A COMMERCIALLY available selenium-type photovoltaic cell was irradiated with X-rays produced with a commercial type of low-voltage X-ray tube with a thermionic cathode and an inclined copper target. Lead covers with circular apertures of different diameters were placed over the photocell to alter the flux of X-rays on the surface of the cell at a constant X-radiation intensity, and the X-radiation intensity was varied by changing the anode current of the X-ray tube. Fig. 1 shows a family of curves representing the photocell current, I_p, as a function of the X-ray tube anode current, I_a, with the anode voltage, V_a, as parameter, the curves having been obtained with a distance of 25 mm. between the photosensitive surface of the cell and the centre of the target of the X-ray tube, 17·5 mm. of the distance being in the vacuum space of the tube, 1·5 mm. the thickness of its cylindrical envelope of soda-lime glass, and the remainder of the air space between the tube and the photocell surface. The curves marked *A* refer to an aperture of 240 mm.^{2} in the lead cover, and those marked *B* refer to a 60-mm.^{2} aperture.

The characteristics of Fig. 1 indicate a linear relation between photoelectric response and X-radiation flux irrespective of whether the flux is changed by altering the X-radiation intensity or by varying the size of the area of irradiation.

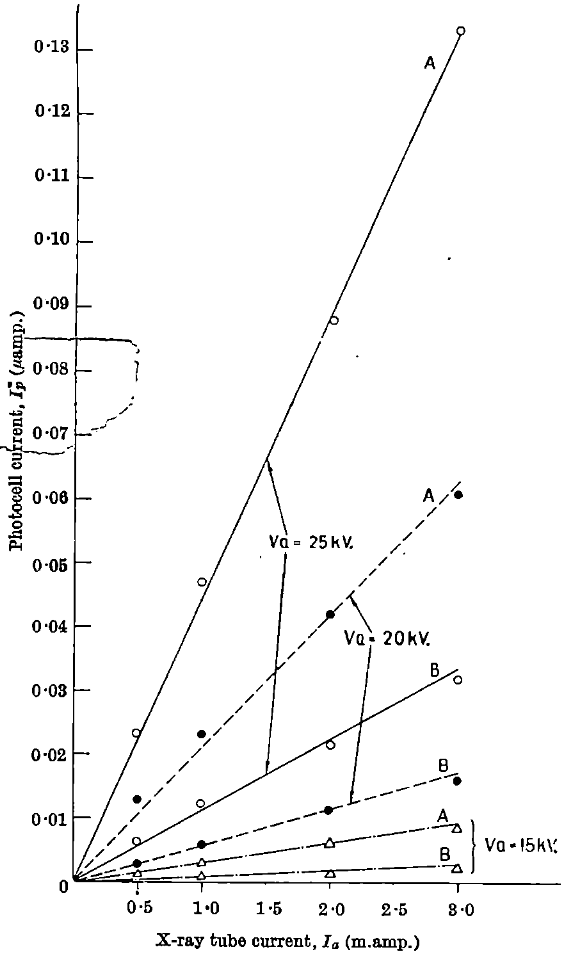

Fig. 1. Curves *A*, irradiation area, 240 mm.^{2}; curves *B*, irradiation area, 60 mm.^{2}

Increasing the aperture of the lead cover over the photocell to a diameter of 25 mm., compared with 17·5 mm. for obtaining the curves *A* in Fig. 1, demonstrated the reduction of radiation intensity towards the boundary of the X-ray beam. The photocurrent response indicated that the X-radiation flux increased only by 50 per cent, whereas it would have doubled if the X-radiation intensity had been uniform over the whole area of the aperture.

A second photocell of the same type gave a similar photoelectric response characteristic, but all photocurrent values were reduced to one-third of those of Fig. 1, although the two cells had the same photoelectric sensitivity to light. The fact that both cells were equally sensitive to light but differently sensitive to X-rays may probably be interpreted in terms of light being effective only at the surface of the photosensitive layer and X-rays being effective in its depth, and that there was a difference in the thickness and/or the structure of the photosensitive layers of the two cells. The depth effect of X-rays may possibly in part also account for the dependence of the photoelectric response on the anode voltage of the X-ray tube.

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Plasticity of Graphite

THE creep behaviour of graphite in the temperature range 1,300–2,000° C. has been examined for the first time. The experiments were carried out by applying loads to cantilevers heated *in vacuo* by the passage of an electric current and to spring specimens heated in a high-temperature high-vacuum furnace. The specimens were made in the laboratory by extruding a wide range of raw materials (pitch coke, petroleum coke, lamp black, cellulose and natural graphite). Springs of rectangular section were also machined from commercially manufactured materials (reactor graphite and commercial electrode graphite). The apparatus and techniques used in these experiments were similar to those used in dynamic experiments previously described[1].

It was found that, for a wide range of temperatures, raw materials, specimen geometries, flexural and torsional stresses, the creep deformation could be statistically fitted within the limits of experimental error to the function:

$$D_t = A + k \log_{10} t + Bt \qquad (1)$$

where D_t is strain at time t and t is time (min.).

A, *k* and *B* are constants for each experiment. Similarly, the creep recovery on removing the load conformed to the function:

$$D_t^1 = A^1 + k^1 \log t \qquad (2)$$

A typical creep curve is shown as a linearized plot in Fig. 1*a*. Fig. 1*b* is a plot of the deviations of the experimental points from the function determined by the method of least squares.

The coefficients *k* and *B* were linearly dependent on the applied stress at constant temperature and were related to the absolute temperature as follows:

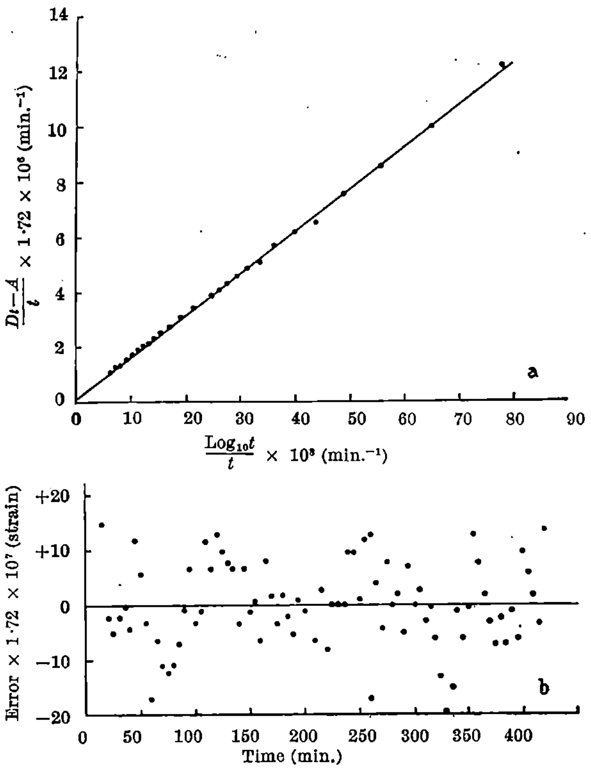

Fig. 1. (*a*) Linearized plot of typical creep curve; equation, derived by method of least squares: $D_t = 0{\cdot}87 \times 10^{-3} + 7{\cdot}0 \times 10^{-8}\, t + 8{\cdot}9 \times 10^{-5} \log_{10} t$. Graphitized cellulose carbon spring No. *C*12, temperature 1,560° C., maximum stress $8{\cdot}9 \times 10^7$ dynes/cm.^{2}. (*b*) Deviation of experimental points from the function derived by the method of least squares

$$k = K(\text{stress}) \exp\left(-\frac{\Delta E}{RT}\right) \qquad (3)$$

and

$$B = K^1(\text{stress}) \exp\left(-\frac{\Delta E^1}{RT}\right) \qquad (4)$$

where K and K^1, and ΔE and ΔE^1 are constants, R the gas constant and T the absolute temperature. The stress relationship is demonstrated in Fig. 2.

The linearity of the stress–strain relationship made possible the use of specimens in which the applied stress was not uniform throughout, and strengthens the belief that equation 1 relates to the structure of the graphites examined and not to the particular stress systems applied to the specimens.

The available evidence shows that $K = C/M$ in equation 3, where M is the elastic modulus at room temperature appropriate to the stress system applied and C a constant for all the materials studied. This is illustrated in Table 1. The product $\frac{k}{\text{stress}} \times M$ is a constant at each temperature.

It is therefore reasonable to rewrite equation 3 as follows:

$$k = \frac{C}{M}(\text{stress}) \exp\left(-\frac{\Delta E}{RT}\right) \; (C \simeq 13) \qquad (5)$$

Since modulus and stress should depend on the same function of the density, this treatment eliminates the effect of density from equation 5. The constant ΔE in equation 5 was found to have a value of 21 kcal./mole for petroleum coke and cellulose carbon springs, which were studied over a range of temperatures. Since the correlation between $\frac{k}{\text{stress}}$ and $\frac{1}{M}$ was found to be true at two temperatures, and if C is assumed to be a universal constant in equation 5, this leads to one value of 20 kcal./mole for all the materials, in reasonable agreement with the value quoted above. No such relationships were found for the coefficient B.

By examining repeated identical cycles of creep and recovery, it was shown that the Bt term in

Table 1. CORRELATION OF TRANSIENT CREEP COEFFICIENTS, STRESS AND ELASTIC MODULUS FOR A RANGE OF MATERIALS.

(*a*) Spring specimens at 1,560° C.

Material	Modulus of rigidity at room temperature G_0 dynes/cm.$^2 \times 10^{-10}$	$\frac{k}{\text{stress}}$ (dynes/cm.$^2)^{-1} \times 10^{12}$	$\frac{k}{\text{stress}} \times G_0$ $\times 10^2$
Commercial electrode graphite	1·33	5·41	7·2
Reactor graphite	1·53	3·69	5·6
Petroleum coke	3·0	1·92	5·8
Reactor graphite	3·23	1·79	5·8
Cellulose carbon	10·0	0·77	7·7
			Mean = 6·4

(*b*) Cantilever specimens at 1,900° C.

Material	Young's modulus at room temperature E_0 dynes/cm.$^2 \times 10^{-10}$	$\frac{k}{\text{stress}}$ (dynes/cm.$^2)^{-1} \times 10^{12}$	$\frac{k}{\text{stress}} \times E_0$ $\times 10^2$
Pitch coke	7·0	0·96	6·7
Petroleum coke (uncalcined)	9·0	1·52	13·7
Petroleum coke (calcined)	10·0	1·38	13·8
Lamp black	13·0	0·97	12·6
Cellulose carbon	14·0	0·87	12·2
Natural graphite	22·0	0·60	13·2
			Mean = 12·0

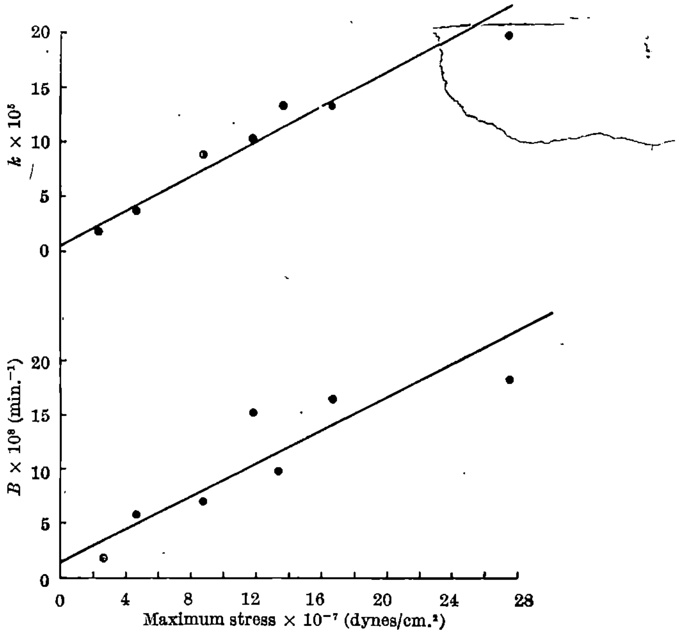

Fig. 2. Variation of creep equation coefficients with maximum applied stress for graphitized cellulose carbon spring specimens. Temperature, 1,560° C.

equation 1 contributed to a permanent set which could be removed only at graphitizing temperatures.

The effect of the gross grain structure on the plastic behaviour of graphite is not noticeable, since it appears possible to relate the transient term to the elastic modulus which, it has already been demonstrated[1], depends on the crystallite parameters of the 'grist' material. The steady-state term has not yet been found to be correlated with any of the known parameters of the materials.

This work forms part of a study of the plastic behaviour of graphite carried out under contract to the Atomic Energy Research Establishment, Harwell.

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Ease of Reduction of a Series of Coals and its Relation to their Structure

WE wish to report an interesting variation in the ease of reduction of coals and solvent extracts of coals with change in ash-free carbon content (change in rank).

Two methods of reduction, each initially involving electron transfer, have been used. They are the reduction of coal with lithium in ethylamine[1] and the controlled potential electrolysis of dimethylformamide extracts of coal in dimethylformamide. The latter was carried out in a cell similar to that used by Bergman and James[2] at $-2{\cdot}2$ V. (*versus* mercury pool) with $0{\cdot}1\,N$ tetraethylammonium iodide as supporting electrolyte: the electrolysis was followed by acetylation of the products *in situ* with acetic anhydride to prevent oxidation of hydroquinones produced from quinones present in the coal. Proton addition from the solvent normally follows electron addition from the lithium or from the mercury cathode[3]. In known aromatics a greater degree of reduction is effected by lithium in ethylamine than by electrolysis (for example, naphthalene is reduced to octalin[1] and to dihydronaphthalene[4] respectively).

The elementary analyses and infra-red spectra of the products showed that reduction had taken place; the electricity consumed in the electrolyses and the polarographic behaviour, in the case of solvent extracts, also supported this conclusion. Various measures of the degree of reduction are presented graphically in Fig. 1 as a function of the carbon content of the coal. The proportion of the reduced coals soluble in cold pyridine varied widely with the carbon content of the coal, and was very high for the coking coals (86–90 per cent carbon); it appears to be a valid and convenient index of the degree of reduction, and is also shown in Fig. 1. The results show that the extent of reduction of the coals increases markedly with increase in rank up to about 89 per cent carbon content and falls rapidly thereafter; that is, both low-rank coals and the anthracite show a marked reluctance, compared with the intermediate coking coals, to suffer addition of hydrogen. The solvent extracts show changes in the same sense, but less marked.

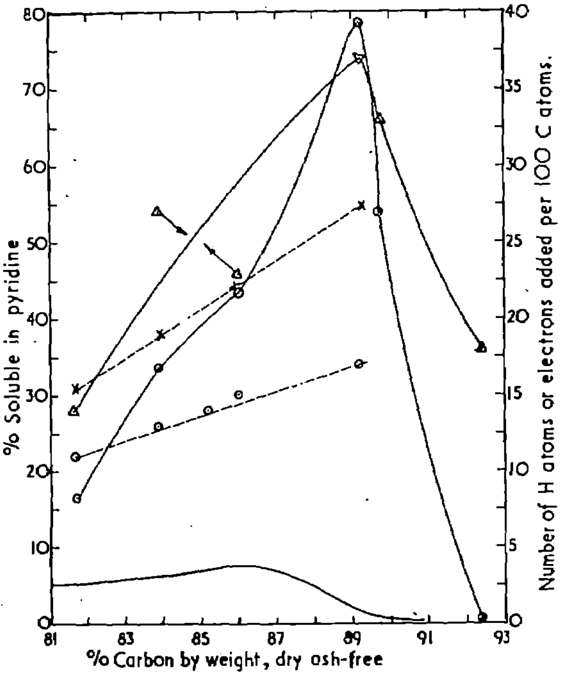

Fig. 1. Reduction of coals and coal extracts. ——, Coals: △, number of hydrogen atoms added per 100 carbon atoms (from elementary analysis); ⊙, per cent reduced coal soluble in pyridine (cold); —, per cent original coal soluble in pyridine (cold). – – – –, Coal extracts: ×, number of electrons added per 100 carbon atoms (from current consumption); ⊙, number of hydrogen atoms added per 100 carbon atoms (from elementary analysis). In calculating these figures the product reduced and acetylated at $-2{\cdot}2$ V. has been compared with that reduced and acetylated at $-1{\cdot}0$ V. where only quinone groups are reduced (ref. 12)

A further point arises from polarography of the products of electrolysis: although polarograms of the electrolysed solutions showed complete absence of waves, those of the products isolated from these solutions showed partial reappearance of the waves associated, in previous work[5], with aromatic reduction. This effect was most noticeable with the products from the low-rank coal extracts. The re-emergence of waves in the polarograms of the isolated products indicates a failure of the ions to complete the reduction by adding protons. This reluctance of the hydrocarbon ions to add protons evidently decreases with increase in rank of the coal.

The only explanation we are able to suggest at present for these changes in behaviour with rank concerns the deformation from planarity which in general occurs when hydrogen is added to aromatic systems, or more specifically, on proton addition to a hydrocarbon ion. Presumably this deformation of structure can only occur to a limited extent with low-rank coals, which indicates that the aromatic systems are held in a rigid cross-linked structure. The greater ease of deformation in the coals of higher rank would therefore indicate less rigidity and consequently less cross-linking of the aromatic systems. This idea has already been suggested by Given[6] in connexion with the poor reduction of a low-rank coal with lithium in ethylamine. Some confirmation for the idea can be deduced from the work of J. K. Brown[7], who, from an estimate of the aliphatic/aromatic hydrogen ratio determined spectroscopically in a series of coals, concluded that in low-rank coals the greater part of the hydrogen is present in methylene groups with little appearing on aromatic rings and still less as —CH_3 (Brown, J. K., private communication, and ref. 8). This, together with Hirsch's[8] estimation of aromatic cluster size, suggests that the aromatic clusters in low-rank coals have little replaceable hydrogen; if therefore the clusters are highly substituted by alkyl side-chains the function of which is, in the main, to join one cluster to another, then the whole molecule, consisting of a number of clusters each tied to others by numerous linkages, would probably be particularly resistant to deformation. This resistance could slow down materially the rate of addition of hydrogen, and might even render the addition thermodynamically impossible. I. Wender (private communication, and ref. 10) has recently achieved a considerable degree of reduction of a low-rank coal with lithium in ethylene diamine at 100–117°. This suggests that the resistance to deformation slows down, but does not entirely prevent, addition of hydrogen.

The work of Brown and Hirsch also shows that there must be less aliphatic material and more aromatic hydrogen as rank is increased, in accordance with a more readily deformed structure. The argument applies to the coals studied up to about 89 per cent carbon content; the decreased ease of reduction beyond this point is probably due to the rapid increase in aromatic cluster size which is generally believed[7,9,11] to occur at this point.

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Electrocapillary Action of Corrosion Inhibitors

Indelli and Pancaldi[1] and I[2] have compared some characteristic phenomena occurring at the interface of a dropping mercury microelectrode and electrolyte solutions with phenomena encountered in corrosion inhibition[2]. It was found[2] that the effectiveness of numerous corrosion inhibitors is reflected in their ability to suppress various polarographic maxima (abnormal current peaks in the current-voltage curves of the mercury microelectrode). In particular, it was shown that the order of relative inhibiting effectiveness of a number of amine inhibitors (for the iron – sulphuric acid system) is the same as that of their effectiveness in suppressing certain polarographic maxima. These amines (both aliphatic and aromatic) were most effective in suppressing maxima corresponding to the negative branch of the electrocapillary curve at which mercury is negatively charged with respect to the solution. This is consistent with Mann's[3] conclusion that amines inhibit the corrosion of iron in sulphuric acid by becoming adsorbed on the cathodic areas of this metal. It was thus demonstrated that significant similarities exist between the processes involved in polarographic maxima and their suppression, on one hand, and in metallic corrosion and its inhibition, on the other[4]. Campbell[5] has also employed polarographic techniques in detecting corrosion inhibitors.

Based on similar reasoning, De[6] has recently proposed "A Unified Theory of the Mechanism of Inhibition of Corrosion of Iron in Acid and Neutral Media based on the Electrocapillary Behavior of Ions". This theory provides a basic approach to many aspects of corrosion inhibition processes. A few years ago, I obtained some experimental results on the electrocapillary properties of representative corrosion inhibitors; these results are quite pertinent to the above theory. Mercury was employed, since electrocapillary studies with solid metals present serious experimental difficulties.

The electrocapillary curves of mercury were obtained in 1 *N* sulphuric acid, 1 *N* hydrochloric acid and 0·1 potassium chloride by applying a potential across a dropping mercury electrode and a mercury pool. The dropping time, which is proportional to the surface tension of mercury, was employed in plotting the electrocapillary curves. The results obtained with aliphatic amines are shown in Fig. 1. It is seen that the inhibiting behaviour of these amines as discussed by Mann[3] is reflected in their electrocapillary properties; that is, their overall effect on the electrocapillary curve of mercury, their specific effect on the negative branch of the curve, and the shift of the electrocapillary maximum towards less negative values, increase with increasing molecular weight of the amines. This behaviour, of course, indicates that in acid solutions amines are adsorbed in the form of ammonium ions, $RNH_3{}^+$. The lower members of the aliphatic amines, namely, methyl- and ethyl-amine, in the concentration range considered, affected the electrocapillary curve only to a small extent.

Representative inorganic inhibitors were also tested for their effect on the electrocapillary curve of

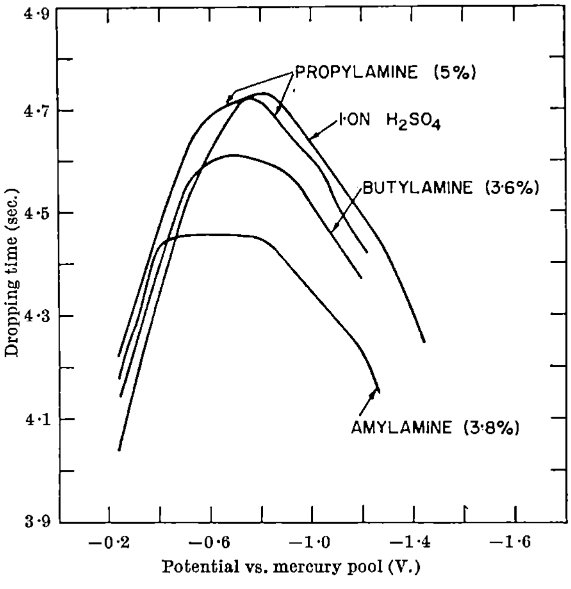

Fig. 1. Effect of aliphatic amines on the electrocapillary curve of mercury in sulphuric acid

mercury in 0·1 *N* sodium chloride and 0·1 *N* potassium chloride solutions. The following inhibitors were included at a concentration of 0·03 per cent: sodium tetraborate, sodium benzoate, trisodium orthophosphate, potassium dichromate, sodium nitrite and sodium silicate. All these inhibitors affected the positive (less negative) branch of the electrocapillary curve, indicating the adsorption of the anions of these inhibitors on the positively charged mercury surface. Such behaviour in this type of inhibitors is among the requirements of De's theory regarding solid metals.

In electrocapillary phenomena, particularly from the point of view of corrosion inhibition, competitive adsorption must be of importance. In aqueous solutions a number of ions are usually present which can compete for sites on a metal surface. Phenomena associated with such competitive processes should, therefore, be taken into consideration in an electrocapillary approach to corrosion inhibition. With this in mind, an attempt was made to determine the action of a given inhibitor on the electrocapillary curve which was obtained in the presence of another inhibitor. Among the above inorganic inhibitors studied, it was found that the effect of potassium dichromate on the electrocapillary curve was independent of any other inhibitor present. Alternatively, in a solution containing potassium dichromate, addition of one or more of the rest of the inhibitors had no further effect on the electrocapillary curve. This result can be considered as representing a case of competitive adsorption where dichromate ions are the most strongly adsorbing among the ions considered. They can thus displace the other ions from the mercury surface; the reverse process does not take place at the concentrations employed. Competitive adsorption in corrosion inhibition could probably be studied indirectly—by dissolution rates and/or electrode potential measurements—much more conveniently than by the electrocapillary action of inhibitors on solid metals.

These results on mercury cannot, of course, serve as a direct verification of the electrocapillary action of corrosion inhibitors; but they will encourage electrocapillary studies on solid metals.

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Influence of Metallic Ions on the Reaction of Ethylene Diamine with Epinephrine and Norepinephrine

THE reaction of ethylene diamine with epinephrine (and norepinephrine) leads to the formation of a highly fluorescent material which is used for the estimation of catechol amines in biological fluids according to a procedure first described by Weil-Malherbe and Bone[1] and slightly modified by a number of other workers.

We found that the presence of metallic ions, even in traces, greatly influences the intensity of fluorescence obtained by this reaction. Among the salts that possess such a marked catalytic action are chiefly aluminium chloride (or acetate) and copper sulphate, although Erne and Canbäck[2] have utilized ammonium molybdate for the same purpose. Ferric chloride, on the other hand, appears to decrease the fluorescence of epinephrine while copper sulphate decreases that of norepinephrine.

In the light of these findings, it is more than probable that the presence of aluminium salts in the eluate should be responsible, at least in part, for the increase of fluorescence observed when ethylene diamine is allowed to react with epinephrine dissolved in aqueous acetic acid solutions that have passed through an alumina column, as compared with solutions in pure acetic acid[3,4]. 10 ml. of acetic acid solution that had been passed through a column of 0·7 gm. of alumina prepared according to Weil-Malherbe and Bone were found to contain about 10 μgm. Al+++. The increase of fluorescence under such conditions was about 30 per cent. The addition of 10 μgm. Al+++ (in the form of acetate or chloride) to pure acetic acid increased the fluorescence by 17 per cent. The difference, however, could be explained by the presence of other impurities in alumina. Spectrographic analysis of one sample of purified product (Brickman and Co., suitable for chromatographic adsorption) revealed the presence of minute amounts of copper, iron, gallium and silicium. The influence of these elements on this reaction is under investigation.

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A Suggested Revision of Nomenclature—Angiotensin

THE vasoactive peptide resulting from the action of renin on an alpha-globulin was discovered by two groups of investigators with the result that it received two trivial names, angiotonin and hypertensin. Synthesis of the octapeptide has now confirmed the identity of this peptide and justifies dropping the double nomenclature. We propose the simplified name, angiotensin, and its derivatives angiotensinase and angiotensinogen. Angiotensin is a hybrid word but does, we think, have the advantage of being easy to pronounce even with a variety of accents, is euphonious, and is understandable despite the most recalcitrant microphone.

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Allelomorphism and the Chemical Differences of the Human Hæmoglobins *A*, *S* and *C*

IN previous communications on this subject, one of us[1,2] reported that normal human hæmoglobin (*A*) and sickle-cell hæmoglobin (*S*) differ in only one out of nearly 300 amino-acids in the half-molecule, and that this is the only demonstrable difference in primary chemical structure. We now wish to report on a similar investigation into the structure of another abnormal human hæmoglobin—that of hæmoglobin *C* disease.

The protein was obtained from individuals known to be homozygous for the hæmoglobin *C* gene. It was first denatured by heat and then digested with trypsin, and the resulting mixture of peptides was analysed by the two-dimensional combination of paper electrophoresis and paper chromatography called 'fingerprinting'[1,2]. The trypsin-resistant 'core' of hæmoglobin *C* was treated with hydrochloric acid–acetone to remove the hæm group. It was then made completely soluble by digestion with chymotrypsin, resulting in a second mixture of peptides. Further examination followed, both by fingerprinting and by more detailed paper chromatography and electrophoresis of groups of peptides from those parts of the fingerprints where the resolution had not been good enough.

When fingerprints of both the chymotryptic and tryptic digests were compared with those of hæmoglobins *A* or *S*, all the peptides of the normal protein were found in their correct positions with the exception of one, which had disappeared. Its place was taken by two peptides in new positions (Fig. 1). The missing peptide is No. 4, the same one which carries the difference between hæmoglobins *A* and *S*. Therefore it is clear that the identical portion of the hæmoglobin *A* molecule is involved in the change to hæmoglobin *C*. Moreover this appears to be the only change, since all the other peptides in the tryptic fingerprint had amino-acid compositions indistinguishable from those of their hæmoglobin *A*, or *S*, counterparts. The peptides of the 'core' still remain to be analysed.

The two new hæmoglobin *C* peptides, called 4*a* and 4*b*, were isolated from tryptic digests by eluting appropriate peptide bands obtained by paper electrophoresis[3], at pH 6·4 at 20 V./cm.; this was followed by a second purification using cooled paper electrophoresis at pH 3·6[3] and 35 V./cm. The amino-acid composition and the N-terminal amino-acid of each peptide were determined qualitatively using the methods previously described[2]. The sequence of amino-acids was found by partial acid hydrolysis and end-group analysis[4] of the products.

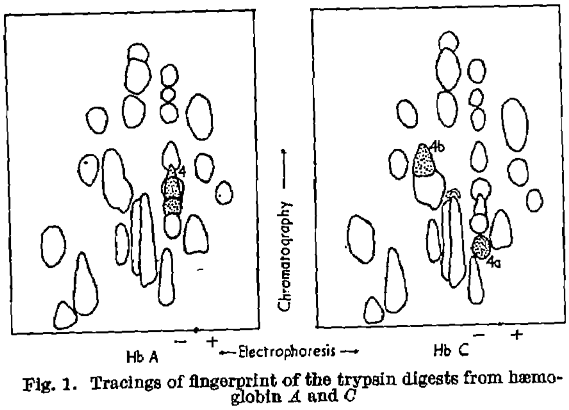

Fig. 1. Tracings of fingerprint of the trypsin digests from hæmoglobin *A* and *C*

Table 1. STRUCTURE OF THE HÆMOGLOBIN *A* AND *S* NO. 4 PEPTIDES AND THE HÆMOGLOBIN *C* NOS. 4*a* AND 4*b* PEPTIDES

(His = histidyl-, Val = valyl-, Leu = leucyl-, Thr = threonyl-, Pro = prolyl-, Glu = glutamyl-, Lys = lysine).

Hæmoglobin *A* . . .	$\uparrow\ \overset{++}{\text{His}}\text{–Val–Leu–Leu–Thr–Pro–}\overset{-}{\mathit{Glu}}\text{–}\overset{-}{\text{Glu}}\text{–}\overset{+-}{\text{Lys}}\ \uparrow\ \ldots$
Hæmoglobin *S* . . .	$\uparrow\ \overset{++}{\text{His}}\text{—Val—Leu—Leu—Thr—Pro—}\mathit{Val}\text{—}\overset{-}{\text{Glu}}\text{—}\overset{+-}{\text{Lys}}\ \uparrow\ \ldots$
Hæmoglobin *C* . . .	$\uparrow\ \overset{++}{\text{His}}\text{–Val–Leu–Leu–Thr–Pro–}\overset{+-}{\mathit{Lys}}\ \uparrow\ \overset{+-}{\text{Glu}}\text{–}\overset{+-}{\text{Lys}}\ \uparrow\ \ldots$

The amino-acid sequences of the No. 4*a* and 4*b* peptides from hæmoglobin *C* are given in the last line of Table 1. Together they add up to the sequence of amino-acids found in the normal No. 4 peptide with the exception of the first glutamic acid residue, which is replaced by lysine. The splitting of the No. 4 peptide into two components during trypsin digestion is now explained, since the new lysine residue constitutes an additional trypsin-sensitive bond. On the basis of these findings we conclude that hæmoglobin *C* differs from hæmoglobin *A* and *S* by only a single amino-acid residue out of nearly 300 in the half-molecule. Moreover, the same glutamic acid residue of hæmoglobin *A* which was changed to valine in hæmoglobin *S* is now replaced by lysine in hæmoglobin *C*. This change from an acidic to a basic amino-acid, involving the loss of two net negative charges per half-molecule, is in agreement with the observed electrophoretic behaviour of hæmoglobin *C*[5].

These results have interesting genetic implications. They are the first steps in a search for a correlation between the linear fine structure of a gene such as that determined recently by Benzer[7] and Pontecorvo[8], and the linear structure of the polypeptide chain of the protein the synthesis of which that gene controls.

The gene mutations which cause the production of the abnormal hæmoglobins *S* and *C* are inherited in a Mendelian manner through nuclear genes[9-11]. Hæmoglobin *C* provides a second example, after hæmoglobin *S*, of the effect exerted by a mutation of this kind on the protein which the gene produces. In both cases the effect is small, since only one out of nearly 300 amino-acids has been altered. We would assume that there have been small alterations in corresponding places on the gene. Hæmoglobin *C* and *S* are most probably independent examples of the same phenomenon, since there is no reason for believing that the two mutations did not arise independently. The fact that both abnormalities occur with high frequency and alter the same amino-acid might well be an accident of natural selection and not an indication of a high mutation-rate at this one particular locus.

Our results also shed light on the position of these two mutations on the hæmoglobin gene or genes. Genetic evidence[9-11] shows that the hæmoglobin *S* and *C* mutations are allelic or occur at linked sites; but the statistical evidence is not sufficiently strong to distinguish between these two possibilities. If we assume a direct relationship between the internal (linear) structure of the gene, and the linear arrangement of the amino-acid residues in the hæmoglobin molecule, then the finding that the same amino-acid residue, glutamic acid, is altered in both mutations implies that they are indeed allelic mutations and occupy the same site on the gene. Thus if these ideas are correct the chemical investigation of proteins such as the human hæmoglobins can provide a powerful, though indirect, tool to help the geneticist in mapping the positions on the gene where certain mutations occur.

In order to obtain sufficient statistical data and a sufficient number of mutants, such a programme must eventually turn to proteins from micro-organisms. However, it is hoped that the abnormal human hæmoglobins will provide a few more useful examples of the effects of gene mutations on protein structure.

We are very grateful to Dr. H. Lehmann, London, Dr. H. A. Itano, Bethesda, and Dr. I. H. Scheinberg, New York, for generous samples of hæmoglobin *C*. We would also like to thank them and Drs. M. F. Perutz and F. H. C. Crick, Cambridge, and Prof. J. V. Neel, Ann Arbor, for many stimulating discussions.

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Protection against Death due to Ozone Poisoning

In a research programme on the physiological effects of ozone, an attempt was made to determine the mechanism of ozone poisoning by studying chemical protection before exposure. Swiss albino mice were treated by intraperitoneal injections of the test chemical followed by exposure for 3 hr. to a concentration of 8–25 p.p.m. of ozone. This ozone concentration caused death in 10–80 per cent of the animals[1]. Usually 10 control (no prior treatment) animals and 10 treated animals were exposed together in a large glass chamber 12·5 in. × 30 in. × 16 in. to ozone generated by a water-cooled corona discharge type of ozonizer. The results of these experiments are recorded in Table 1.

Since death due to ozone poisoning is accompanied by considerable œdematous fluid in the respiratory system[2], atropine sulphate was tested as a possible protective agent, for it is widely used in surgery to minimize bronchial and nasal secretion. It was successful in preventing death in some of the mice exposed to ozone. Whether this protection is due to the blockage of the response of effector cells to stimulation of postganglionic cholinergic fibres is unknown. The role of the nervous system in pulmonary œdema is not clear. However, Balagot, Reyes and Sadove[3] believe that the autonomic nervous system is implicated. Sarnoff and Sarnoff[4] report that blockade of the sympathetic impulses to systemic vessels lowers pulmonary blood volume and pressure. Avaido and Schmidt[5] present evidence of chemoreceptors in the lungs, with a possible implication in œdema.

The success of the atropine sulphate, a cholinergic blocking drug, in affording some protection against ozone poisoning may be explained by reduction of œdema via the nervous system. However, hexamethonium chloride (Table 1), a ganglionic blocking drug, did not protect mice from death induced by ozone. The ganglion-blocking agents prevent the initiation of postganglionic impulses at the ganglia, while atropine prevents the action of postganglionic impulses upon smooth muscles or glands.

Several reducing substances were tested to determine whether they would protect mice against death from ozone. Since ozone is a powerful oxidizing agent, there is a good possibility that damage to the respiratory system is due to the formation of free radicals and peroxides. Thus a reducing agent should aid animals to survive an exposure to ozone, provided that an intraperitoneally injected reducing substance would be carried as a reducing agent in the blood stream to the respiratory system. Cole *et al.*[6] found that sodium nitrite injected intraperitoneally afforded some protection against death due to radiation.

Table 1. Effects of Various Agents Injected into Mice in Protection against Death from 8–25 p.p.m. of Ozone for 3 hr.

Agent	Dosage/mouse		Treated mice			Control mice			X^2*
	(mgm.)	(ml.)	Total	Survived (*a*)	Dead (*b*)	Total	Survived (*a*)	Dead (*b*)	
Atropine sulphate	0·00325	0·1	118	88	30	119	74	45	4·2
Hexamethonium chloride ('Hexameton', Burroughs Welcome)	0·125	0·1	110	70	40	111	63	48	0·59
Sodium thiosulphate (*p*H 7·7, sodium hydroxide)	40	0·5	71	55	16	70	42	28	4·62
Ascorbic acid (sodium ascorbate, Barry Laboratories)	20	0·2	90	70	20	90	56	34	5·18
Glutathione (*p*H 8·0, sodium hydroxide)	65·8	1·0	20	12	8	20	11	9	0·0
Sodium nitrite (*p*H 7·2, sodium hydroxide)	2·5	0·5	20	7	14	20	18	2	0·0
Sodium nitrite (*p*H 7·2, sodium hydroxide)	1·75	0·25	67	35	32	68	35	33	0·0
p-Aminopropiophenone (in 2 parts 100 per cent ethyl alcohol and 8 parts propylene glycol)	1·0	0·1	40	11	29	40	22	18	0·0

* G. S. Snedecor, "Statistical Methods", p. 19 (Iowa State College Press, Ames, Iowa, 1940).

* $X^2 = \dfrac{(ad - bc)^2\,(a + b + c + d)}{(a + c)\,(b + d)\,(a + b)\,(c + d)}$

If the value of X^2 is 3·84, there is more than a 95 per cent chance that the treated population is different from the control.

With this in mind, other reducing agents were used. Both sodium thiosulphate and ascorbic acid (Table 1) protected mice against death by ozone poisoning. These compounds may react with ozone before it has a chance to come into contact with lung tissue, or afford protection by decreasing capillary permeability in the lungs, and by sustaining the alveolar capillary cells during conditions of anoxia. Sodium nitrite at 2·5 mgm. per mouse (Table 1) did not protect mice but made ozone more toxic. At a level of 1·75 mgm. per mouse there was no effect on mortality due to ozone. The apparent increase in death-rate of mice injected with 2·5 mgm. of sodium nitrite can be explained by the induction of methæmoglobinæmia[7] by this compound. A sharp reduction in available hæmoglobin would handicap an animal severely injured by ozone and would hasten death due to asphyxiation.

Glutathione and *p*-aminopropiophenone[9], which have had some success in protection against death due to radiation, were not successful in protecting against death induced by ozone poisoning. Gerschmann and colleagues[10] pointed out the similarities between oxygen poisoning and injury due to radiation and found that glutathione protected against oxygen poisoning. It appears that compounds which protect against death by radiation and oxygen poisoning are not effective against ozone poisoning. The difference in protection is due to the fact that damage in ozone poisoning appears to be limited to the respiratory tract only, whereas in radiation and oxygen poisoning the whole body is involved.

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Isolation of β-Sitosterol-D-Glucoside from Groundnut Phospholipids

NATURALLY occurring sterol glycosides (sterolins) were first characterized in 1913 by Power and Salway[1], since which time these compounds have been isolated from a variety of plant materials[2,3].

In the course of experiments on the lipids of groundnuts, a sterol glycoside has been isolated from a crude phospholipid fraction and has been identified as β-sitosterol-D-glucoside.

The initial phospholipid was produced on an industrial scale; in order to remove small amounts of triglyceride the material was washed several times with three times its weight of acetone, dissolved in ether and reprecipitated with acetone. The precipitate was filtered off on a Buchner funnel and final traces of solvent then removed *in vacuo*.

129 gm. of this material was ground with about 300 gm. of anhydrous sodium sulphate and the mixture extracted with acetone in a large Soxhlet extractor for 22 hr. The acetone extract on cooling gave a yellow waxy solid which after washing with ether yielded a white powder, insoluble in most of the usual solvents but soluble in pyridine. Further quantities of this material were obtained by concentrating the acetone extract, and in all 2·3 gm. (1·8 per cent of the crude phospholipid) was obtained.

The product was recrystallized from pyridine–ethanol as a loose white solid giving positive Lieberman–Burchard and Molisch tests, m.p. 290–292° (dec.) and $[\alpha]_D^{20} - 45{\cdot}7$. These values correspond with those reported by other workers[4,5] for β-sitosterol-D-glucoside, and the identity of the solid was confirmed by the melting points and specific rotations of the acetyl and benzoyl derivatives, and by identification of the sterol and sugar components following hydrolysis of the glycoside by the method of Thornton and co-workers[6]. Chromatographic analysis showed glucose to be the only carbohydrate component in the water-soluble portion of the hydrolysis products, and the presence of glucose was confirmed by osazone formation. Recrystallization of the ether-soluble hydrolysis products yielded a sterol, m.p. 135–136°, $[\alpha]_D^{20} - 37{\cdot}17$, in 75 per cent yield. The acetate (m.p. 126° $[\alpha]_D^{20} - 43{\cdot}01$) and benzoate (m.p. 142–143°, $[\alpha]_D^{20} - 15{\cdot}1$) correspond to β-sitosterol derivatives.

In further experiments the crude phospholipid was fractionated with alcohol; the alcohol-insoluble material corresponded to 75 per cent of the initial phospholipid and contained 87·5 per cent of the total sterol glycoside.

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Site of Catabolism of Serum Albumin

THE relative importance of the liver, kidneys and intestines for the catabolism of serum albumin has been examined in Swiss albino mice, 5–6 weeks of age. Mouse serum albumin and human serum albumin were labelled with iodine-131 as described elsewhere[1] and given to the mice intravenously, about 0·5 μc. or 5–15 μgm. iodoalbumin per mouse. The biological half-lives of the radioiodinated albumins were determined by one or more of three methods: (1) the living whole mouse was counted at intervals in a crystal scintillator; (2) pooled serum was obtained by exsanguination of two or three mice at a time

Table 1. Half-lives of Iodinated Albumins in Mice

Conditions (see text)	Half-lives during first 24 hr.* (days)
Normal diet: unoperated or sham-operated	0·7
Partial hepatectomy (40 per cent)	1·7
'Thorotrast' (0·6 ml.)	2·2
Indian ink (0·1 ml.)	1·8
Starvation	1·1
Sham operation and starvation	1·2
Bilateral ureteral obstruction	1·4–1·7
Bilateral nephrectomy	1·4
Intestinal resection	0·7

* Average values for at least 15 animals per group, excepting nephrectomy, which included eight animals. Data on individual animals varied by less than 20 per cent from the average.

from a given group and the protein-bound radioactivity of the serum determined; (3) protein-bound radioactivity in the individual whole mouse of a given group was estimated after homogenization of the animal in 10 per cent trichloracetic acid. All animals were given sodium iodide in their drinking water throughout the period of an experiment. Surgical operations were performed under ether anæsthesia. In these experiments, iodinated human albumin behaved *in vivo* as did iodinated mouse albumin; detectable antibodies to human serum albumin were not formed during the periods of study chosen.

The half-life of serum albumin in normal mice was found to be about 0·7 day (Table 1) (this value has been averaged with additional data obtained by G. Terres and W. Wolins and is based on more than 50 animals). Since the mice in several experiments were anorexic, the half-life of albumin in mice not given food was determined and found to be about 1·1 days. Sham operations were also performed in which the peritoneal cavity was opened and the intestines lifted out and replaced. The half-life of albumin in sham-operated mice with or without food was similar to that obtained for unoperated mice on the same diet (Table 1).

The ureters were obstructed bilaterally in a group of mice approximately 3 hr. prior to injecting labelled albumin by applying a gold clamp at the base of the bladder. These animals were not given food. The half-life of serum albumin under these conditions was found to vary from 1·4 to 1·7 days in different groups of mice; these values should be compared with 1·2 days for the sham-operated controls. The half-life of albumin in mice that were bilaterally nephrectomized was 1·4 days.

Removal of both large and small intestines appeared to accelerate the catabolism of iodinated albumin, since the half-life was only 0·7 days as compared with 1·2 days for starved controls (Table 1).

Removal of 40 per cent of the liver resulted in a marked decrease in the catabolism of albumin (Table 1). During the first day after the operation, the half-life was found to be 1·7 days. During the second day, the half-life of albumin was 0·9 days. Five days after the operation, the half-life of albumin was normal and post-mortem examination revealed that the liver had regenerated to normal size. The hepatectomized mice were eating soon after the operation, and the half-life value found is to be compared with that for mice on a normal diet. Removal of approximately 40 per cent of the liver decreased the fractional rate of catabolism by about 50 per cent. Similarly, removal of about 20 per cent of the liver decreased the fractional rate of catabolism about 20 per cent.

An attempt was made to determine the relative influence of the hepatic cells and the Kupffer cells on albumin catabolism. 'Thorotrast', which is a 24–26 per cent suspension of thorium dioxide, and indian ink are known to block the reticulo-endothelial system. Consequently, 0·05–0·1 ml. of indian ink or 0·2–0·6 ml. of 'Thorotrast' was given to mice intravenously, followed 1 hr. later by iodinated albumin; there was a profound inhibition of albumin catabolism (Table 1). Large doses of 'Thorotrast' reduced the catabolism of iodinated albumin to an extent even greater than that observed in mice with 40 per cent of their livers removed.

It would appear from these results that the liver and kidneys in mice play significant parts in the catabolism of albumin. The liver would seem to have the greater importance, since removal of only 40 per cent of the liver was more effective than complete nephrectomy. At the cellular level, the experiments with indian ink and 'Thorotrast' strongly implicate the reticulo-endothelial system of the liver in this catabolism, although a possible role of the hepatic cells cannot be excluded.

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Effects of Pituitary Hormones and Cortisone upon Liver Regeneration in the Hypophysectomized Rat

The finding that growth hormone increased the rate of mitosis and nucleic acid synthesis in rat regenerating liver[1], suggested that this hormone might play an important part in liver regeneration following partial hepatectomy. To test this hypothesis it was necessary to study the effect of hormones upon liver regeneration after removal of the pituitary.

Three series of experiments were performed on rats subjected to partial hepatectomy 7–28 days after hypophysectomy. It is believed that the use of this preparation has not been previously described; full details will be reported later (by J. T. H.). Rats were killed at two hourly intervals from 27 hr. to 50 hr. after partial hepatectomy and mitotic counts were made on the livers.

The first series of saline-injected controls (80 rats) 14–21 days after hypophysectomy showed that liver regeneration can occur in the absence of the pituitary, but is delayed. Normal rats show a peak of regeneration of about 40 mitoses/1,000 cells at about 28½ hr. after partial hepatectomy[2]; but in hypophysectomized rats the peak is at 38–45 hr. and is only 20–30 mitoses/1,000 cells.

A second series of 80 hypophysectomized rats were given hormone replacement at hepatectomy and during liver regeneration. Six groups were used, given respectively: growth hormone only, crude pituitary extract only, cortisone only, growth hormone +

cortisone, crude pituitary extract + cortisone, and a control group injected with saline. Giving growth hormone + cortisone or crude pituitary extract + cortisone resulted in an increase of the height of the mitotic peak with little alteration of the time at which maximum regeneration occurred. Results from growth hormone and crude pituitary extract alone were equivocal.

In the group treated with cortisone only, a consistent and characteristic cytoplasmic and nuclear degeneration was noted (by D. B. C., who did mitotic counts on these two first series of rats). The cells undergoing degeneration appeared to follow a series of changes, beginning with a hyaline droplet type of degeneration of the cytoplasm, followed by vacuolation of the nucleus and extrusion of the nucleolus. The nucleus in the more degenerate cells became pyknotic and finally broke into fragments. These changes were much more marked than the cytoplasmic vacuolation and nuclear displacement reported in liver cells of mice treated with cortisone[3].

A third series of experiments was then begun (by J. T. H.) to test the hypothesis suggested by the work of Bullough (recently reviewed[4]), that the nutritional state of the liver at hepatectomy greatly influenced the subsequent regeneration, and that some conditioning of the cell by hormone activity was essential for normal regeneration.

Injections of the same combinations of hormones were therefore given three days prior to hepatectomy and during the period of regeneration.

65 hypophysectomized rats have so far been examined, and in all those receiving cortisone only (2 mgm./100 gm. rat twice daily) no mitoses were found at any regeneration time from 27 to 60 hr. (Cortisone inhibition of liver regeneration in the mouse, with intact pituitary, has been reported[3].) Glycogen content of the liver was high at hepatectomy and was still high at post-mortem, suggesting that glycogen utilization was small in the cortisone-treated rat. Except in very small doses, growth hormone or crude pituitary extract given alone was toxic to hypophysectomized-partially hepatectomized rats, many animals dying through hypoglycæmia and ketosis. Such material as was available indicated that mitotic rates were low (5–20 mitoses/1,000), and that glycogen accumulation was also low. Further work is in progress.

When growth hormone or crude pituitary extract was given with cortisone the whole picture changed; the highly pyknotic and degenerating nucleus gave place to more normal appearances with clear mitotic figures. When the dose of growth hormone was in the correct proportion to the dose of cortisone high mitotic counts were seen. High accumulation and utilization of glycogen also occurred. Thus, 1·5 mgm. growth hormone or 0·6 ml. crude pituitary extract (100 gm. rat twice daily) with 2 mgm. cortisone gave high counts of 45–60 mitoses/1,000 cells. Reducing the dosage of either to an eighth and keeping the cortisone dose at 2 mgm. gave low mitotic counts and slight signs of cytoplasmic and nuclear degeneration.

Thus growth hormone prevented the inhibition of mitosis and the nuclear degeneration produced by cortisone. With cortisone alone there was nuclear degeneration in spite of accumulation of glycogen in the cytoplasm. Failure to regenerate deoxyribonucleic acid has also been reported after cortisone administration to the intact mouse[3]. These facts suggest the possibility of a metabolic block set up by cortisone between the cytoplasm and the nucleus; this block is removed or neutralized by growth hormone. Conversely, this work supports that of many workers showing growth hormone to diminish glucose uptake by the cell in hypophysectomized animals, and in particular is direct support for the view that growth hormone requires the co-operation of adrenal corticoids for normal carbohydrate metabolism[5].

In physiological conditions it may well be that growth hormone is the more constant basal secretion allowing nuclear activity and this is modified by hour-to-hour variation in adrenal corticoid output. When cortisone is excluded there are indications that glycogen utilization is related to mitotic rate. It is possible that the autonomy of neoplastic cells is in part a loss of response to corticoid inhibition, and the relation between these two possibilities is being examined. In those cases of inoperable cancer which have been treated by hypophysectomy and maintained on cortisone, these studies suggest that part of the beneficial therapeutic response may be due to a direct effect of cortisone on the dividing cancer cells, probably accentuated by absence of pituitary growth hormone.

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Fine Structure of the Alveolar Wall of the Lung

SINCE electron microscope techniques have been applied to histology, several workers have confirmed that the blood–air barrier of the lung consists of a capillary endothelium, a basement membrane and an uninterrupted alveolar endothelium. The permeability of this three-layered wall is explained, in the classical physiological literature, solely by a passive physicochemical mechanism.

Palade[1] was the first to observe with the electron microscope that the fine structure of the capillary wall was much more intricate than had been previously assumed. He saw invaginations of the plasma membrane which are pinched off to form small vesicles of 500–750 A. diameter. It seems likely that they move across the endothelial cytoplasm and approach the opposite plasma membrane. Palade[2] himself believes that substances from the capillary lumen can thus be actively and selectively incorporated into the endothelial cytoplasm. This mechanism, formerly called pinocytosis, appeared to depend, so far as the capillary endothelium is concerned, upon the requirements of the surrounding medium.

Quite recently, Moore and Ruska[3] described capillary endothelia of the mammalian heart and suggested that the plasma membrane vesiculation mechanism, described by Palade[1,2], is a prevalent process of active and selective transport of substances across the cytoplasm and cell membranes. They call this exchange mechanism 'cytopempsis'.

Nevertheless, Moore and Ruska[3] suppose that in pulmonary capillaries physicochemical permeability is enough to maintain transport through the blood-air barrier, because their layers are extremely thin. Therefore, they did not expect to find morphological images of cytopempsis at this level.

We did not consider the negative results convincing proof of the absence of cytopempsis, therefore we have re-investigated the fine structure of this three-layered wall.

The present observations are based upon techniques recently described[4] and were made on lungs of adult albino mice.

Structural details assumed to be concerned in cytopempsis are shown in the alveolar wall in Figs. 1 and 2. There are many small vesicles of 500–700 A. diameter in the endothelial cytoplasm. They are usually spherical, consisting of a relatively light portion surrounded by a thin dark membrane. The exterior and the interior plasma membrane invaginations show in several places. Some of the spherules approach these invaginations and often fuse with the bottom of them.

The thin epithelial lining of the alveolar cells surrounding the capillary vessels has a structure remarkably like that of the endothelial cytoplasm. There are also small vesicles of about the same size as those described in the endothelium. Invaginations of exterior and interior plasma membranes can easily be identified.

Finally, numerous small cell-membrane infoldings, similar to those belonging to the exterior cell membranes, are found in contact with the alveolar basement membrane. Some of these in profile are closed, whereas others appear to be partially or completely open at the level of the basement membrane.

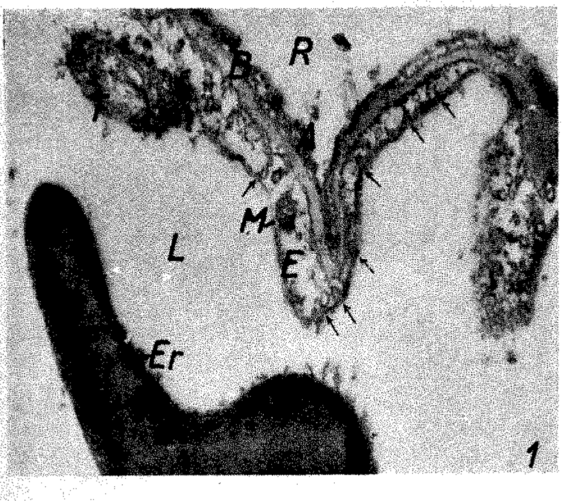

Fig. 1. Blood-air barrier in mouse lung. A large capillary lumen (*L*) is visible below, with a red blood cell (*Er*) and a thrombocyte (*T*) in close contact with the endothelial lining. Vesicles, which are bounded by dense membranes, appear throughout the entire endothelial cytoplasm (*E*), often in connexion with small invaginations (→) of the exterior plasma membrane. A mitochondrial profile (*M*) can be recognized in the endothelial cytoplasm. The alveolar lumen (*R*) is bounded by the alveolar epithelium (*A*). The basement membrane (*B*) is represented by a layer between endothelium (*E*) and epithelium (*A*). (× 25,000)

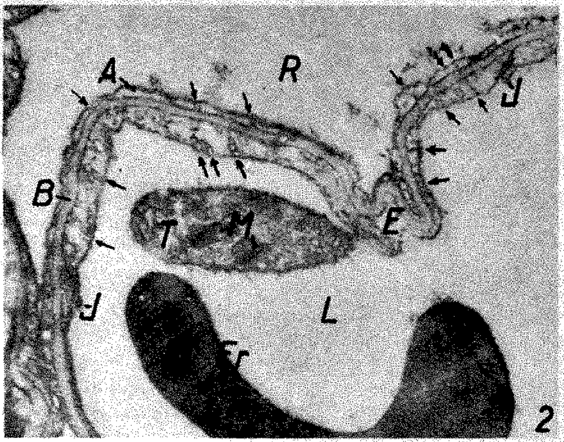

Fig. 2. Another portion of the blood-air barrier in mouse lung, showing numerous small vesicles in the capillary endothelial (*E*) and the alveolar epithelial (*A*) cytoplasm, and invaginations (→) of the exterior and interior plasma membranes. The vesicles are often associated with the bottom of an infolding of the cell membrane. Two endothelial junctions (*J*) are visible. (× 26,000)

Schulz[5] described vesicles of 500–1000 A. diameter within the alveolar and endothelial cytoplasm of the blood-air barrier in lungs of mammals submitted to artificial lung-œdema. He is convinced that these structural details must be due to the experimental œdema produced. Obviously, he did not know that Palade[3] had found the same vesicles three years before in quite normal circumstances, within the capillary endothelium of the mammalian heart. Moreover, Schulz did not use controls, an omission which makes his conclusion less convincing. The electron microscope literature is still too small to distinguish between the so-called 'normal fine structures' and artefacts.

On the basis of these results, we believe that the idea that transmission of substances through the alveolar wall occurs only by passive diffusion should be further studied. The occurrence of cytopempsis within the normal alveolar wall is important evidence in favour of both alveolar epithelial and capillary endothelial cells being active and selective in the exchange of substances in the lung.

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Inability of Hydrogen Peroxide to influence the Survival-Time of Rats bearing *RD3* Sarcoma and the Walker Carcinoma

It has recently been claimed that orally administered hydrogen peroxide (0·45 per cent by weight) causes regression of the transplantable Walker carcinoma in rats[1], and it was also claimed that two of four cancerous patients benefited from this treatment. It seemed to us that orally administered hydrogen peroxide was unlikely to survive passage through the gut, but an impurity or added stabilizer which was to some extent carcinolytic might be present. In order to try out this likelihood the experiments described below were made. We found that the survival-times for rats bearing either Walker carcinoma or *RD*3 sarcoma were almost identical in the animals treated with hydrogen peroxide and those fed tap-water. There was, however, some possible difference affecting the rate of tumour growth in the two groups (possibly slower in the animals treated with hydrogen peroxide) and an explanation of that phenomenon is given in the discussion below.

The *RD*3 sarcoma used in these experiments was originally induced by 1 : 2 : 5 : 6-dibenzanthracene injection into the right flank of an inbred strain of albino rats. The Walker carcinoma was obtained from the Department of Experimental Pathology, University of Leeds.

Animals used in these experiments were inoculated subcutaneously in the right flank with 0·2 ml. of a thick pasty suspension of tumour mince under strict aseptic conditions. (Walker carcinoma or *RD*3 sarcoma.)

The diet used throughout these experiments was diet 86 purchased from the North-Eastern Agricultural Co-operative Society Ltd., Bannermill Place, Aberdeen. All animals were fed *ad lib.* and were housed in separating cages and weighed individually twice a week.

The commercial concentrated aqueous solution of hydrogen peroxide (Laporte Chemicals Ltd., Luton) was diluted to give a final concentration of 0·45 per cent (by wt. : the suggested optimum of Holman[1]). This solution was fed *ad lib.* to the experimental groups of animals. The solution was replaced every 3 days and an analysis of the hydrogen peroxide concentration showed that no deterioration had occurred.

Experiment 1. Male rats were inoculated with *RD*3 sarcoma in the right flank. At the end of 5 days, 66 animals showing fairly uniform palpable tumour nodules measuring approximately 1·0 cm. in diameter were selected and divided into two groups. Group *A* received 0·45 per cent hydrogen peroxide from then on until the end of the experiment while the control group *B* received ordinary tap-water. Table 1 summarizes the results obtained. There was no statistically significant difference between the survival times and the final tumour weights in these groups.

Table 1. THE EFFECT OF 0·45 PER CENT HYDROGEN PEROXIDE (AS A SUBSTITUTE FOR DRINKING WATER) ON THE GROWTH OF TRANSPLANTED *RD*3 SARCOMA, HOST TISSUES, AND ON SURVIVAL-TIME IN THE RAT

Treatment started 5 days after transplantation of the tumour)

Exp. 1	Group *A* : Fed 0·45 per cent hydrogen peroxide		Group *B* : Fed tap-water	
	Rats with continued tumour growth	Complete regressions	Rats with continued tumour growth	Complete regressions
No. of rats	13	20	16	17
Survival-time (days)	37·6±34·3	136	34·6±25·0	136
Final tumour wt. (gm.)	65·5±61·5	none	92·3±45·5	none
Initial host wt. (gm.)	239·0±18·7	231·0±10·9	230·0±13·2	234·0±14·4
Final host wt. (gm.)	208·0±38·3	280·0±30·2	218·0±40·5	309·0±21·2

Table 2. EFFECT OF 0·45 PER CENT HYDROGEN PEROXIDE (AS A SUBSTITUTE FOR DRINKING WATER) ON THE GROWTH OF TRANSPLANTED WALKER CARCINOMA, HOST TISSUES, AND ON SURVIVAL-TIME IN THE RAT.

(Treatment started 5 days after transplantation of the tumour)

	Exp. 2		Exp. 3.	
	Fed hydrogen peroxide	Fed tap-water	Fed hydrogen peroxide	Fed tap-water
No. of rats	14	15	18	17
Survival-time (days)	25·8± 8·5	26·7± 4·0	20·1± 3·4	21·9± 4·2
Final tumour wt. (gm.)	73·4±30·7	97·8±60·0	40·1±11·4	58·5±12·9
Initial host wt. (gm.)	279·0±26·5	278·0±31·2	240·0±11·6	240·0±12·8
Final host wt. (gm.)	232·0±43·5	300·0±20·0	173·0±39·2	248·0±35·9

Experiment 2. Male rats were inoculated with the Walker carcinoma. At the end of 5 days, 29 animals showing fairly uniform palpable tumour nodules measuring about 1·0 cm. diameter were selected and divided into two groups and treated in the same way as animals in exp. 1. Table 2 summarizes the results obtained. Once again there was no statistically significant difference between the survival times and the final tumour weights in these groups, although as in exp. 1 there was a lower final body-weight and tumour weight in the experimental animals.

Experiment 3. This is a repeat of exp. 2 ; but, as in this experiment the Walker carcinoma grew at a faster rate than that in exp. 2, the results were considered separately from those in exp. 2.

Once again hydrogen peroxide failed to prolong significantly the survival rate of the treated animals. The tumours in group *A* were, however, significantly smaller than those in group *B* : the final host weight of group *A* was less than that of group *B*, but not significantly so.

In view of the persistent tendency to a smaller body-weight in animals receiving hydrogen peroxide in all our experiments, it was decided to study the effect of hydrogen peroxide on the food intake and body weight of normal animals.

Experiment 4. Forty-eight rats were divided into two groups. Both groups were fed *ad lib.*, but group *A* (24 rats) received 0·45 per cent hydrogen peroxide instead of the tap-water which group *B* (24 rats) received. The amount of food eaten by each group was estimated by weighing the amount of food given and that left over and wasted. The animals were weighed individually every few days. The initial weight of the control rats was 189 ± 11 gm. (mean and standard deviation) and that of the experimental rats was 190 ± 9 gm. At the end of the experimental period (57 days) the rats in the control group weighed 253 ± 21 gm. and the experimental rats weighed 236 ± 13 gm., showing a significant difference in the rate of growth in the two groups. Group *A* consumed 23·8 kgm. food and group *B* 28·4 kgm.

The results of our experiments fail to confirm the findings of Holman[1]. In common with Green and Westrop[2] we find no evidence to suggest that hydrogen peroxide increases the survival-time of rats bearing the Walker carcinoma.

So far as the effect of hydrogen peroxide on final tumour size is concerned our results are more difficult to interpret. In any experiment designed to reveal inhibition or stimulation of tumour growth the nutritional status of the animals must be taken into consideration (Tannenbaum[3]; Rous[4]; Ghadially and Wiseman[5]), for it is well known that if the animal loses weight tumour growth is likely to be impaired. The results of exp. 4 (above) on non-tumour rats show that hydrogen peroxide diminished food intake and retarded normal growth, and a tendency for animals receiving hydrogen peroxide to show a decrease in carcass weight and somewhat smaller tumours is to be expected.

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Spontaneous Crystallization of Amylase from Pancreatic Juice of the Rat

IN the assay of secretin by Love's method[1] in which pancreatic secretion from the fasted rat is collected in calibrated capillary tubes, it was observed that a slight precipitate very occasionally formed in the tube at room temperature. When the secretion was kept at +2° C. a heavy white deposit almost invariably formed within two days or so which consisted of very fine birefringent needles, often in balls, fans, or sheaves (Fig. 1). The difference in ultra-violet absorption of the secretion before and after formation of the deposit (Fig. 2) suggested that the latter might be a protein. Further experiments showed it to be amylase, and it became of interest to compare its properties with those of crystalline pancreatic α-amylase from human[2] and pig[3].

Isolation and recrystallization. The crystals were only sparingly soluble in water and could be washed repeatedly in cold water. They were much more soluble above *p*H 10, and could be recrystallized by suspending in water, adding ammonia to a final concentration of 0·2 *M*, agitating for 15–20 min., and centrifuging; about one-quarter of an equivalent of hydrochloric acid was then added, the slight turbidity was spun down after half an hour, and the tube placed in a closed container with several ml. of dilute sulphuric acid to absorb ammonia, the whole being kept at 2° C. Several days were required for crystallization, and the crystals thus obtained have not yet been larger than those separating spontaneously from crude pancreatic juice.

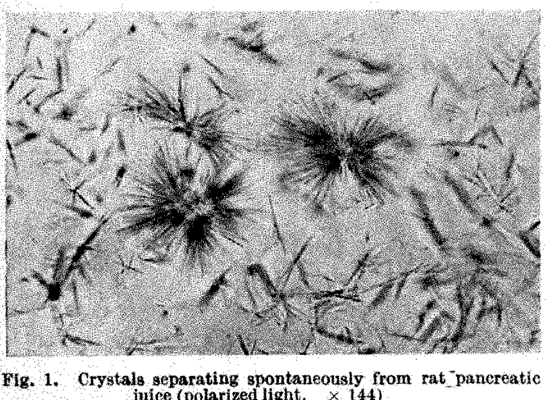

Fig. 1. Crystals separating spontaneously from rat pancreatic juice (polarized light. × 144)

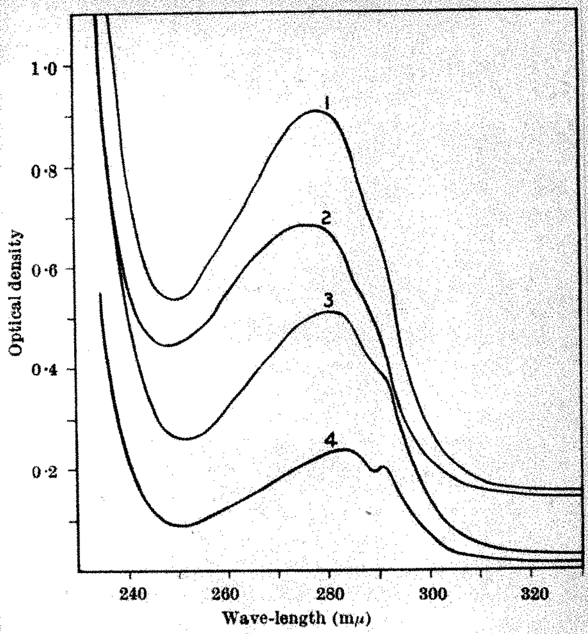

Fig. 2. Ultra-violet absorption (1 cm.) of: (1) pure pooled pancreatic secretion of three rats, collected over a period of 11–12 hr. (with frequent stimulation by secretin) diluted 1 in 40; (2) supernatant from the same after 7 days at 2° C., diluted 1 in 40; (3) recrystallized material, 0·256 mgm./ml., *p*H 7; (4) difference between 1 and 2

Stability. Well-washed crystals suspended in water appeared to retain their activity at 2° C. for many weeks. At 20° C. all activity was destroyed in a few seconds in 0·02 *N* hydrochloric acid; in acetate buffer *p*H 4, about nine-tenths of the original activity remained after 3 hr., and at *p*H 5 there was little or no destruction. In the *p*H range corresponding to 0·1–1·0 *M* ammonia the stability showed a sharp change. Thus, in 1·0 *M* ammonia at 20° C. destruction was virtually complete after 30 min.; in 0·5 and 0·1 *M* ammonia after 3 hr. about 30 per cent and 90 per cent of the original activity remained. A suspension of crystals dried quickly over phosphorus pentoxide and kept over it for two weeks retained only about one-quarter of its original activity.

Solubility. A dense suspension of crystals was distributed among a number of sealed glass capillaries which were gently agitated at the appropriate temperature for varying lengths of time. After centrifuging, the concentration of amylase in the supernatant was estimated in terms of its amylase activity. In water the approximate solubility was: at 2° C., 0·3 mgm./ml.; at 20° C., 1·5 mgm./ml.; at 37° C., 3 mgm./ml.

The crystals still formed spontaneously in the presence of bile or of 'Teepol' (which was sometimes used for ensuring smooth movement of the meniscus in the secretin assay).

Amylolytic activity. This was measured by the method described by Noelting and Bernfeld[4] based on that of Sumner and Howell[5], using British Drug Houses 'Analar' starch as substrate. The potency is expressed in units equivalent to the number of milligrams of maltose liberated by 1 ml. of enzyme solution in 3 min. at 20° C.

Once recrystallized material had a specific activity of about 620 units/mgm. That repeated recrystallization would enhance this considerably seems unlikely since well-washed crude crystals (not recrystallized) had almost the same activity.

Table 1

Origin of amylase	pH range of stability	Activity (maltose units/mgm.)
Pig pancreas*	7– 8·5	630
Human pancreas*	4–11	1,000
Rat pancreatic juice	5–10·5	620

* Based on results summarized by Bernfeld (ref. 6)

Comparison with human and porcine pancreatic amylase. All three enzymes have certain properties in common (ultra-violet absorption spectrum, low solubility, high stability when pure). The porcine and human enzymes differ in their pH stability-range and in activity, and it is interesting that the rat amylase resembles human, rather than porcine, enzyme in the first of these properties, and porcine rather than human enzyme in the second (Table 1).

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Serine–Glycine Interconversion in Plant Tissues

THE conversion of serine to glycine in animal tissues was first demonstrated by Shemin[1] by a feeding experiment using serine labelled with nitrogen-15 and carbon-13 in the carboxyl group. The involvement of a folic acid derivative as a co-factor in the reaction was shown both by Kisliuk and Sakami[2] and Blakley[3].

That the interconversion occurred in plant tissues seemed probable in view of labelling data obtained by Tolbert and Cohan[4], who fed 1-^{14}C- or 2-^{14}C-labelled glycollate to wheat and barley leaves and found, in short experiments, that serine and glycine were the only major products labelled. The 2-C atom of glycollate was observed to enter the 3-C atom of serine, presumably glyoxylate formed by oxidation of the glycollate being split by the Sakami reaction to form formate[5], which is known to enter largely into the 3-C atom of serine[6]. Attempts to demonstrate the interconversion in cell-free systems from plants have not previously been successful[4].

This communication reports the occurrence of this interconversion in a cell-free system prepared from turnips. The tissue was homogenized in 2-3 vol. cold 0·2 M potassium phosphate buffer, pH 7·4, in a bottom-drive blender. The suspension was strained through a linen cloth and then centrifuged at 1,000g, for about 5 min. to remove cells and debris. Ammonium sulphate was then added to 80 per cent saturation. The protein was separated by centrifugation and dissolved in about 30 ml. of the same buffer. The solution was dialysed overnight against a flow of 2·5 l. of 0·01 M buffer, pH 7·4. The enzyme preparation was centrifuged at 30,000g for 10 min. before use. All these operations were carried out in a cold-room at 2° C.

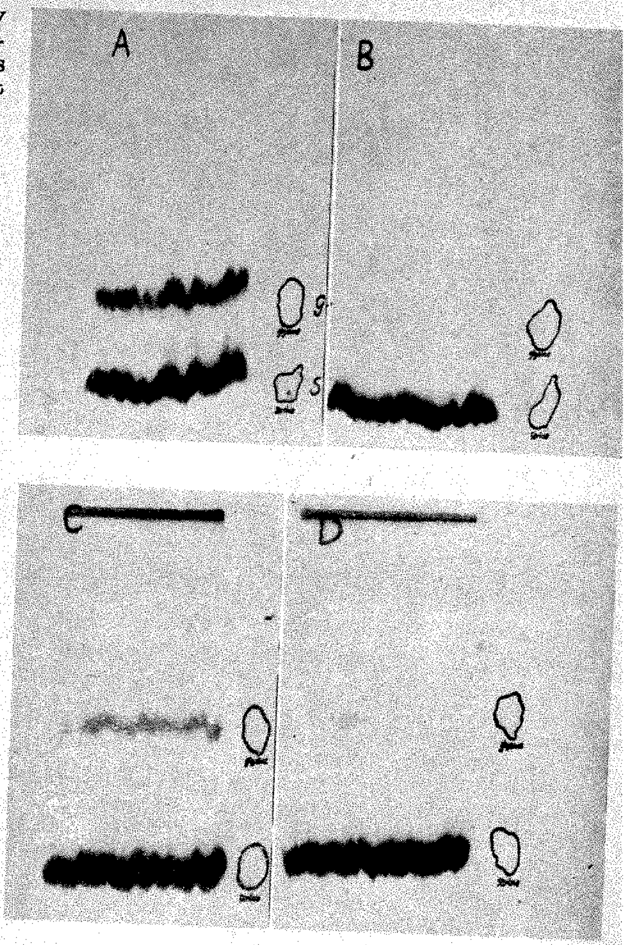

Fig. 1. Radioautographs of chromatograms demonstrating serine–glycine interconversion. *A*, Full system; *B*, ethanol at zero time; *C*, no pyridoxal phosphate; *D*, no tetrahydrofolic acid; *G*, glycine; *S*, serine markers. The full system contained: enzyme, 1 ml.; generally labelled carbon-14 L-serine 8 × 10^4 counts per min.; L-serine carrier to a final concentration of 1 μmole; glycine, 1 μmole; DL-tetrahydrofolic acid approximately 0·33 mM; pyridoxal phosphate, 0·25 mM; Mg^{2+}, 1 μmole. Total volume 1·53 ml. The flasks were gassed with hydrogen and incubated at 37° for 150 min.

The DL-tetrahydrofolic acid solution was prepared by the catalytic hydrogenation of folic acid in neutral aqueous solution[7].

The reaction was stopped by the addition of ethanol to a final concentration of 80 per cent and the protein removed by centrifugation. The supernatants were reduced to dryness on a water-bath, and the contents of the dishes transferred to Whatman No. 1 filter paper in 50 per cent ethanol. The solvent used to run the chromatograms contained acetone (80 parts), triethylamine (5 parts) diluted to 100 with water[8]. The papers were dried and exposed to X-ray paper. The appearance of the latter after development is shown in Fig. 1.

There appears to be an absolute requirement for tetrahydrofolic acid, presumably established by the prolonged dialysis alone; the enzyme had not been treated with 'Dowex-1-Cl'[2]. The reverse reaction has also been demonstrated, starting with glycine generally labelled with carbon-14. The enzyme catalysing this reaction has also been shown to occur in extracts of immature cauliflower.

Further work is in progress on quantitative aspects of this reaction and similar C_1-transferring reactions are being studied.

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Carbon Dioxide Fixation in Particulate Preparations from Barley Roots

Carboxylation of phosphoenolpyruvate in plant material has been reported by various workers[1-5]. In the present investigation we have observed it in particulate preparations from barley roots. This reaction, coupled with malic dehydrogenase activity in the presence of reduced diphosphopyridine nucleotide, leads to the incorporation of carbon-14 dioxide into malate and other organic acids.

The particles prepared from 6-day old barley roots were separated by centrifuging between 2,000 and 16,000 × *g*. Exposure to labelled potassium bicarbonate was carried out for a period of 1 hr. After acidification to terminate the reaction and removal of the excess carbon-14 dioxide, the medium was centrifuged to give two fractions: the supernatant and the residue. Aliquots of the supernatant and the residue were plated and from these the total carbon-14 dioxide fixation was determined.

Initial experiments in the absence of reduced diphosphopyridine nucleotide and with phosphoenolpyruvate showed a marked stimulation of the carbon dioxide fixation as compared to the fixation with pyruvate. Table 1 shows the fixation obtained in the two systems. Radioautographs of the paper chromatograms of the supernatants from both systems showed that only traces of labelled malate were present. 2,4-Diphenylhydrazones were prepared, and the activity expressed as the percentage of the total carbon-14 fixed gave figures of 80 per cent for the phosphoenolpyruvate and 5 per cent for the pyruvate. Radioautographs of paper chromatograms showed that in both systems labelled oxalacetate and pyruvate were formed, with a large accumulation of labelled oxalacetate in the presence of phosphoenolpyruvate. The results indicated that conditions were limiting for the further metabolism of the labelled oxalacetate.

The presence of added reduced diphosphopyridine nucleotide resulted not only in an increase in the total carbon dioxide fixation, but also in the activity of the ether-soluble fraction, particularly in malate. The organic acids in the supernatant were isolated by ether extraction followed by silica gel chromatography after the method of Bulen *et al.*[6]. Addition of malate increased the total fixation; however, the proportion of activity in the ether-soluble fraction remained the same except in the presence of added reduced diphosphopyridine nucleotide.

Table 1. Carbon-14 Dioxide Fixation in Barley Root Particles with no Added Reduced Diphosphopyridine Nucleotide (Activity as percentage of total carbon-14 added)

Fractions	Supernatant	Residue	Total
Substrate			
1. Pyruvate (sodium salt)	1·1	1·0	2·1
2. Phosphoenolpyruvate (cyclohexamine salt)	12·0	2·6	14·6

Reaction mixture: 1 ml. particles containing 1·30 mgm. nitrogen, 60 μmoles substrate, 4·5 μmoles magnesium chloride, 0·6 μmoles manganese chloride, 90 μmoles phosphate buffer (1) *p*H 5·6, (2) *p*H 7·4 and 1 μmole potassium bicarbonate-^{14}C with 2·5 × 10^5 counts/sec. carbon-14 activity in a total volume of 3·3 ml.

In addition: (1) Adenosine triphosphate 9 μmoles; (2) adenosine monophosphate 9 μmoles.

Experimental conditions: Temperature, 25° C.; exposure period, 1 hr.; reaction terminated by 0·5 ml. 2 *N* sulphuric acid; excess carbon-14 dioxide removed by bubbling with inert carbon dioxide for 15 min.

The addition of reduced diphosphopyridine nucleotide to the medium stimulated the malic dehydrogenase activity, resulting in reduction of labelled oxalacetate to malate. Spectrophotometric determinations had shown the presence of malic dehydrogenase in the preparations. The presence of added malate apparently stimulated carbon dioxide fixation. The addition of malate in the presence of reduced diphosphopyridine nucleotide would result not only in this increase in fixation, but also serve as a trap for the malate formed by the reduction of the labelled oxalacetate. Results from experiments in which the added reduced diphosphopyridine nucleotide was increased twofold in the presence of malate showed a reduction in the total carbon dioxide fixation. The addition of oxalacetate (18 μmoles) to the medium markedly decreased the fixation.

The results show that this particulate preparation from barley roots provides an active system for carbon dioxide fixation through carboxylation of phosphoenolpyruvate. The results shown in Table 2 are representative of the general level of fixation, although in some experiments with added reduced diphosphopyridine nucleotide and malate as much as

Table 2. Carbon-14 Dioxide Fixation in Barley Root Particles. (Activity as percentage of total carbon-14 added)

Treatment	PEP	PEP + DPNH	PEP + DPNH + Malate	PEP + Malate
Total fixation	13·08	28·27	30·77	28·87
Total ether extract	0·86	6·04	12·99	1·64
Fraction				
Acetate	0	0·06	0·12	0·01
Pyruvate	0	0·03	0·03	0·01
Fumarate	0·06	0·88	2·16	0·14
Succinate	0·09	0·33	0·25	0·22
Pyrrolidone carboxylate	0·31	0·30	0·34	0·38
Oxalate	0·04	0·05	0·10	0·08
Malate	0·29	4·13	9·69	0·66
*iso*Citrate	0·03	0·18	0·25	0·10
Citrate	0·03	0·06	0·04	0·02
Tartrate	0·01	0·02	0·01	0·02
Fixation in ether extract expressed as percentage of total carbon-14 fixed	6·6	21·4	42·2	5·8

Reaction mixture: 1 ml. particles containing 1–2 mgm. nitrogen, 1 μmole phosphoenolpyruvate (PEP) cyclohexamine salt, 3 μmoles magnesium chloride, 1·2 μmoles manganese chloride, 9 μmoles adenosine monophosphate, 90 μmoles phosphate buffer at *p*H 7·4, and 1 μmole potassium bicarbonate-^{14}C with 2·5 × 10^5 counts/sec. carbon-14 activity in a total volume of 4·3 ml. 1·6 μmoles reduced diphosphopyridine nucleotide (DPNH) and 18 μmoles malate added as indicated.

Experimental conditions: see Table 1.

75 per cent fixation of the total carbon-14 added, and 53 per cent incorporation into the ether-soluble fraction, have been obtained.

A full account of the work will be presented elsewhere. We wish to thank Dr. L. Jacobson for his helpful suggestions throughout the investigation, and Dr. E. Conn for his generous supply of reduced diphosphopyridine nucleotide.

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Decumbin, a New Compound from a Species of *Penicillium*

An organism isolated during a microbiological study of corn spoiled in storage produced an aroma reminiscent of exaltone and crystalline bodies in artificial culture. The chief component of the crystalline bodies has been isolated as colourless, odourless needles, melting at 204° C. We have named this compound decumbin. We have concluded from work to be presented elsewhere that it is a previously unreported dihydroxy, α-β unsaturated lactone ($C_{16}H_{24}O_4$).

The organism producing decumbin has been identified as a strain of *Penicillium decumbens* Thom. (We thank Dr. Kenneth Raper for assistance in specific identification of the mould.) Our strain differed from the American Type Culture Collection No. 10436 (Raper N.R.R.L. 742) strain in that the A.T.C.C. strain did not produce detectable amounts of decumbin in comparable cultures. Both strains produce the characteristic aroma, however, and other characteristics convince us they are the same species.

Among several media tried, the production of visible crystals was best upon a broth prepared by steaming 200 gm. of peeled diced potatoes in 500 ml. of tap water for 30 min. The fluid was drained through one layer of cheese cloth, added to 20 gm. of commercial glucose, and made up to 1 litre. Stationary surface culture was used since the decumbin produced in submerged culture was more difficult to purify. Sterile potato dextrose broth, 300 ml. per rectangular, 2-quart milk bottle, was inoculated with a heavy spore suspension of *P. decumbens*. In about six days at 23–26° C., growth appeared complete with uniform grey-green sporulation and orange droplets of fluid on the surface of the mycelium. Needles of decumbin up to ¼ in. long attached to the submerged side of the mycelium began to appear after about eight days. Cultures were usually harvested after 10–12 days, but a small increase in decumbin yield continued for several more days.

To isolate decumbin, the contents of 100 bottles were strained through two layers of cheese cloth, and the mycelium extracted with three 1-litre portions of boiling methanol. The beer was chilled to 10° C., the precipitate collected, and extracted with 200–300 ml. of hot methanol. The combined methanol extracts were chilled overnight, filtered, diluted with 100 ml. of distilled water, and concentrated *in vacuo* until free of methanol. During the concentration, decumbin crystals began to form and, after chilling to 10° C., were filtered from the aqueous solution and the latter discarded. The average yield of this crude decumbin, m.p. about 190° C., was 278 mgm./l. of medium in a total of 1,404 bottles processed. Individual cultures yielded up to double this amount.

Decumbin was purified by washing the crude crystals with petroleum ether (3 ml./gm.) and recrystallizing them from 50 per cent (v/v) aqueous methanol (33 ml./gm.) and ethyl acetate (60 ml./gm.). The pure decumbin produced by several recrystallizations from these two solvents was not altered by careful sublimation *in vacuo* or drying *in vacuo* over phosphoric anhydride at 100° C.

The solubility of decumbin at 26° C., determined by weight loss from a single crystal after 19 hr. with frequent stirring, was 0·6 mgm./l. of water and 1·2 mgm./l. of 9·5 per cent ethanol. Absolute ethanol dissolved about 24·9 gm./l. These solubility characteristics made biological testing of decumbin difficult. For example, decumbin crystals were tasteless, but a saturated solution in 50 per cent ethanol applied to the back of the tongue was bitter.

Preliminary tests with decumbin showed it to be toxic to rats and to goldfish, and inhibitory to wheat germination, but not an active antibiotic under the tested conditions. Decumbin gave no zones of inhibition when 1 mgm./ml. solutions in 40 per cent (v/v) methanol in water were used in agar cup diffusion tests against *Staphylococcus aureus*, *Escherichia coli*, and *Hormodenrum cladosporoides*. A sample of *Triticum aestivum* var. Knox, of which 92 per cent germinated on filter paper moistened with water, was reduced to 82 per cent germination by 10 per cent (v/v) ethanol in water and to 52 per cent by 1·2 mgm./l. of decumbin in 10 per cent ethanol. Eight goldfish (*Carassius auratus*), average weight 1·7 gm., were each placed in 250 ml. of a filtered aqueous solution of decumbin containing 0·6 mgm./l. In about 4 hr. they became noticeably inco-ordinated. Death followed in about 20 hr.; the smallest (0·9 gm.) succumbed in 12 hr., the largest (2·95 gm.) in 29 hr. Three other fish which had developed definite symptoms (6 hr.) were removed to fresh water; one survived. Control fish in 250 ml. of distilled water remained normal. Young (approximately 100 gm.) albino rats (*Rattus norvegicus*, Wistar–Purdue strain) were fed measured doses of decumbin mixed with about ½ gm. of their normal diet. Fasted rats ate the material readily and consumed the entire dose. From a total of 38 rats dosed with 400 mgm./kgm. body-weight or more, only one rat survived. The toxic symptoms included a rapid onset of loss of appetite (about 2 hr) and diarrhœa (about 6 hr.), followed by increasing lethargy and finally cyanosis, laboured breathing, stupor, and death in about 24 hours. Many rats had slight nasal bleeding. The typical autopsy findings included congestion of the auricles and associated blood vessels with dark blood and fullness of the stomach with undigested food. Ten rats received a dose of 300 mgm./kgm. and two survived. All five rats which received 250 mgm./kgm.

survived. The rats that survived began to eat in about 36 hr. and became apparently normal in five days or less. The acute, oral $LD50$ for rats would be of the order of 275 mgm./kgm. based on these results. Hydrogenated decumbin was not toxic to two rats at 2,700 mgm./kgm. The physiological activity or toxicity of decumbin in mammals, cold-blooded animals and plants is similar to that found with other unsaturated lactones and the loss of toxicity upon hydrogenation is also typical[1].

In addition to its interest as a new compound and one with physiological activity, decumbin was considered as a possible though uncommon grain contaminant. The results of feeding tests with corn meal infected with this mould suggest that decumbin is produced, but not to a degree highly toxic to rats.

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Muscle Fibres of the Fast and the Slow Contracting Muscles of the Mesothoracic Leg of the American Cockroach (*Periplaneta americana* L.)

It is well known that some muscle fibres in the coxa of the mesothoracic leg of the American cockroach contract rapidly while others contract slowly[1,2]. Until recently the difference in contraction-speed of insect muscles was attributed mainly to a difference in innervation. Krüger[3], however, discovered that in vertebrates the structures of fast and slow muscles did not differ only in degree of innervation. The specific locomotory muscles apparently consist of fibres that show a uniform distribution of the myofibrils in cross-section (*Fibrillenstruktur*), whereas in posture muscles the fibrils are in small groups, in which the individual muscle fibres are sometimes scarcely discernible. These groups often form angular areas (*Felderstruktur*). The question now arises whether similar differences occur in insect muscles. In order to investigate this problem some muscles of the coxa have been examined in cross-section. They were fixed in 15 per cent formol, Champy, Susa and Bodian 2, and embedded in the usual way in paraffin (alcohol, methyl benzoate, benzol, benzolparaffin). For frozen sections the muscles were embedded in 15 per cent gelatine.

Examination of the whole muscle in cross-section shows that the muscle fibres do not all have the same structure. Two types may be distinguished.

Type A. Muscles 136 and 137 (Carbonell's numbering[4]). In the periphery of the fibres radially arranged partitions are observed, wherein, at greater magnification, the sarcostyles may be discerned. The protoplasm between the sheets is of a lighter colour. In the middle of the fibre is a large central lumen. The nuclei are always situated in the layer of sarcoplasm just under the sarcolemma. This picture is obtained both in paraffin and in frozen sections (Figs. 1 and 2). The radial arrangement is not always equally clear and sometimes not one can be seen in the whole fibre. Fibres without a central lumen are always smaller than the others in cross-section and their fixation is different.

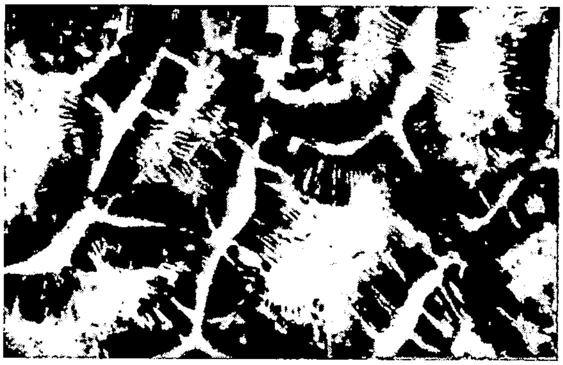

Fig. 1. Cross-section from the fast muscle 137 fixed by Champy paraffin section, iron–hæmatoxylin stain. (× 540)

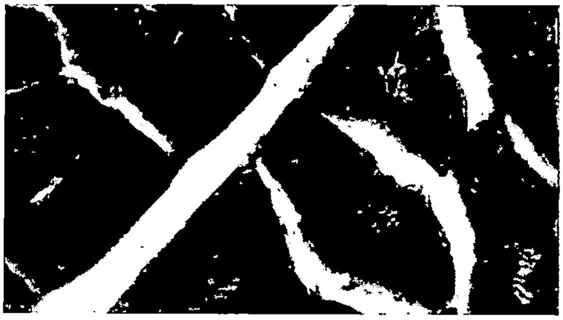

Fig. 2. Right, cross-section from the fast muscle 136. Left, from the slow muscle 135 *e*, fixed by Bodian 2, frozen section, sudan black stain. (× 540)

Type B. Muscles 135 *b*, *d* and *e*. In paraffin sections the fibres of these muscles generally have no central lumen. The sarcostyles are not radially arranged in partitions, but are either arranged in arbitrary rows or scattered all over the fibres. Cross-sections (Fig. 3) show these fibres to be smaller than those of Type *A*. In frozen sections, however, a central lumen is found not infrequently, in which case the sarcostyles are radially arranged (Fig. 2).

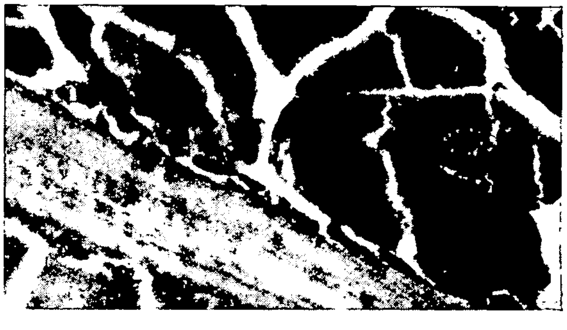

Fig. 3. Cross-section from the slow muscle 135 *d*, fixed by Bodian 2, paraffin section, stained with hæmatoxylin and eosin. (× 540)

With sudan black the fibres of muscles 135 *b*, *d* and *e* stain darker than those of muscles 136 and 137, moreover, with methylene blue the reducing capacity of 135 *b*, *d* and *e* is stronger than that of 136 and 137. As was the case with Type *A*, the nuclei of this type are situated in the layer of protoplasm right under the sarcolemma. Occasionally, however, they may be found nearer the centre of the fibre.

Muscles 135 *a* and *c* do not always give the same picture as 136 and 137; generally these are identical, but in some cases there is a closer resemblance to 135 *b*, *d* and *e*. This phenomenon was observed especially after fixation in Bodian 2.

According to Becht and Dresden[2] the muscles 136, 137 and 135 *a* and *c* are fast-contracting, and 135 *b*, *d* and *e* slow-contracting. The observations described above show that in frozen sections both the slow and the fast muscles are of Type *A*, whereas in paraffin sections the fast muscles are for the greater part of Type *A*, but the slow muscles are always of Type *B*. This difference can be explained only in terms of a different reaction with the fixation liquids, alcohol, methyl benzoate, benzol and paraffin.

This seems to indicate a difference in physicochemical composition that causes the slow muscles to shrink more under the influence of the fixation liquids than the fast ones and that also causes the radial arrangement of the sarcostyles to be lost. Moreover, it is evident that the fibres of the slow muscles contain more lipoids and water and have a stronger reducing capacity than the fibres of the fast muscles.

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Masculinizing Action of Pregneninolone on Female Gonads in the Cyprinodont, *Lebistes reticulatus* R.

Several authors have tried to induce sex inversion in *Lebistes reticulatus* experimentally by the use of sex hormones. Berkowitz[1] found that a high percentage of males treated from birth with œstrogenic substances developed ovotestes. The expected result with androgenic hormones would be the production of ovotestes in treated females. Treating young from birth, for a period of two to three months, Eversole[2] and Gallien[3] arrived separately at the same conclusion: that pregneninolone causes the ovaries to undergo a considerable regression, but that they always keep their female structure. Gallien added that after the cessation of treatment the ovaries returned to normal.

Suspecting that their failure to produce masculinization of the gonads was due to the relatively short duration of their experiments, and to the excessively high dose of pregneninolone used, we have carried out the following experiment: 55 animals, all the same brood of *Lebistes*, were treated from birth for a period of 6 months. Treated animals were divided into two groups: the first was given a high dose of 0·03 mgm. of pregneninolone (Ethistérone, UCLAF), three times a week. The second received a low dose of 0·015 mgm. of the same hormone, thrice weekly. A third group of control animals was raised in a manner identical with the treated ones. At the end of the experiment, histological examination of gonads showed that out of 55 treated animals, 37 were males, 15 possessed hermaphrodite gonads and 2 were typical females. Out of 16 control fish, we found 11 males and 5 females.

All treated animals, regardless of sex, showed a transformation of the anal fin into a more or less typical gonopodium. Gonopodia of treated animals were shorter than those of the control ones, and those of the high-dose group were shorter than those of the low-dose group. Specific characters of the gonopodium were present (that is, ventral and dorsal spines, as well as the terminal hook). There were not so many in treated fish as in the controls. Terminal bifurcations, normally found in both sexes, on the fourth, fifth and sixth rays of the anal fin, were partially or completely absent in treated animals. Treatment inhibited growth to a great extent, in both sexes. While treated males had typical body colorations, females had few, if any, body pigments, and when present they were very pale.

The first hæmal spine persisted in all treated animals except one; normally this regresses in both males and females[4,5]. This spine has the same morphology as the following hæmal spines. In almost all treated animals, the gonactines (interhæmal spines) have normal male morphology; in the others the gonactines are completely welded together.

The chronology of development between different secondary sexual characters is disturbed in many cases, due to an acceleration in the development and differentiation of the gonopodium with regard to internal suspensorial elements.

Treated males have testes more or less normal in structure, but in the high-dose group there is an obvious stimulation of spermatogenesis, in such a way that late stages predominate. Sperm ducts are more numerous than in control testes, and their epithelium seems to be highly stimulated.

Gonads of all treated animals, presumed to be genetic females (except two), are transformed into ovotestes. These gonads show different degrees of masculinization. Male elements existing include cysts of spermatogonia, spermatocyte I and II. Cysts of spermatids are less numerous, and spermatophores are rare; whenever present, these are abnormal in structure. In the ovotestes, a certain number of tubules can be distinguished, probably deriving from the epithelium of the ovarian cavity. Those tubules are the homologues of sperm-ducts in female gonads. The cranial region of gonads seems to be more sensitive to the masculinizing action than the posterior region, which sometimes maintains its typical ovarian aspect. In most cases, the persisting ovarian cavity is much expanded. Besides these male elements, and side by side with them, cysts of oogonia, and ovules at different stages of development, can be distinguished. Fully mature ovules are exceptional. Atrophied follicles appear here and there in the gonad.

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Preservation of Hæmocyanin

THE hæmocyanins are important proteins since they contain a marker atom (copper) and are remarkably good antigens. Since other investigators may wish to prepare and preserve hæmocyanins, we wish to direct their attention to our observations. In the course of experiments with preparations from *Busycon canaliculatum* and *Limulus polyphemus*, we noted that the dry product obtained by lyophilization (freeze-drying) could not be dissolved in water, in 0·85 per cent saline or in Tyrode's solution (*p*H 3·0–11·0). The hæmocyanin had also lost its oxygen-binding capacity and no longer turned blue when exposed to air. On the other hand, we have kept serum containing hæmocyanin at 4° C. under a layer of toluene, and find that it has retained antigenicity in guinea pigs, rabbits and mice after as long as ten years storage.

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Detection of Polythionate in Cultures of *Thiobacilli* by Means of the Folin–Ciocalteu Reagent

A SUBSTANCE giving a typical blue colour with the phospho-tungstate–phospho-molybdate reagent of Folin and Ciocalteu[1] was found to accumulate in cultures of *Thiobacillus thioparus* and *T. thiocyanoxidans* growing in a medium containing thiosulphate. The component in question was not associated with the bacterial cells since it remained in the supernatant fluid of cultures centrifuged at high speeds. The possibility suggested itself that the material involved was an oxidation product of thiosulphate, possibly tetrathionate or one of the other polythionates. These compounds have been reported to be intermediate oxidation products of thiosulphate by the *Thiobacilli*[2].

Polythionate was found to form in cultures of both species when culture fluids were analysed by means of Starkey's qualitative test[3]. This test depends upon the action of potassium hydroxide on the polythionates, converting them to mixtures of thiosulphate and sulphite, products which can be estimated by titration with iodine. Increased titration values during the incubation of cultures would indicate in a general way an increase in the amount of polythionate. The formation of trithionate at the expense of the other polythionates would confound this observation, since this compound on treatment with potassium hydroxide gives a higher iodine titration than do the others. The production of the Folin–Ciocalteu reactive substance was found to parallel the accumulation of polythionate. This was especially noticeable in cultures of *T. thiocyanoxidans*, which failed to produce any reactive substance until late in the incubation period (Table 1).

Sodium tetrathionate was prepared according to the technique described by Partington[4] and was purified by two recrystallizations from ethyl alcohol. The phenol reagent was readily reduced by the purified salt, which was very nearly as active in this capacity as tyrosine. Sulphite also reduced the reagent, but was considerably less active than tetrathionate (Table 2). If formalin were present during the reaction, the colour produced by sulphite was completely eradicated and the density of that produced by polythionate was reduced. The activities of these two substances differ from each other to such an extent as to make untenable the seemingly likely explanation that the mechanism involves the formation of sulphite from tetrathionate. That some alteration does occur was indicated by the necessity for the pre-incubation period in the alkaline copper solution of the usual Folin–Ciocalteu procedure.

Table 1. POLYTHIONATE ACCUMULATION IN CULTURES OF *T. thioparus* AND *T. thiocyanoxidans* AND THE FORMATION OF THE FOLIN–CIOCALTEU-ACTIVE SUBSTANCE

Organism	Incubation (days)	Polythionate*	Optical density of blue colour
T. thioparus	0	0	0·00
	3	40	0·36
	4	90	0·53
	5	84	0·60
	7	69	0·51
T. thiocyanoxidans	0	0	0·00
	3	0	0·00
	4	0	0·00
	5	15	0·24
	7	31	0·31

* Expressed as microequivalents of iodine per 5 ml. of culture fluid. The cultures were grown in Roux bottles containing 50 ml. of medium[2]. Individual cultures were used for the daily analyses. The optical density measurements were made using the 'Unicam model *SP*.500' spectrophotometer. Wave-length, 500 mμ.

Table 2. RELATIVE CHROMOGENIC ACTIVITY OF TYROSINE, TETRATHIONATE, SULPHITE AND CULTURE FLUID. EFFECT OF FORMALIN

Sample	Optical density of colour formed Without formalin	With formalin
Tyrosine, 0·5 μM	0·40	0·39
Tetrathionate, 1·2 μM	0·35	0·19
Sulphite, 30 μM	0·43	0·02
Culture fluid, 1·0 ml.	0·35	0·17

The optical density was measured in the Klett–Summerson photometer, employing the No. 47 filter. The culture fluid was a sample from a culture of *T. thiocyanoxidans* grown for five days in the usual thiosulphate medium, except that it contained a reduced concentration of phosphate. The medium after incubation was centrifuged for 30 min. at 10,000 r.p.m. and the supernatant was used for analysis.

The material formed in the culture fluids was found to behave toward formaldehyde in much the same way as tetrathionate; however, further work is needed to identify the culture material positively as a particular polythionate.

The use of the Folin–Ciocalteu reagent appeared to give an easy procedure for indicating the presence of polythionates in bacterial cultures. Its use for more quantitative purposes will require further study to determine the relative reactivity, if any, of the polythionates other than tetrathionate. Possibly alteration of the reagent and procedure would enhance its specificity.

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A Ripple Effect in the Audiogram

In the course of some psycho-acoustic experiments it was found that one observer's thresholds of acuity at two frequencies separated by only a few tens of cycles differed by nearly 10 decibels. Dips in an audiogram are not uncommon; but the difference observed pointed to an uncommonly sharp change of sensitivity. Further tests revealed other equally sharp fluctuations in this observer's audiogram. Eventually a systematic exploration of the right-ear thresholds of this and one other observer was undertaken. Thresholds were measured at 10-cycle intervals over the range 400–3,000 c./s.

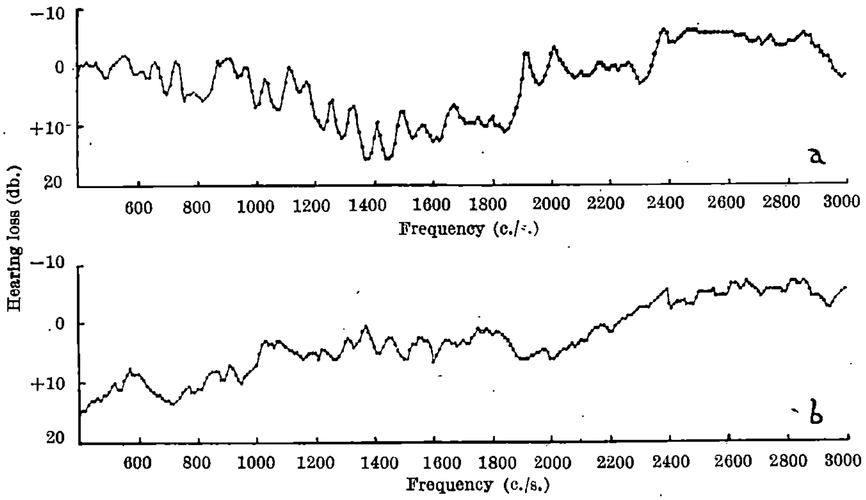

Fig. 1. Audiograms (*a*) for subject *A*, aged 21, and (*b*) for subject *B*, aged 28 years

The remarkable feature of these audiograms (Fig. 1) is the appearance of distinct ripples covering the range of frequencies up to about 2,000 c./s. Further experiments showed (1) that the ripples were stable over a period of at least two months, (2) that the left-ear audiograms also showed ripples, but the periods and amplitudes differed, and (3) that the ripple effect must be a very common, if not a universal phenomenon, since three additional observers also had the same sort of rippling audiograms in the narrower band from 1,000 to 1,400 c./s. This ripple phenomenon seems to have been unnoticed hitherto.

Threshold sensitivity fluctuates quite widely from one test session to another, and even within a single session if it is at all prolonged. To demonstrate the ripple effect it was necessary, therefore, to keep the test sessions short; but each session included measurements of threshold at frequency intervals which were small compared with the period of the ripple, and the frequency band covered was more than twice the period.

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Magnitude of Discomfort caused by High Brightness

Hitherto the greatest care has been taken here in the studies of building efficiency to avoid methods of subjective judgment which depend on assessment of sensation magnitude in terms of numbers. For certain reasons, however, a numerical assessment of the magnitude of the sensation of discomfort due to glare was required.

An experiment was designed in which subjects, so far as possible naïve in the context, were asked to adjust conditions in a room with glaring light sources until the sensation of discomfort was 'twice', 'ten times', 'one-half' and 'one-tenth' of the original level of discomfort. Eight out of twelve subjects were able to make judgments without trouble, the other four being either unco-operative or unable to follow what was required of them. The results were consistent and showed less variance than expected. The precise relations, which will be reported elsewhere, are not of importance in the present context because they depend on the experimental conditions.

It is of interest, however, that discomfort magnitude was found not to be correlated linearly with (apparent) brightness of the glaring sources. Whereas, under the given conditions of adaptation, apparent brightness was known from previous work[1] to be related to photometric brightness (luminance) by a power law of the form:

$$M = k\,L^{0\cdot 5}$$

where M is apparent brightness magnitude and L is luminance, the magnitude G assigned to the glare discomfort was found, under essentially the same conditions, to follow a law

$$G = k\,L^{1\cdot 23}$$

In other words, whereas the luminance of the sources must be raised four times $\left(\text{antilog}\ \frac{\log_{10}2}{0\cdot 5}\right)$ to appear twice as bright, the sources will appear twice as uncomfortable (for glare) if their luminance is raised only 1·8 times $\left(\text{antilog}\ \frac{\log_{10}2}{1\cdot 23}\right)$.

If these data are valid, it raises an important principle in practical engineering matters involving subjective judgments of magnitude, especially if this principle is applicable in other modalities, such as noise. This is, that if a stimulus gives rise to both a primary sensation (loudness or brightness) and also an associated secondary sensation (pain or discomfort), it does not follow that the magnitude of the secondary sensation is directly or simply linked to the magnitude of the primary sensation. Hence, if we wish to find out about discomfort or pain, we must assess discomfort or pain directly in relation to stimulus energy, and must not make implications from brightness or loudness magnitude assessments.

The experimental work was undertaken by Mr. R. C. Bradley (Cornell University) working at the Building Research Station with a grant from the Illuminating Engineering Research Institute of the United States.

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Interaction between Consecutive Responses in a Hemileucid Moth, and the Evolution of Insect Communication

Moths of the neotropical Saturnioid family Hemileucidae perform a special movement on assuming the resting position from any preceding activity, which has been termed 'rocking'[1]. It is rigidly co-ordinated, and consists of fast, rhythmic side-to-side oscillations of the entire animal. This movement is unique to the Hemileucidae, and appears to be a highly conservative character within that family, for it occurs in all species so far examined, irrespective of either size or mode of protective coloration[2]. Its function, if any, is unknown, but it is not concerned with the sexual responses of either sex, nor do the moths possess any known non-sexual social behaviour. The strength of this response may be scored as the number of complete oscillations performed; an analysis has shown that the strength of rocking executed by unconstrained moths of the Brazilian species *Automeris aurantiaca* Weym. is related to the nature of the sequence of acts preceding it[1].

The experiment here reported investigates the effect of different periods of forced, tethered flight upon the strength of the rocking response, at two different intervals after eclosion. Pupal development and emergence were allowed to proceed at about 25° C. Moths stored for intervals after eclosion were transferred to 20° C. in continuous artificial light and remained undisturbed throughout that period. They were suspended for flight in one of two ways. Either a small tab of paper was attached to the dorsal surface of the thorax with a quick-drying cellulose adhesive, and held in a clip, or a small dorso-lateral pinch of the second abdominal tergite was held in fine curved artery forceps, from which it could be released as required. The method of suspension did not influence the results. All moths were de-alated at the time of preparation. They were stimulated to fly at 26–29° C. by the tarsal reflex[3], at 4–8 hr. (26 moths) and 24–48 hr. (15 moths) after eclosion, immediately placed on a standardized vertical surface, and the number of rocks performed counted (Fig. 1). The strength of the rocking response increases with increase in preceding duration of flight, to which it bears a simple linear relationship which shifts as the moths age. For moths 4–8 hr. old, $y_1 = 2{\cdot}45 + 0{\cdot}790x$; and for moths 24–48 hr. old, $y_2 = -0{\cdot}75 + 0{\cdot}663x$. The difference between the two regression coefficients is not significant ($P < 0{\cdot}2, > 0{\cdot}1$).

Moths may be re-tested for the strength of the rocking response at intervals after settling following flight; in moths of both ages it is stable, certainly for periods of 30 min., and probably for at least 90 min., and would seem not to be affected by intercalated activities unrelated to flight. Further preliminary experiments, to be reported in full elsewhere, suggest that these relationships are not mediated either by feed-back from peripheral receptors[4] or by the chemoreception of the state of metabolic reserves[5].

Results of this kind have been obtained in studies of the behaviour of other arthropods[6]. They suggest that the arthropod nervous system may be so constructed as necessarily to store information about its past performance. The present case is of particular interest, for it concerns a rhythmic response. Recent work[7] tends to confirm the prediction[8] that the rhythmic 'waggle' phase of the honey-bee dance is a potentially important carrier of information about distance from hive to food-source when this is greater than 50–100 metres. The relationship between distance flown and the number of oscillations in each repetition of the straight run of the dance is simple and nearly linear over much of its range[7]; it differs from certain other quantitative features of the dance[9] in that it is not affected by the sugar-concentration of the food-source.

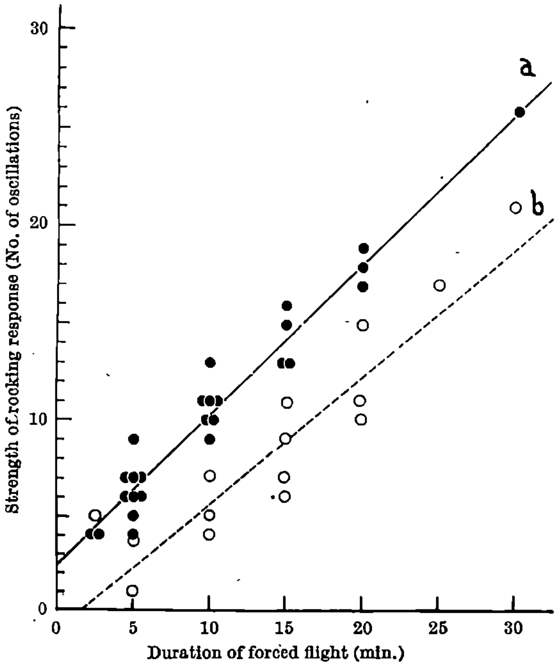

Fig. 1. The relation between the duration of forced flight (abscissa) and the strength of the rocking response (ordinate), for *Automeris aurantiaca* of two different ages: (*a*) 4–8 hr.; (*b*) 24–48 hr.

Dethier[5] has shown that those features of the bee-dance which show simultaneous dependence upon flight-distance and sugar-concentration may plausibly be interpreted in terms of the known mechanisms governing the central regulation of taste-thresholds, once it is assumed that feeding is itself the stimulus to dance. But such a mechanism cannot be assumed to mediate the 'waggle' phase of the dance in its quantal aspect, and for this some alternative evolutionary precursor must be found. Such a system would appear to be involved in the interaction between flight and settling behaviour in *Automeris*, which already possesses two of the most salient features of the 'waggle' dance, namely, the linear relationship described above, and a considerable measure of quantitative temporal stability. It is not, however, used in communication. It is likely that a full understanding of the causal basis of the bee-dance will only be possible when mechanisms of both kinds are taken into account.

The present results do not permit any very exact comparison of the two performances. However, if it is assumed that foraging bees fly at an average speed[4] of 14 m.p.h. ($\equiv 375{\cdot}5$ m./min.) and that both the outward and return journeys are registered in the waggle phase[7], then for the bee, 3·34 oscillations $\equiv$ 1 min. of flight, as compared with 0·79 oscillations for moths 4–8 hr. old. *Reproducible* information, therefore, is stored with less efficiency in the moths than in the honey-bee. These results emphasize a further problem: the presence of a teleologically perfect relationship of this kind in a non-communicating insect implies that it is dangerous to assume that the mere presence of an isolable factor in the bee-dance necessarily means that it is used in communication.

These experiments were started during a visit to the Ornithological Field Station, Madingley, Cambridge, part of the expenses of which were met by a Parliamentary grant-in-aid administered by the Royal Society. I am also indebted to Prof. V. G. Dethier, Johns Hopkins University, for a discussion of some unpublished work on *Phormia*.

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Feulgen-Positive Cytoplasm of *Molgula* Eggs

The Feulgen technique has been used with success for chromosome studies in whole mounts of the eggs of marine animals such as *Arbacia* and *Chaetopterus*[1]. Hundreds of specimens can be fixed, stained and mounted in an hour or two—a fraction of the time and effort involved in an embedding-sectioning procedure.

Recently, in expectation of preparations suitable for scoring chromosomal aberrations (investigations supported by a U.S. Atomic Energy Commission grant to the Marine Biological Laboratory), I applied exactly the same methods to fertilized eggs from the ascidian *Molgula manhattensis*. To my surprise, the cytoplasm stained so deeply that nuclei and chromosomes were completely obscured. Several papers of historical interest[2] report intense cytoplasmic coloration of *Molgula* eggs with non-specific staining methods. However, deep staining with the classic means of demonstrating deoxyribonucleic acid was not expected.

A maturing series of oocytes carried simultaneously through the solutions demonstrated that the stainable material accumulated during maturation. Only mature oocytes stained deeply.

Substituting one fixative for another made little difference. The cytoplasm was Feulgen-positive if Gilson's fixative, which contains no aldehyde, was used instead of Kahle's fluid. Digestion with cold perchloric acid (10 per cent for 11 hr. at 4° C.) did not eliminate the cytoplasmic stainability. This is a recognized method of removing ribonucleic acid. The Schiff reagent was a standard batch which was performing normally in the staining of *Habrobracon* (wasp) eggs.

Brachet[3] has referred to positive Feulgen reactions of the ooplasm of higher chordates but was unwilling to admit that deoxyribonucleic acid could be responsible. Amphibian and hen eggs were outstanding examples. Since that time, scattered reports of cytoplasmic deoxyribonucleic acid or deoxyribosides have appeared for a variety of organisms[4], and a hypothesis has emerged that the cytoplasm serves as a deposit for nuclear building materials required promptly and in quantity during cleavage[5].

The cytoplasm of *Molgula* eggs suggests itself as material worthy of attention by biochemists interested in morphogenesis.

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Relation between Breeding and Ecdysis in Cirripedes

In all major groups of Crustacea except in cirripedes it is well known that breeding is closely bound up with the moulting cycle. First, the male generally copulates with a female which has just moulted. Secondly, the moulting cycle is often interrupted while the eggs are being carried so that eggs are not lost by the shedding of the cuticle to which they are attached.

The Cirripedia are exceptional in being hermaphrodite and in having the egg masses lying free in the mantle cavity during incubation. As a result they do not necessarily lose them when they moult[1]. Crisp[2] suggested that a moult might be expected to accompany copulation as it does in other arthropods. Barnes and Barnes[3] later discussed the same idea, and without giving any definite evidence suggested that it occurred after fertilization.

During the past three years we have investigated six species of sessile barnacles, *Balanus balanoides* (L.), *Balanus balanus* (L.) (= *B. porcatus* da Costa), *Balanus crenatus* Brugière, *Balanus perforatus* Brugière, *Elminius modestus* Darwin and *Chthamalus stellatus* Poli.

In none of these species have we found evidence for a moult soon after copulation. On the contrary, the intermoult period is prolonged when the barnacle is carrying embryos, although the extension of the intermoult period is not absolutely regular. Normally ecdysis does not occur until after the young have hatched and escaped from the mantle cavity.

When hatching is delayed by withholding food[1] the intermoult period is further prolonged so that in the majority of individuals moulting still occurs just after liberation. Sometimes the moulting cycle seems to reassert itself before liberation; but the eggs still develop normally and a further moult usually occurs after liberation. Very occasionally developing eggs are ejected from the mantle cavity; but this usually occurs under abnormal temperature conditions and is not necessarily related to moulting.

In *B. balanoides* the breeding cycle is long and the period of anecdysis, which commences with the copulation in November, lasts until sometime between December and March, varying with the individual (Fig. 1). In this species the first cast skin after the period of anecdysis, irrespective of whether fertilization has occurred or not, contains all the tissues of the penis. The penis is thus separated by an abscission layer of new cuticle, and a new penis gradually

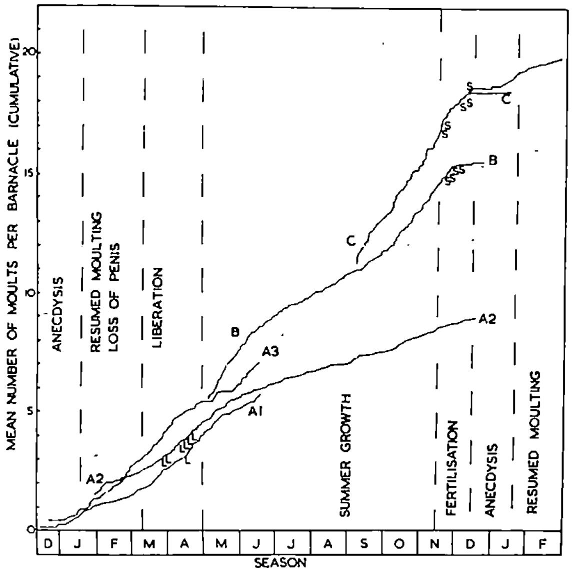

Fig. 1. Moulting-rate of small groups of *B. balanoides* kept without food. A_1, A_2, A_3, groups of fertilized barnacles showing resumption of casting after anecdysis; A_1, 5–7° C. temp.; A_2, sea temp. (8° C. rising to 15° C.; A_3, 13–15° C.; *L*, liberation of nauplii. *B*, groups of barnacles which had previously fed in the sea during spring. *C*, groups of barnacles fed in the sea until September, showing anecdysis; *S*, sperm pool indicating fertilizations

develops before the onset of the next breeding season. This remarkable phenomenon is natural, and is not the result of abnormal laboratory conditions. It occurs in the sea, since barnacles from the shore in January have either a complete penis or none at all. Moreover, it has been shown to occur regularly each year since 1954 in the laboratory and is therefore a part of an annual rhythm.

We have also found that individuals of this species which have moulted less than about a week previously are better able to act as females, fertilization occurring more frequently than in barnacles which had cast the skin more than a week before. In none of the other species could this effect be demonstrated, perhaps because the normal intermoult period of only 6–10 days is so short that every individual can be regarded as having recently moulted.

In *B. crenatus*, *B. perforatus*, *Elminius modestus* and *Chthamalus stellatus* embryonic development is relatively short, especially at higher temperatures, and after the brief interval for incubation normal moulting is resumed, its rate depending on the food supply and temperature. In *B. balanoides*, on the other hand, the moulting-rate only gradually increases after anecdysis, its resumption depending upon the amount of food taken in and the temperature. The inter-moult period usually reaches the normal summer value of 10–15 days by May. If the individuals are not fed in the spring, hatching is delayed and the resumed moulting continues at a slower rate (Fig. 1, curve A_2). The slower rate of moulting after anecdysis is not, however, a direct consequence of carrying the eggs but is due to prevailing lower temperature in April and lack of food. The moulting-rate does not increase appreciably when the eggs are artificially hatched with an extract of shell tissue[1]; but it does increase if the barnacle is fed or the temperature raised.

The continued regular casting of starved specimens which are losing rather than gaining weight is interesting. It suggests that ecdysis may have another function in addition to that of allowing for growth. Indeed, where casting is disadvantageous, as it is for the caterpillars of some butterflies which live with ants (for example, *Maculinea arion*), the body can grow four or five times in length by simply stretching the skin[4]. Perhaps another important function of ecdysis in filter-feeding Crustacea is to renew the fine setæ and so prevent the filtering apparatus from becoming clogged and inefficient.

These observations, which bring the Cirripedia in line with other arthropods, will be published in detail elsewhere.

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Plant Growth on 'Fly Ash'

In a previous communication[1], reference was made to research work in progress at Leeds on the reclamation of land covered with pulverized fuel waste ('fly ash'). Further to that work, we have concluded that aluminium and manganese, as found by Rees and Sidrak[2], are not the dominant causes of the toxicity in the 'fly ashes' investigated at Leeds.

Evidence from records on the tolerances of crop plants to 'fly ash', together with observations of leaf symptoms, suggest that boron is the dominant toxic element, and this theory has been strengthened by direct agronomic tests, together with relevant chemical analyses. The evidence is summarized below.

Information gained from pot and plot experiments has enabled a preliminary classification of agricultural and horticultural crops into the following three main groups on the basis of their ash tolerance:

Tolerant: Fodder beet, mangels, red beet, spinach, swede, turnip and sweet clover.

Moderately tolerant: Clovers, lucerne, kales, rape and mustard, other cultivated members of the Cruciferae and ryegrass.

Sensitive: Cereals (especially barley), peas, vetches, beans, potatoes, lettuce, carrots, parsnips, buckwheat and cocksfoot.

This list bears close resemblance to those of Eaton[3] and Berger[4], who grouped crops according to their boron tolerance.

Visual symptoms which develop on plant leaves under conditions of boron toxicity have been described by Eaton[3]. There is a close similarity between the recorded symptoms and those which have been observed on plants grown in 'fly ash', although the leaves of beets and kales in our experiments have not shown the characteristic marginal scorch. Barley

Table 1

Conc. of added boron in borax solution (p.p.m.)	Severity of leaf symptoms	Dry weight of plants (gm.)	Boron content of plants (p.p.m. in d.m.)
0	0	1·29	28
10	+++	1·11	248
20	+++	0·90	626
40	++++	0·64	1,738
60	++++	0·40	2,860
80	{ leaves dying	0·21	3,280
100		0·15	4,415

Table 2

Percentage ash (by vol.) added to soil	Ash *A*			Ash *B*			Ash *C*		
	Dry weight plants (gm.)	Leaf symptoms	Boron content (p.p.m. in d.m.)	Dry weight plants (gm.)	Leaf symptoms	Boron content (p.p.m. in d.m.)	Dry weight plants (gm.)	Leaf symptoms	Boron content (p.p.m. in d.m.)
0	1·22	0	17	1·27	0	15	1·35	0	18
12½	1·42	0	48	1·56	+	65	1·45	+	95
25	1·44	+	100	1·40	++	200	1·32	++	206
50	1·38	++	213	1·03	+++	351	1·02	+++	518
100	—	—	—	—	—	—	0·74	++++	1,420

Table 3

Percentage ash *C* added by volume to sand/vermiculite	Untreated fly ash *p*H 9·0			Acid-treated fly ash *p*H 6·1		
	Mean dry weight per pot (gm.)	p.p.m. of boron in d.m.	Severity of leaf symptoms*	Mean dry weight per pot (gm.)	p.p.m. of boron in d.m.	Severity of leaf symptoms*
0	4·66	44	0	5·14	33	0
6¼	3·26	260	+	5·11	75	0
12½	2·55	313	++	5·26	138	0
25	1·40	643	++++	4·89	310	+
50	0·82	796	++++	3·76	367	+
100	1·05	433	++++	0·40	1,246	++++

Dry weights L.S.D. = 1·07 gm. ($P = 0{\cdot}05$); boron content L.S.D. = 117 p.p.m. ($P = 0{\cdot}05$).

* Mild leaf symptoms took the form of leaf tip die-back, severe symptoms showed in addition a white interveinal striping of the lamina.

leaves, however, have consistently developed the marginal scorch, leaf tip die-back and brown necrotic spots and blotches associated with boron toxicity. Christensen[5], investigating the cause of non-parasitic spotting of barley leaves, was able to reproduce the spotting experimentally by adding borax or boric acid to a soil which otherwise produced healthy plants. The lesions which occur on barley leaves under conditions of manganese deficiency and toxicity[6] do not appear to be typical of those caused by 'fly ash'.

A small, non-replicated pot experiment was designed to compare the growth of barley on 'fly ash'/soil mixtures and on soil irrigated with solutions of borax. Three 'fly ashes', *A*, *B* and *C*, were used in this experiment. The leaf symptoms which developed on plants grown in 'fly ash'/soil mixtures were identical to those developed on the boron-irrigated plants. The 'soil' results are presented in Table 1 and the 'ash' results in Table 2.

Further evidence of boron toxicity has resulted from chemical analyses of oats from a replicated pot experiment specifically designed to compare the toxicities of untreated and acid-treated 'fly ash' when incorporated in increasing quantities with an inert medium of sand and vermiculite. The dry weights of oats, their boron contents and leaf symptoms are summarized in Table 3.

The accumulated evidence suggests that boron is a major component of the 'toxic principle' in 'fly ash' and determinations of the water-soluble boron contents confirm that this element is present in high concentration, samples *A*, *B* and *C* containing 19, 18 and 51 p.p.m. respectively. The degree to which the toxicity manifests itself will be dependent partly on the source of the ash and the degree of weathering or leaching to which it has been subjected. It must be emphasized that work referred to in this communication has been carried out on unweathered ash, that is, that taken directly from the pulverized fuel furnaces. (Boron has been determined after Higgons[7].)

This work has been made possible by a research grant to the University of Leeds by the Central Electricity Authority to which full acknowledgment is made.

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Effect of a Single Light Exposure on Germinating Broad Bean Seeds

In the course of investigations into the cytological and anatomical aspects of etiolation in *Vicia faba* L. (broad bean), experiments were carried out to determine the stage at which the germinating seeds first become sensitive to light in regard to subsequent development of the internodes.

Seeds were soaked for 24 hr., planted in soil and grown for 12 days. Throughout the period of soaking, during planting and for the whole period of growth the material was kept at 20° C. and in complete darkness, except for a single exposure to light for 2 hr. at approximately 600 ft.-candles. The seeds were divided into batches of fifty, each batch being given a single exposure to light, starting at various intervals up to 7 days from the beginning of soaking. As a control, one batch was given no light. The internode length of all seedlings was measured at the end of the 12-day growth period. Fig. 1 summarizes the results.

At 12–14 hr. after the beginning of soaking, when the testa is still intact, a 2-hr. exposure to light gives rise to a reduction of approximately 15 per cent in the mean ultimate length of the first internode as compared with seeds soaked and grown in complete

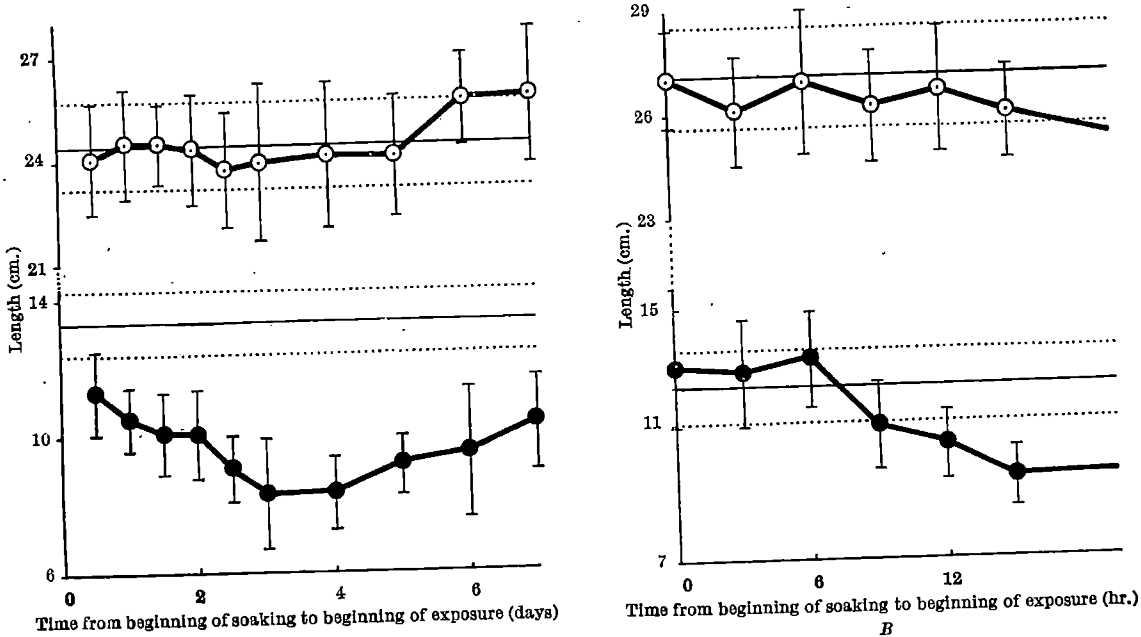

Fig. 1. Effect of a single light exposure on germinating seeds. ⊙—⊙—⊙, Whole shoot; ●—●—●, first internode. The vertical bars indicate the fiducial limits at the $P = 0{\cdot}05$ level. The horizontal lines represent the dark control values and their fiducial limits

darkness. The reduction reaches a maximum of approximately 35 per cent when the light is given at 3–4 days.

From the results it appears likely that the sensitivity to light may develop earlier than 12 hr. This view is supported by the observation of a pronounced increase in the frequency of plants in which a third internode elongates after an exposure to light as early as 6–8 hr. This development of the third internode, coupled with a general increase in the length of the second internode after early light treatment, appears to compensate for the reduction in length of the first internode, so that the effect of light is not revealed in the ultimate total length of the shoot.

The situation seems to be similar to that shown in *Avena* by Lange[1], Avery *et al.*[2] and Goodwin[3]. Thomson[4], also working on *Avena*, concludes that light accelerates whatever growth processes are going on while the light stimulus acts, exposure early in the course of either cell division or cell elongation accelerating that phase of growth. Exposure when either phase is well under way hastens transition to the next phase and reduces the final number or length of cells. The first internode in *Avena* is thus suppressed by light given at one day or earlier when cell division is already in progress.

In *Vicia*, however, the light sensitivity, as revealed by suppression of the first internode, appears to develop in the partially soaked, intact seed immediately the embryo has taken up water, although no cell division was observed until the third day. It may well be that sensitivity has already developed in the maturing seed and is one of the factors contributing to the great variation in development within batches of seeds germinated and grown in the same conditions. This possibility is being investigated.

Apart from these considerations, the practical implications of our findings for etiolation and light-growth studies is that seeds must be soaked in complete darkness if a true picture of the completely etiolated plant and the effects of light during subsequent growth is to be obtained.

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Effect of Gibberellic Acid and Kinetin on Growth of the Primary Leaf of Dwarf Bean (*Phaseolus vulgaris*)

IN the course of experiments on the effect of gibberellic acid on leaf area it was found that this substance accelerated expansion of the primary leaf of dwarf bean (var. Canadian Wonder); but the final area attained was identical with that of leaves receiving no treatment. Kinetin (6-furfurylaminopurine), on the other hand, depressed the rate of leaf expansion. Areas were estimated by use of a regression equation relating to the product of length × breadth calculated from measurements of more than 100 leaves. This equation is: area (cm.^{2}) = $0{\cdot}8682\ (\pm\ 0{\cdot}0196) \times p + 3{\cdot}19$, where p is length × breadth in cm.^{2}. The application of the allometry formula indicated that treatment produced no change in shape of leaf, so it is justifiable to apply this regression equation irrespective of treatment. The leaves were sprayed as soon as they had unfolded and assumed a horizontal position (length about 5·0 cm.), and were kept in darkness for about 16 hr. in case kinetin was destroyed by light. The average daily increments in area plotted for the mean period are shown in Fig. 1.

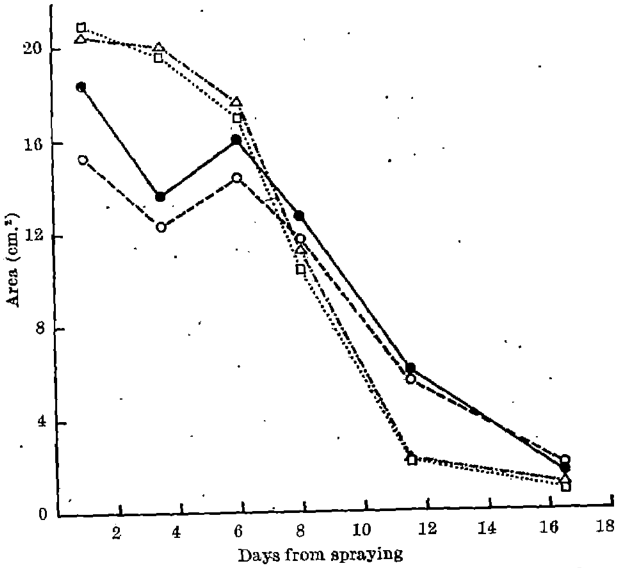

Fig. 1. Mean increase in area per leaf per day. ●—●, Control; ○—○, kinetin; □···□, gibberellic acid; △—·—△, gibberellic acid + kinetin

Leaves sprayed with gibberellic acid (50 p.p.m.) or gibberellic acid + kinetin (0·1 p.p.m.) at first increased in area at a greater rate than the control. Kinetin alone slightly depressed the rate of leaf expansion. About six days after spraying, the position was reversed and the control and kinetin-sprayed plants increased in area at a greater rate. The final area of the leaves sprayed with gibberellic acid was the same as that of the controls, but kinetin alone depressed final area (Table 1).

Table 1. Mean Final Area of Primary Leaf of Dwarf Bean

Treatment	Final area (cm.^{2}) *a*	 *b*
(–)	61·4	205·6
Kinetin	54·8	187·5
Gibberellic acid	62·4	199·4
Kinetin + gibberellic acid	61·2	202·4

a, Growing point intact; *b*, growing point removed.

It is to be noted that the depressing effect of kinetin was overcome in the presence of gibberellic acid. It was thought possible that the growth of the primary leaves might be affected by initiation of growth of the main axis (which was greatly extended by gibberellic acid) and that the subsequent depressing effect of gibberellic acid might be due to this. Precisely similar results were obtained, however, when the growing point was removed before treatment, except that the primary leaves in all treatments reached a greater final size (Table 1).

Morgan and Mees[1] found that gibberellic acid at first stimulated growth of grass swards but afterwards the yield was depressed and the dry matter and crude protein yields at the second cut were depressed by approximately the amount of increase at the first cut. Leben and Barton[2] also found an ultimate depressing effect of gibberellic acid on growth of grass. Humphries[3] found that gibberellic acid at first increased and then diminished leaf area and dry-matter production in the potato plant. In addition, it was found that gibberellic acid overcame a depressing effect due to kinetin.

Thus, the effect of gibberellic acid on the primary leaf of dwarf bean is analogous to its effect on whole plants in the instances quoted, namely, a preliminary stimulation and subsequent depression of growth.

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Inhibitory Effect of Gibberellins on Nodulization in Dwarf Beans, *Phaseolus vulgaris*

Gibberellins of fungal and higher plant origin are now widely used in experimental plant physiology, and are known to produce a great variety of effects on the growth and development of many different plants[1]. With very few exceptions, the effects noted are promotive, even high concentrations of gibberellins being relatively non-toxic, to both plants and animals[2]. The results to be reported in this communication, demonstrating an inhibition of nodule formation in dwarf beans, are therefore of interest.

Commercial dwarf beans (*Phaseolus vulgaris*) were planted in 3-in. clay pots containing potting soil supplemented with limestone. The plants were grown in a greenhouse uncontrolled as to temperature and light conditions. On the sixth day after planting, the pots were divided into 5 equal groups of 4 plants each, and on the seventh day each plant was watered with 20 ml. of a 1 : 500 (w/v) 15 : 15 : 15 fertilizer to ensure an adequate level of mineral nutrition during the growth experiment.

Eleven days after planting, when the mean height of the plants approximated 15 cm., the groups were sprayed, according to different schedules, with 'Gibrel', a Merck product containing 0·005 per cent potassium gibberellate in an aerosol preparation. Thirteen days later, the plants were carefully removed from the soil and various measurements made. The results are presented in Table 1. Among the notable effects of the gibberellin treatments are: (*a*) up to fourfold enhancement of elongation without significant effects on fresh weight; (*b*) enhanced lateral bud growth; (*c*) decreased dry weight in plants given daily sprays; (*d*) greatly decreased nodulization, especially in those plants subjected to daily sprays.

Table 1. Effects of Repeated Applications of Potassium Gibberellate on *Phaseolus vulgaris*. All Plants were examined on the Thirteenth Day of Growth after Spray Application

Group	Spraying schedule	Average height to terminal bud (cm.)	Average lateral bud growth (cm.)	Average fresh weight (gm.)	Average dry weight (gm.)	Degree of nodulation
A	Controls (no spray)	27·5	27·5	8·8	2·0	Numerous large clusters
B	Every 5th day	112·75	148·75	11·2	2·1	6–8 small nodules per plant
C	Every 4th day	93·25	93·25	8·1	2·1	9 small nodules on one plant
D	Every 3rd day	100·0	145·0	8·2	2·2	5–6 small nodules per plant
E	Every 2nd day	91·5	150·5	8·8	2·3	2 small nodules on one plant
F	Daily	93·5	159·5	9·4	1·5	None

Table 2. Effect of Gibberellin Applications to Soil Alone and to Plant and Soil. Measurements were made 19 days after planting, the plants having been sprayed only once, 5 days after planting

	Treatment		
	None	Soil only	Soil + plant
No. of plants	16	14	17
Terminal bud height (cm.)	24·2	36·6	75·0
Average dry weight per plant (gm.)	0·82	0·95	0·50
Percentage of plants showing nodulization	62·5	76·5	14·2

In a subsequent experiment, it was shown that gibberellin treatment of the soil was ineffective in inhibiting nodulization, though some growth effects were readily apparent. Gibberellin sprays applied to the plant and soil were more effective, both in increasing elongation and in decreasing nodulization (Table 2).

Although the mechanism of the inhibition of nodulization is not clear from these experiments, the results indicate the need for caution in the application of gibberellins to leguminous plants. They also suggest the possibility that nodulization may result from a local accumulation of gibberellins.

These experiments were performed as a project supplementing classroom exercises in plant physiology at a National Science Foundation-sponsored Summer Institute for Teachers held in the summer of 1957 at Iowa State Teachers' College at Cedar Falls, Iowa.

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Mitotic Delay in Irradiated Roots of *Vicia faba* : the Effect of Oxygen

It is well known that the presence of oxygen during the irradiation of biological materials by X- or gamma-rays usually increases the amount of radiation damage. At the cellular level a considerable amount of quantitative data exists on the effect of oxygen, given during irradiation, on the yield of chromosome aberrations[1], but little information is available concerning the influence of oxygen on the amount of mitotic inhibition. Early work on the fall in mitotic index values of broad bean root tips[2] and the more recent studies on mitotic rates of *Chortophaga* neuroblasts[3] and *Tradescantia* microspores[4] have all indicated that the degree of mitotic inhibition is dependent on the amount of oxygen present during irradiation.

We have investigated the oxygen effect on mitotic delay in broad bean root tips with the view of making a comparison with parallel results which we are obtaining for chromosome breakage and root elongation in this material. In our experiments gamma-rays from a cobalt-60 source were used, and the primary roots of seedlings were irradiated while maintained at 19° C. in aerated or oxygen-free water (nitrogen water, obtained by bubbling nitrogen). For irradiation the seedlings were transferred from their normal aerated water into the aerated or nitrogen water of the irradiation chamber for 5 min. before irradiation. Doses of 109 r. and 192 r. were used and both doses were given in 4·9 min. It was shown that a 10-min. immersion of control seedlings in nitrogen water did not affect mitotic rate.

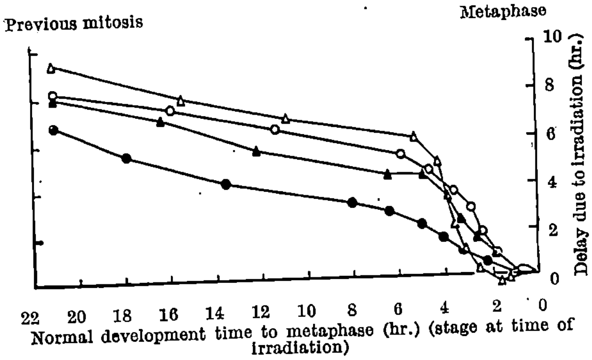

Fig. 1. Delay in reaching metaphase of cells irradiated at various stages of interphase. Normal mitotic cycle time, 21 hr. △, 192 r. in aerated water ; ○, 109 r. in aerated water ; ▲, 192 r. in nitrogen water ; ●, 109 r. in nitrogen water

Mitotic delay was measured by our colchicine method[5] which involved comparing the rate of accumulation of cells at metaphase in control material with the rates in the irradiated materials, at closely spaced time-intervals after irradiation. From these results we obtain the time required for cells to reach metaphase after being irradiated at any given point in interphase. The excess time over cells of control material, that is, the mitotic delay, is illustrated in Fig. 1.

The results show a marked oxygen effect for mitotic delay, and this effect is apparent for cells irradiated at any stage of interphase, the shape of the air and nitrogen curves being very similar. It is clear from these results that a dose of 192 r. in nitrogen is less effective in delaying the progress of cells through the mitotic cycle than a dose of 109 r. in air. Comparisons of the delays induced by both doses of radiation, in air and nitrogen, for cells which were more than 6 hr. from metaphase at the time of irradiation, gives an air/nitrogen ratio of about 2. This compares with the air/nitrogen factor of 2·4 for inhibition of root growth[6] and the factor of 2·2–2·5 which we have found for the production of micronuclei.

Further details of these experiments will be published elsewhere.

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Natural Cross-Pollination in Lettuce, *Lactuca sativa* L.

SELF-FERTILIZATION in *Lactuca sativa* L. is commonly regarded as being complete, although the inflorescences are visited by insects and the possibility of cross-pollination does occur[1,2]. Some indication that natural crossing takes place was provided by the fact that progenies raised from seed, taken from random plants grown in adjacent plots of a trial of a large number of varieties at Wellesbourne, have contained widely different proportions of off-types. An experiment was carried out in 1955, therefore, to ascertain the amount of crossing which might occur.

Two varieties were planted in each of four plots, these consisting of 15 rows of 11 plants, the odd rows and alternate plants in the even rows being of a pigmented variety, while the remaining plants were of an unpigmented variety. Each unpigmented plant was thus surrounded by 8 pigmented ones. The gene for anthocyanin pigmentation[3] behaves as a dominant in F_1.

The first plot contained two winter lettuce varieties which flower rapidly in long days[3], while the second plot, which was sown at the same time as the former, contained two varieties of summer lettuce. The remaining two plots consisted of the same varieties of summer lettuce as the previous one, but were sown at three-weekly intervals. The flowering periods of all plots differed from one another, and times of flowering within plots were made to coincide by the removal of any capitula from unpigmented plants which opened before those of the pigmented ones. Seed collected from the unpigmented plants was sown in 1956 and the number of pigmented and of non-pigmented seedlings was recorded.

The weather in 1955 was dry and warm, encouraging insect activity; but the lettuce did not appear to have the same abundance of pollinating insects as brassica plants flowering in the vicinity. Insects most attracted by the open lettuce capitula were various species of hover-fly and a few butterflies. Bumble- and honey-bees were rarely seen on the plants. This comparative scarcity of insects suggested that the proportion of hybrids produced would be low, and this was confirmed by the results from the earlier flowering plants. The percentage of hybrids produced by the later flowering plants, however, showed a sharp increase as indicated in Table 1. It has been suggested by Mr. J. A. Dunn, of this station, that this increase was probably due to the seasonal rise in the hover-fly population, and it appeared probable that hover-flies were the main pollinators in this experiment with lettuce.

Unsuccessful attempts were made to use hover-flies as pollinators by enclosing them in muslin bags together with flowering lettuce plants; in every instance they made continual attempts to escape, and lived a maximum of only 36 hr.

Table 1

Plot No.	Varieties (pigmented variety first)	Flowering period	Mean per cent cross-pollination
1	Rouge à pomme dure d'hiver, Lees Immense	July 18–Aug. 26	0·75±0·053
2	Mignonette, Cheshire Green	Aug. 6–Sept. 8	0·15±0·009
3	Mignonette, Cheshire Green	Aug. 13–Sept. 16	3·19±0·186
4	Mignonette, Cheshire Green	Aug. 30–Sept. 26	11·52±2·749

The statistical analysis of the results showed that plants flowering late in the season exhibited a significant increase in the percentage of natural cross-pollination. With the exception of three plants in plot 3, cross-pollination during each of the different flowering periods was entirely at random.

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Sex Chromosomes in the Hop *Humulus lupulus*

STUDIES of meiosis in male plants of the hop *Humulus lupulus* have resulted in conflicting reports on the nature of the sex chromosomes. Winge[1] and Jacobsen[2] have described an unequal pair of sex chromosomes which Jacobsen also identified in the somatic cells of male and female plants. Sinoto[3] found no heteromorphic pair, but described a chain of four sex chromosomes which he designated $X_1Y_1X_2Y_2$. No evidence was put forward in support of this interpretation. Ono[4], however, demonstrated in *H. lupulus* var. *cordifolius* (the wild hop of Japan) that a quadrivalent occurred in meiotic divisions in the male, but not in the female plant. More recently[5] he has described the occurrence, in a number of male varieties, of five different sex chromosome types, one of which is a homomorphic pair, two are heteromorphic pairs with different length ratios, and two are complexes of four chromosomes, also with differing length ratios.

During the 1957 season meiosis was studied, at Wye, in six male plants, five of which were seedlings from open pollination of wild Canadian or New Mexican female plants and one (No. 15) was of unknown origin. In all six a heteromorphic pair of chromosomes could be distinguished. In four of these males a quadrivalent association was found in addition to the unequal pair. Whereas the latter was a constant feature of all divisions, the quadrivalent was not present in a number of nuclei (Fig. 1,

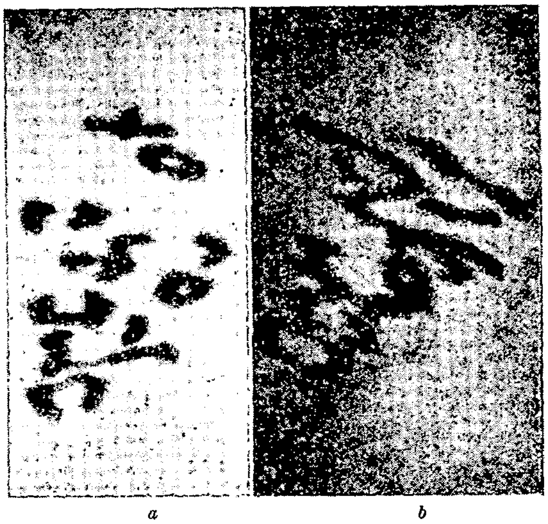

Fig. 1. Meiosis in male 321. *a*, Nucleus containing a heteromorphic pair and nine bivalents; *b*, nucleus containing a heteromorphic pair, a quadrivalent and seven bivalents

Table 1

Male plant No.	No. of nuclei without quadrivalent	No. of nuclei with quadrivalent
15	13	0
OL 45	1	0
321	5	11
OR 80	6	1
RY 83	2	1
OB 79	1	2

Table 1), and in view of Jacobsen's work it seems likely that the heteromorphic pair consists of the sex chromosomes, in which case the quadrivalent must be an association of autosomes.

These observations raise doubts concerning the identity of Sinoto's and Ono's quadrivalents. The only evidence to suggest that they include the sex chromosomes is Ono's work on var. *cordifolius*. Since he has reported both quadrivalent and homotype chromosomes in wild Canadian male plants, his observation of a similar difference between male and female plants of var. *cordifolius* is not conclusive evidence that this difference is related to sex determination. Examination of meiosis in males of var. *cordifolius* by Dark (unpublished work) showed that of 66 nuclei recorded only 45 contained trivalent or quadrivalent associations, and since Ono does not indicate the number of *cordifolius* nuclei studied, this raises further doubts as to the validity of his conclusions.

Even if the quadrivalent of var. *cordifolius* is accepted as being a sex chromosome complex, it is clear from the results reported here that there is no justification for making a similar assumption about quadrivalents found in other strains, in the absence of supporting evidence.

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[5] Ono, T., *Bull. Brew. Sci.*, **2**, 1 (1955).

A Chromosome Count in *Schizaea*

The Schizaeaceae are a very ancient family of ferns, with only four very distinct genera still living. In view of their great antiquity, the cytology of these plants is of considerable interest for fern phylogeny. Manton[1] has recorded chromosome numbers in two of the four genera, namely, $n = 38$ and 76 in *Anemia*, and $n = 29$ and 30 in *Lygodium*. No information is available for *Mohria*, nor, until now, for *Schizaea*. The extreme difficulty of maintaining any of the known species of *Schizaea* in cultivation is no doubt a principal reason for this omission.

During a year's stay in New Zealand, during the tenure of a New Zealand National Research Fellowship, an opportunity arose on two occasions to obtain meiotic fixings from wild material of *Schizaea asperula* Wakefield[2] (formerly included in *S. bifida* Willdenow). The localities were Waikumete, near Auckland, and West Wanganui Inlet (West Haven), N.-W. Nelson, South Island. The same chromosome number was obtained for both localities. An example of diakinesis is illustrated in Fig. 1, showing unequivocally that $n = 77$.

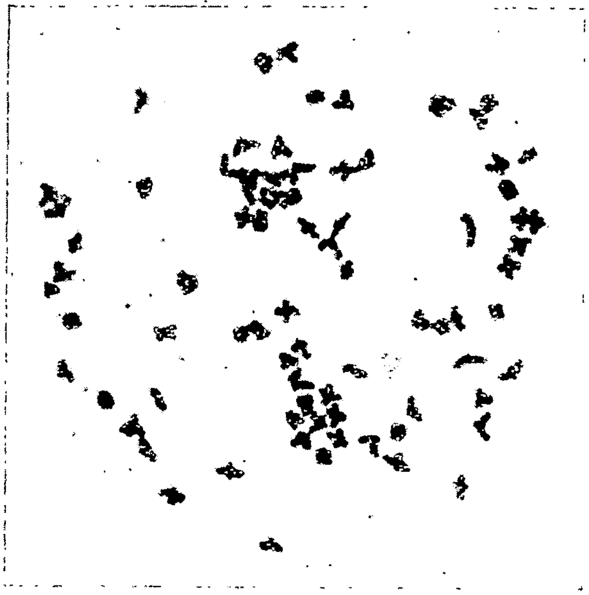

Fig. 1. Diakinesis in *Schizaea asperula* from West Wanganui Inlet, N.-W. Nelson, New Zealand, with $n = 77$. (× 750)

It is premature to discuss the interpretation of this number except to point out that there need not be any direct relationship to the $n = 76$ found in one species of *Anemia*.

A more detailed description of this investigation will be published elsewhere, together with an account of work on the taxonomy and distribution of *Schizaea* in New Zealand.

J. D. Lovis

Department of Botany,
University of Leeds. Feb. 12.

[1] Manton, I., *Phil. Trans. Roy. Soc.*, B, **238**, 127 (1954).

[2] Wakefield, N. A., *Victorian Naturalist*, **59**, 89 (1942).

Pseudofertilization in the Genus *Lumbricillus* (Enchytraeidae)

Natural populations of the common enchytraeid worm *Lumbricillus lineatus* Müll., occurring in decaying seaweed, contain diploid ($2n = 26$) and triploid ($3n = 39$) individuals. The Enchytraeidae are normally hermaphrodite but the triploid form of *L. lineatus* reproduces parthenogenetically and is distinguishable from the diploid type by the absence of seminal vesicles. Spermatogenesis in the parthenogenetic form does not proceed beyond the spermatid stage and no mature spermatozoa are produced[1]. In spite of this, the spermathecæ of triploid worms from natural populations always contain spermatozoa. Experiments were designed to determine the origin of these spermatozoa as well as their possible role in the activation of cleavage in triploid eggs. The triploid form will be referred to as *L. lineatus* 3 × and the diploid as *L. lineatus* 2 ×.

Cultures were set up containing either *L. lineatus* 3 × alone, or together with related species of the genus *Lumbricillus* also occurring in decaying seaweed. The different combinations used are shown in Table 1 (col. 1); each culture contained at least ten worms of each species. All *L. lineatus* 3 × individuals were isolated at a sexually immature stage, before they had copulated. The cultures were examined at frequent intervals for the presence of spermatozoa in the spermathecæ of *L. lineatus* 3 × (col. 2). The cocoon production of *L. lineatus* 3 ×

Table 1. PRESENCE OF SPERMATOZOA IN THE SPERMATHECÆ, COCOON PRODUCTION AND EMBRYO DEVELOPMENT IN *Lumbricillus lineatus* 3 × IN PURE AND MIXED CULTURES

Culture combinations	Spermatozoa present in spermathecæ	Cocoons laid, cleavage beginning	Cocoons hatching, cleavage completed
L. lineatus 3 ×	—	+	—
L. lineatus 3 × *L. lineatus* 2 ×	+	+	+
L. lineatus 3 × *L. rivalis*	—	+	—
L. lineatus 3 × *L. pagenstecheri*	—	+	—
L. lineatus 3 × *L. viridis*	—	+	—

and the development of the embryos were also followed (cols. 3 and 4).

Table 1 shows that spermatozoa were present in the spermathecæ of *L. lineatus* 3 × only in the *L. lineatus* 3 × /2 × cultures, whereas none of the other species considered (col. 1) provided spermatozoa to *L. lineatus* 3 ×. Hence the triploid parthenogenetic form can only copulate with the closely related diploid species. The experiments also prove that spermatozoa from *L. lineatus* 2 × are necessary for the successful development of the eggs of *L. lineatus* 3 × (col. 4), since only in the 3 × /2 × cultures did the embryos of *L. lineatus* 3 × hatch. In all the other combinations development was arrested before the typical dorso-ventral curvature[2] of the embryo had occurred. It has been definitely established that *L. lineatus* 3 × reproduces parthenogenetically[1] and, although spermatozoa from *L. lineatus* 2 × are necessary for normal cleavage of the eggs, they do not contribute chromosomes to the 3 × nuclei. The exact role of the spermatozoa remains to be determined and will be dealt with in a later paper.

The observed phenomena represent a special case of pseudofertilization in which spermatozoa from a sexual diploid hermaphrodite species are necessary for the normal development of the eggs of a parthenogenetic relative. Thus although the triploid form has a parthenogenetic reproductive mechanism and is genetically isolated, it cannot exist independently of the diploid species. The term 'obligatory co-existence' gives an adequate description of this relationship. A similar case has been observed in the spider beetles *Ptinus latro* ($3n = 27$) and *P. hirtellus* ($2n = 18$)[3].

While it is recognized that the situation described presents a problem in nomenclature, the two forms will be provisionally referred to as subspecies of *L. lineatus*. Thus the name *Lumbricillus lineatus* ssp. *lineatus* is proposed for the diploid form and, because of the absence of seminal vesicles, the name *Lumbricillus lineatus* ssp. *avesiculatus* is proposed for the triploid form. The nomenclatural problem will be discussed further in a later paper.

The work is being financed by a grant from the Danish State Research Foundation (B. C.) and a University of Wales Research Fellowship (F. B. O'C.).

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[1] Christensen, B. (in course of preparation).
[2] Penners, A., *Z. wiss. Zool.*, 137, 55 (1930).
[3] Woodroffe, G. E., and Moore, B. P., *Pest Infestation Research* (1955–56).

Records of the Group Pogonophora in the Skagerrak

UNTIL recently, specimens of the strange deep-sea animals belonging to the group Pogonophora were known only from the Pacific. The first records were from Indonesia, and later on large samples were found by the Russians in the north-western part of the Pacific, and several species were described from this area. In 1956 I described some new finds from the eastern part of the Pacific, namely, from the Gulf of Panama, where they were taken by the *Galathea*[1]. At the same time a description appeared of a new species, *Siboglinum ekmani*, by G. Jägersten[2]. This species was found in the Skagerrak, many miles from the earlier habitats. It was taken during the Skagerrak Expedition in 1933, but not identified until recently.

In April 1957 I had the opportunity of joining the Danish Fisheries Investigations ship, s.s. *Dana*, in the same area in the Skagerrak, where *Siboglinum ekmani* had been found. At the deepest part of the Skagerrak off the south coast of Norway, 700 m. below the surface, we obtained fairly large quantities of the same species. The tubes are small, having a

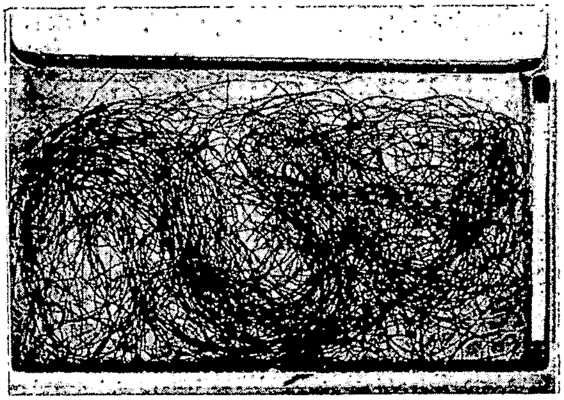

Fig. 1

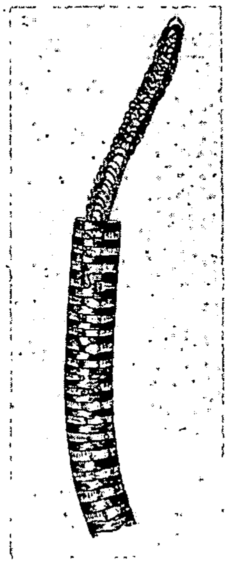

Fig. 2

diameter of 0·15 mm. and a length of about 100 mm. They are hair-like, and appear like small threads of algae or threads from the trawl (Fig. 1). But when they are seen in the microscope they are recognized at once, the structure being very characteristic (Fig. 2). The distribution of this species is probably wider than indicated by my finds. The animals seem to prefer cold water, as all the records in the world are from deep water with low temperatures. In the deep part of the Skagerrak the temperatures are about 5° C. throughout the year.

J. B. Kirkegaard

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[1] Kirkegaard, J. B., *Galathea* Report, 2, 183 (1956).

[2] Jägersten, G., *Zoologiska Bidrag från Uppsala*, 31, 211 (1956).

British Pea-crabs (*Pinnotheres*)

The adult male and female of *Pinnotheres pisum* (Pennant) are unlike in appearance, the male being thick-shelled, with a conspicuous colour pattern, the walking legs flattened and bearing fringes of long plumose hairs, enabling it to swim. The adult female is considerably larger, thin-shelled, generally without a colour pattern and without swimming hairs.

It was formerly considered that the males of *P. pisum*, young and adult, were normally of one form, although a few so-called abnormal crabs resembling the female in consistency and lack of colour had been found[1,2]. Further work has made it clear that the male occurs in two main forms. The one which approaches the young stage-II female in appearance is seasonal in occurrence, being found mostly in the summer, June–August inclusive in south-west England, that is, during the moulting season of the male and when young crabs occur in mussels, and rarely at other times. It therefore appears that males occur in the thin-shelled form during periods of rapid growth.

Rearing of a number of males within *Mytilus*, and the moulting of others soon after their arrival in the laboratory, has shown that the male repeatedly changes from one form to the other. A curious fact is that not once did the thick-shelled male moult into the same form, one to three thin-shelled forms intervening. With few exceptions the crabs remained for a longer time in the thick-shelled than in the thin-shelled form: in the former condition they were restless, frequently leaving and re-entering their hosts, while in the latter they never did so, being unable to swim.

The thin-shelled male has a normal male abdomen, only slightly wider in relation to the width of the thorax than that of the thick-shelled male. Thick-shelled males have been found at a carapace width of 1·4–7·6 mm.; thin-shelled males 1·9–6·3 mm.

Males resembling the female in consistency and lack of colour have been recorded in *P. maculatus* by Rathbun[3] and in *P. ostreum* by Stauber[4]. In *P. pinnotheres* (L.) (= *veterum* Bosc.), in which there is no comparable sexual dimorphism, I have found only one type of male, although eight have been reared in the laboratory—one for 22 months—through as many as five moults. In this species the young adult female is capable of swimming.

The juvenile females of *P. pisum* resembling hard-shelled males have been found to pass through several growth-stages to reach the adult[1,2]. These stages have now been followed in each of four crabs with initial carapace widths of 3–4 mm., which lived for up to two years before being killed: two spawned.

All male-like females were termed stage I: this did not imply that they are the first crab stage[2]. The smallest *P. pisum*, a male, taken from *Mytilus*, had a carapace width of 1·4 mm. and this is probably not less than the third crab stage, for the megalopa has a carapace width of about 0·57 mm.[5]. Stage I females have been found with a carapace width of up to 4·9 mm., so it is evident that growth can occur with little or no widening of the abdomen. The smallest stage-II female with abdomen appreciably wider than that of the male had a carapace width of 2·1 mm. It appears that during growth, without or with only slight widening of the abdomen, the crab does not remain thick-shelled, but that one or more periods may intervene during which it is stage II in consistency, in lack of colour and of swimming hair, but with narrow abdomen. During this time the pleopods remain as little developed as in the thick-shelled stage I[2]. That these crabs are not the result of laboratory conditions is proved by their occurrence in the wild. Those few reared had empty spermathecæ.

In addition to the rearing of both *P. pisum* and *P. pinnotheres* in hosts in the laboratory, a population of *P. pisum* in the Camel Estuary, north Cornwall, was sampled approximately monthly for two years, and populations from other localities less frequently. It was found that the male *P. pisum* reaches sexual maturity at a carapace width of about 2·0 mm.: copulation is precocious, a female of 1·75 mm. carapace width being found with full spermathecæ, while the smallest ovigerous female had a carapace width of 6·5 mm.

In *P. pisum* the main spawning months in south-west England are May–August; spawning can occur three days after hatching of the previous brood, and it is probable that a crab spawns several times during the season. The main moulting season of the male is June–August, that of the female June–October.

A full account of this work and of other aspects of the biology of *P. pisum* and *P. pinnotheres* will be published elsewhere.

D. Atkins

The Laboratory,
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Plymouth.

Jan. 30.

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[1] Orton, J. H., *Nature*, 106, 533 (1920–21).

[2] Atkins, D., *J. Mar. Biol. Assoc. U.K.* (N.S.), 14, 475 (1926).

[3] Rathbun, M. J., *Bull. U.S. Nat. Mus.*, No. 97 (1918).

[4] Stauber, L. A., *Biol. Bull.*, 88, 269 (1945).

[5] Atkins, D., *Proc. Zool. Soc.*, 124, 687 (1955).

The Cromer Forest Bed: Preglacial or Interglacial?

Now that the detailed palæobotanical account of the interglacial deposits at Bobbitshole, Ipswich, by Dr. R. G. West[1], of the University Sub-department of Quaternary Research, Cambridge, has appeared we are better able to appreciate the magnitude of our debt to him and to their finder, Mr. H. E. P. Spencer, of the Ipswich Museum. Correlation of East Anglian and Continental late Pleistocene events has been thereby substantially aided, but in the concluding section of the paper a statement re-appears about the correlation of an older phase which is difficult to reconcile with our records of East Anglian stratigraphy. The statement is that, in the opinion of the well-known authority, Prof. P. Woldstedt[2], the palynology of the Cromer Forest Bed series shows that it "was formed in the oldest (Cromerian) interglacial period in East Anglia". Dr. West has, apparently independently, reached the same conclusion. It therefore becomes desirable to direct attention to some of the geological difficulties that arise from this interpretation.

The occurrence of an interglacial phase implies that of a preceding glaciation, but no moraines or till belonging to such are known in East Anglia before the Cromer Forest Bed was formed. Admittedly, all traces may have been removed in the course of a subsequent glaciation, or completely covered and not revealed by borings and excavations since. In that event, we are driven to utilize the evidence from neighbouring areas, for example, northern Europe. Before referring to the latter, however, I may note that the East Anglian shelly sands and gravels, known as Crag, which are in the main (if not wholly) older than the Cromer Forest Bed, furnish no sound evidence of climatic change other than a gradual cooling (shown by the Mollusca) and the possible transport of erratics by icebergs from the north. The implications of a Crag glaciation were reviewed in detail some years ago[3], when efforts were made to resolve certain difficulties that had arisen in the linking up of the industries of early man with well-established glacial and interglacial events; but the assumption of an early Crag glaciation seemed to increase rather than lessen the difficulties.

The succession that has served us reasonably well as a standard in the east of England for many years past is set out in Table 1 (in which I have retained the older nomenclature as well as the newer terms because it remains more appropriate in several respects). The various early human industries can be fitted into the scheme (allowing for time occupied in migration) without excessive strain.

Table 1

Hunstanton Boulder Clay (Newer Drift) = Warthe, ? Weichsel = Würm
  Interglacial (Bobbitshole, etc.) = Eemian in part
Upper Chalky Drift (Gipping Boulder Clay) = Saale = Riss
  Interglacial (Hoxne, etc.) = Elster/Saale = Mindel/Riss
Chalky-Jurassic Boulder Clay (Lowestoft Boulder Clay) = Elster = Mindel
  Interglacial ("Middle" glacial, Corton Beds, etc.) = ? Günz/Mindel
North Sea Drift (Norwich Brickearth, Cromer Tills ?) = ? Donau, ? Günz 1, ? Günz 2
  Cromer Forest Bed series
  Pleistocene shelly sands (Crags)

The succession recorded in the lower half of the table is based on the evidence from inland and coastal exposures in northern and eastern Norfolk. At Corton, north of Lowestoft, for example, a peaty bed at beach-level, tentatively referred by Clement Reid to the Cromer Forest Bed, is seen to be succeeded by the Norwich brick-earth, then by the sands and gravels termed by D. F. W. Baden-Powell the Corton Beds (in which, in the nearby Flegg Hundred, S. V. Wood, jun., found molluscan assemblages of mixed character), and finally by the Chalky-Jurassic Boulder Clay. On the northern coast of Norfolk the Cromer Forest Bed visibly underlies the Cromer Till, which in turn underlies sands containing a shelly fauna and identified by Baden-Powell with his Corton Beds. The interglacial phase here represented was marked by widespread weathering and erosion of the Norwich brick-earth and the overlying sands and gravels, the major valley-systems of the region being then brought into existence.

In passing, I may note that if the Cromer Tills come to be regarded as a facies of, not the North Sea Drift, but the Chalky-Jurassic Boulder Clay, the Cromer Forest Bed may prove to belong to this interglacial interval. In that event, however, the peaty bed at Corton cannot be the Cromer Forest Bed. Further investigations of this peaty bed throughout eastern Norfolk are thus highly desirable. Although we possess much information about the fossil contents of the Cromer Forest Bed at its type locality, we know strikingly little about its areal distribution or about the extent in space and time of the unconformity that underlies it.

Evidence from the Continent in support of the view that the Cromer Forest Bed belongs to the oldest interglacial is far from good. Geologists have hitherto been unable to agree that any trace of the earliest (Günz) glaciation of the Alps occurs in the area of northern Europe extending from the Netherlands to the U.S.S.R. While some authorities still doubt the existence of the Günz in the Alpine area itself, others see in the pre-Mindel moraines and other glacial deposits of the peripheral area the relics of separate glaciations which have been termed[4] the Donau, Günz 1 and Günz 2. Early interglacial or interstadial deposits have in places yielded pollen-bearing beds, but the stratigraphical relationships are not sufficiently precise to enable geological correlation to be established. Baden-Powell's comparison[5] of the shelly faunas of the Mediterranean Pleistocene marine stages (terraces, etc.) with those in East Anglia favours the view that the oldest interglacial follows rather than precedes the North Sea Drift glaciation. With considerable skill he has diagnosed the Corton Beds fauna as the climatic equivalent of the Tyrrhenian stage of the Mediterranean under a modified Pleistocene isothermal distribution. This phase followed the first cold stage in that area—the Sicilian—which he would correlate with the earliest glaciation of northern Europe.

Until the figures for absolute age obtained by tests for radioactivity become available (and they are slow to accumulate), we rely for correlation on the evidence provided by fossil groups such as the Mammalia, Mollusca and plants, among others; also, in order that the risk of homotaxial relationships being mistaken for contemporaneity may be reduced to a minimum, we hope the lines of evidence will converge. The classification of the East Anglian Pleistocene set out above is doubtless over-simplified by the omission of stadia and interstadia, but there seems little advantage in altering the status (for example, glaciation into stadial ice-advance, or *vice versa*) of our well-individualized events, even for the time being. The alternative is to await new evidence. Until some of the difficulties outlined in the foregoing have been met, it would appear premature to assign the Cromer Forest Bed to the oldest interglacial period in East Anglia.

P. G. H. Boswell

Imperial College of Science and Technology,
London, S.W.7.

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[1] *Phil. Trans. Roy. Soc.*, B, **241**, 1 (1957).

[2] *Nature*, **165**, 1002 (1950).

[3] *Proc. Geol. Assoc. Lond.*, **42**, 87 (1931). Rep. Brit. Assoc. Meeting York, 1932, 63. *Proc. Prehistoric Soc. Lond.*, No. 6, 149 (1936).

[4] See, for example, Zeuner, F. E., *Nature*, **173**, 1178 (1954).

[5] *Nature*, **172**, 762 (1953); *Proc. Geol. Assoc. Lond.*, **66**, 271 (1955).

FORTHCOMING EVENTS

Monday, April 14

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. G. W. Kirkland, M.B.E.: "Pre-stressed Concrete". (First of three Cantor Lectures. Further Lectures on April 21 and 28.)

Society for Visiting Scientists (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Personality". Chairman: Prof. C. A. Mace. Speakers: Prof. Marc Klein, Dr. W. Mays and Dr. J. D. Sutherland.

Tuesday, April 15

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

Institution of Electrical Engineers, Measurement and Utilization Sections (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. E. Bradshaw, Mr. M. Wagstaff and Mr. F. Cooke: "A Train Performance Computer"; Mr. J. F. Meredith and Mr. E. A. Freeman: "The Stimulation of Distributed-Parameter Systems, with particular reference to Process Control Problems"; Dr. J. L. Douce and Dr. J. C. West: "A Magnetic-Drum Store for Analogue Computing".

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. E. G. Walker: "Factors in the Design of Airborne Doppler Navigation Equipment".

Tuesday, April 15—Thursday, April 17

Society of Chemical Industry, Plastics and Polymer Group (in the William Beveridge Hall, Senate House, University of London, London, W.C.1)—Silver Jubilee Symposium on "The Physical Properties of Polymers".

Wednesday, April 16

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. W. E. Tremlett: "The Structure of the Lower Palæozoic Rocks of the Arklow District (Ireland)".

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.15 p.m.—Discussion on "Some Problems in the Measurement of Price Changes, with special reference to the Cost of Living" opened by Dr. S. J. Prais.

Institution of Electrical Engineers, Supply Section (joint meeting with the British Nuclear Energy Conference, at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. K. L. Stretch: "Operational Experience—Calder Hall".

Society for Analytical Chemistry, Biological Methods Group (at "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion on "The Mathematics of Sterility Testing", introduced by Mr. D. Maxwell Bryce.

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Annual General Meeting. Dr. W. H. J. Vernon: "Corrosion Research and its Industrial Background" (Spring Lecture).

Thursday, April 17

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. P. G. Safeman and Sir Geoffrey Taylor, F.R.S.: "The Penetration of a Fluid into a Porous Medium or a Hele-Shaw Cell containing a More Viscous Liquid"; Mr. C. Kemball and Mr. C. T. H. Stoddart: "The Catalytic Hydrogen Reduction and Deuterium Exchange of *cyclo*pentanone on Evaporated Metallic Films and some Observation on *cyclo*hexanone".

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. E. O. Lilge, Mr. T. E. Fregren and Mr. G. R. Purdy: "Apparent Viscosities of Heavy Media and the Driessen Cone"; Mr. H. H. Fraser: "Scientific Management Principles Applied to West African Mining".

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. G. Clunie: "Meromorphic Schlicht Functions".

Institution of Mechanical Engineers, Applied Mechanics Group (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m. Discussion on "Training in Engineering Design".

Society of Chemical Industry, Road and Building Materials Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. R. J. Schaffer: "The Preservation of Building Stone".

Royal Photographic Society (at 16 Princes Gate, London, S.W.7), at 7 p.m.—Mr. J. B. Collins: "Some Applications of Photography to Lighting Research".

Thursday, April 17—Friday, April 18

British Association for the Advancement of Science (in the Hall of the Royal Geographical Society, Kensington Gore, London, S.W.7), at 10 a.m. daily—Conference on "Science in Schools".

Friday, April 18

Institute of Physics, Non-Destructive Testing Group (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Meeting on "High Speed Radiography". Mr. R. F. Thumwood: "Tubes and Mechanisms"; Mr. B. Meakin: "Circuits and Evaluation".

Institution of Mechanical Engineers (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Annual General Meeting.

Society of Chemical Industry, Fine Chemicals Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. E. G. E. Hawkins: "Organic Peroxides and their Industrial Uses".

Friday, April 18—Saturday, April 19

Biochemical Society (at University College, Gower Street, London, W.C.1), at 10.45 a.m. on Friday and 10.30 a.m. on Saturday—Annual General Meeting.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Research Worker in Rumen Biochemistry (Scientific Officer or Senior Scientific Officer grade)—The Secretary, Institute of Animal Physiology, Agricultural Research Council, Babraham, Cambridge (April 17).

Lecturer in Geology; a Lecturer in Mathematics; a Senior Lecturer or Lecturer and an Assistant in Natural Philosophy; a Senior Lecturer or Lecturer and an Assistant in Experimental Physics; and a Lecturer and an Assistant in Theoretical Physics—The Secretary, The University, Aberdeen (April 18).

Lecturer (with a good honours degree in botany, a special interest in mycology and able to teach botany to degree standard and also industrial mycology) in Botany—The Principal, Wigan and District Mining and Technical College, Wigan (April 18).

Assistant Lecturer (science graduate or medically qualified) in Pharmacology in the Faculty of Medicine—The Registrar, The University, Manchester 13 (April 19).

Biochemist (Basic grade), to work mainly on problems of calcium and phosphorus metabolism in the Metabolic Ward Laboratories—The Administrator and Secretary, University College Hospital, Gower Street, London, W.C.1 (April 19).

Scientific Officer (with a good honours degree in zoology, some research experience in invertebrate physiology, and an interest in ecology) at Merlewood Research Station, Grange-over-Sands, Lancashire, to join a team studying fauna and woodland soils—The Nature Conservancy (E), 19 Belgrave Square, London, S.W.1 (April 21).

Assistant Lecturer, Grade B (with good academic qualifications and special experience in physical chemistry), in Chemistry—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (April 25).

Assistant Lecturer (man or woman) in Botany—The Principal, Royal Holloway College, Englefield Green, Surrey (April 25).

Assistant Lecturer or Lecturer in the Department of Zoology—The Registrar, The University, Liverpool (April 26).

Fellow in the Department of Geophysics, Research School of Physical Sciences, Australian National University, Canberra, to assist in the Department's programme of work on rock magnetism—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (*Australia*, April 30).

Lecturer (medical graduate, with lecturing experience and practical experience in virology and bacteriology) in Bacteriology—The Registrar, The University, Bristol (April 30).

Turner and Newall Research Fellows in Engineering, Inorganic Chemistry, Physics and allied subjects—The Registrar, The University, Manchester (April 30).

Assistant Lecturer or Lecturer in Physics—The Secretary, The University, Exeter (May 3).

Assistant Lecturer or Lecturer (specially qualified in plant biochemistry and/or cell physiology) in the Department of Botany—The Registrar, University College, Singleton Park, Swansea (May 3).

Lecturer in the Department of Metallurgy—The Registrar, The University, Liverpool (May 3).

Research Demonstrator in Botany—The Registrar, University College, Singleton Park, Swansea (May 3).

Research Fellow in the Department of Mathematical Physics—The Registrar, The University, Birmingham 15 (May 5).

Reader in Experimental Physics at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 7).

Reader in Statistics at the London School of Economics and Political Science—The Academic Registrar, University of London Senate House, London, W.C.1 (May 9).

Lecturer in Biochemistry; an Assistant in Biochemistry; and an Assistant in Logic and Metaphysics and Moral Philosophy in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (May 10).

Lecturer in Microbiology in the Department of Brewing and Applied Biochemistry—The Principal, Heriot-Watt College, Edinburgh (May 15).

Research Students or Assistants for work in the Physical Chemistry Department on the mechanism of reactions of biological interest—The Secretary of University Court, The University, Glasgow (May 15).

Senior Lecturer in Zoology at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 16).

Senior Research Fellow (preferably theoretical physicist) in Physics at the University of New England, Australia, to undertake a programme of experimental or theoretical research, preferably but not necessarily on the field of ionization and discharge physics or of solid state physics—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 26).

Chair of Geography in the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 30).

Chair of Pharmaceutics in the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (May 31).

Lecturer in Psychology at Canberra University College, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, May 31).

Scientific Assistant (preferably with a Ph.D. in biochemistry and some experience with proteins) in the Department of Pathology, for research work on intrinsic factor—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne.

Senior Lecturer or Lecturer in Physics at the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Senior Lecturer (with at least three years experience of teaching to degree standard and also preferably a higher degree) in Zoology—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Night Sky, 1958: *The Times* Stars of the Month. Pp. 27. (London: The Times Publishing Co., Ltd., 1958.) 3s. net. [131

Falkland Islands Dependencies Survey. Scientific Reports, No. 16: Notes on Weather Analysis in the Falkland Islands Dependencies, Antarctica. By A. W. Mansfield and S. D. Glassey. Pp. 1+27. (London: H.M. Stationery Office, 1957.) 12s. net. [42

Science and Freedom. Bulletin No. 10: Apartheid and the World's Universities: Report on a Meeting held in London, November, 1957. Pp. 70. (Manchester: George and Priscilla Polanyi, Joint Secretaries, Lime Cottage, 818 Wilmslow Road, Didsbury, 1958.) [42

Ministry of Housing and Local Government. Progress Report of the Standing Technical Committee on Synthetic Detergents. Pp. 8. (London: H.M. Stationery Office, 1958.) 6d. net. [42

British Plastics Federation. Report of the "Toxicity" Sub-Committee of the Main Technical Committee. Pp. 20. ((London: British Plastics Federation, 1958.) 5s. [42

Linnean Society of London. Synopses of the British Fauna, No. 11: British Millipedes (Diplopoda), With Keys to the Species. By J. Gordon Blower. Pp. 74. (London: Linnean Society of London, 1958.) 10s. 6d. net. [42

National Parks and Access to the Countryside Act, 1949. Eighth Report of the National Parks Commission for the year ending 30th September, 1957. Pp. iv+66+8 plates. (London: H.M. Stationery Office, 1958.) 5s. 6d. net. [42

Ministry of Labour and National Service. Annual Report of the Chief Inspector of Factories for the year 1956. Pp. 195. (Cmnd. 329.) (London: H.M. Stationery Office, 1958.) 9s. 6d. net. [42

Liverpool Observatory and Tidal Institute. Annual Report, 1957. Pp. 16. (Liverpool: Liverpool Observatory and Tidal Institute, 1957. [42

Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Season 1956–57. Nyasaland. By J. M. Munro. Pp. 16. (London: Empire Cotton Growing Corporation, 1958.) 1s. [42

Proceedings of the Royal Irish Academy. Vol. 58, Section A, No. 3: Application of Quaternions to the Representations of a Binary Quadratic Form as a Sum of Four Squares. By G. Pall and O. Taussky. Pp. 23–28. 1s. 6d. Vol. 58, Section A, No. 4: An Invariant Gravitational Density. By J. L. Synge. Pp. 29–39. 1s. 6d. Vol. 58, Section B, No. 12: The Gola Granite (Co. Donegal) and Its Regional Setting. By Eric Harold Timothy Whitten. Pp. 245–292+plate 21. 6s. 6d. Vol. 58, Section B, No. 13: The Geology of the Summerhill Basin, Co. Meath, Ireland. By W. E. Nevill. Pp. 293–303+plate 22. 2s. Vol. 58, Section B, No. 14: Preliminary Observations on the Diurnal Migration of the Crustacea in the Plankton of Gouganebarra Lake. By J. N. R. Grainger. Pp. 305+319. 2s. Vol. 58, Section B, No. 15: Movements of Salmon around Ireland, 7: From Rath, Co. Kerry (1950-1953). By E. D. Toner. Pp. 321–328. 1s. 6d. (Dublin: Hodges, Figgis and Co., Ltd., 1957.) [42

Ministry of Agriculture, Fisheries and Food: Department of Agriculture for Scotland. Report on the Animal Health Services in Great Britain, 1956, including Report of Proceedings under the Diseases of Animals Act, 1950. Pp. iv+112. (London: H.M. Stationery Office, 1958.) 6s. net. [42

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Annual Report of the Board of Regents of the Smithsonian Institution showing the Operations, Expenditures, and Condition of the Institution for the year ended June 30, 1956. Pp. ix+580+105 plates. (Publication 4272.) (Washington, D.C.: Government Printing Office, 1957.) 4.50 dollars. [131

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Fisheries Research Board of Canada. Bulletin No. 112: The Processing of Dried Salted Fish. By S. A. Beatty and H. Fougère. Pp. vii+54. 50 cents. Bulletin No. 113: Recent British Columbia Spring and Coho Salmon Tagging Experiments, and a Comparison with those Conducted from 1925 to 1930. By D. J. Milne. Pp. vii+56. 50 cents. Bulletin No. 115: Biology of the Bloodworm *Glycera dibranchiata* Ehlers, and Its Relation to the Bloodworm Fishery of the Maritime Provinces. By W. L. Klawe and L. M. Dickie. Pp. vii+37. 50 cents. Bulletin No. 116: Food and Natural History of Mergansers on Salmon Waters in the Maritime Provinces of Canada. By H. C. White. Pp. viii+63. 65 cents. (Ottawa: Queen's Printer, 1957.) [131

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Tea Research Institute of East Africa. Pamphlet No. 13: Proceedings of the Fourth Conference, 19th December, 1956. Pp. 55. (Nairobi: Tea Research Institute of East Africa, 1957.) [131

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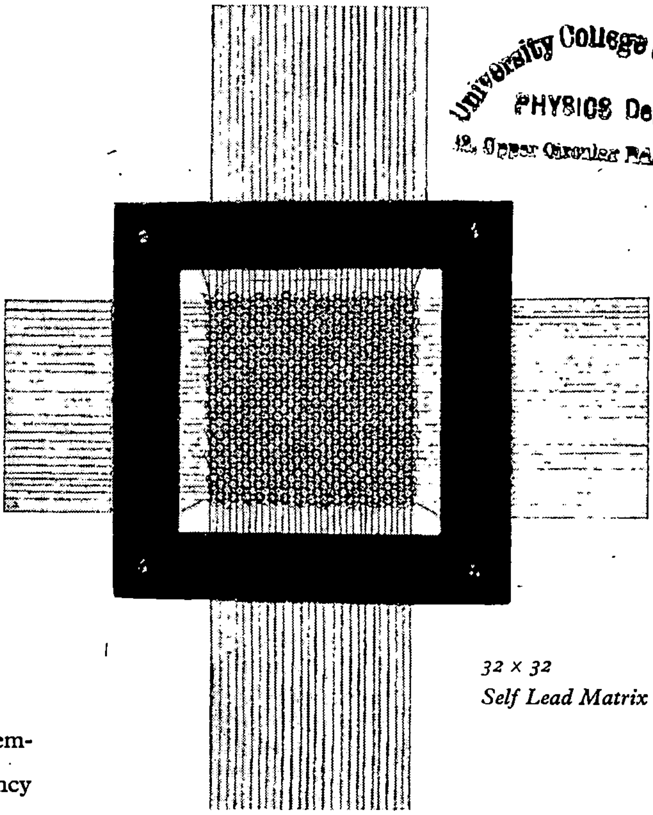

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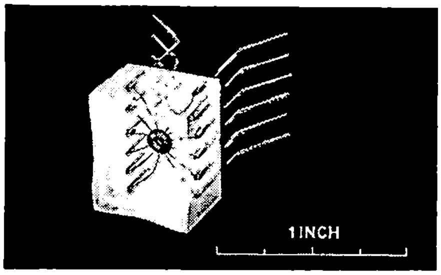

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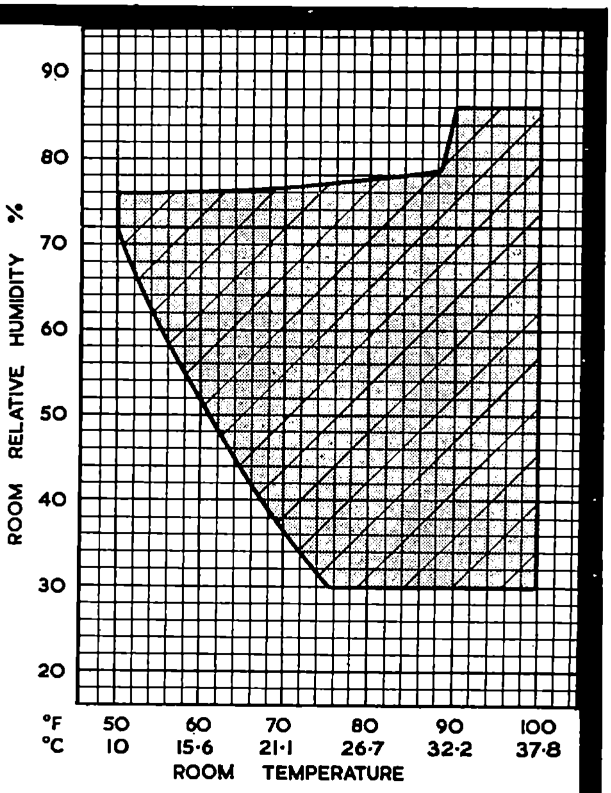

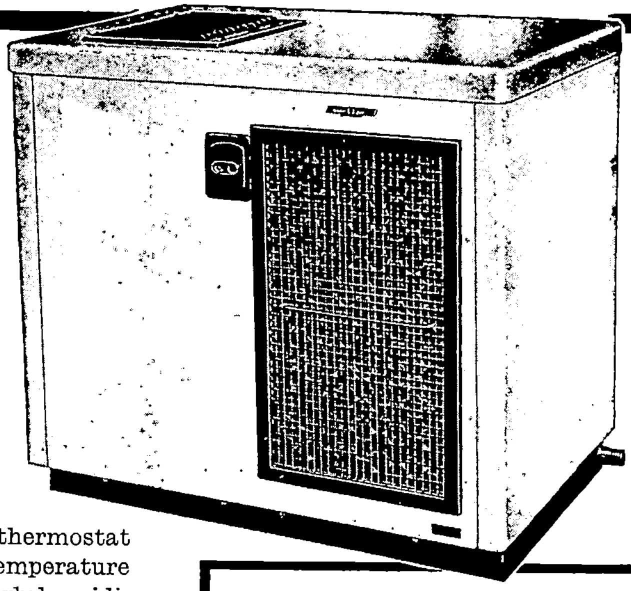

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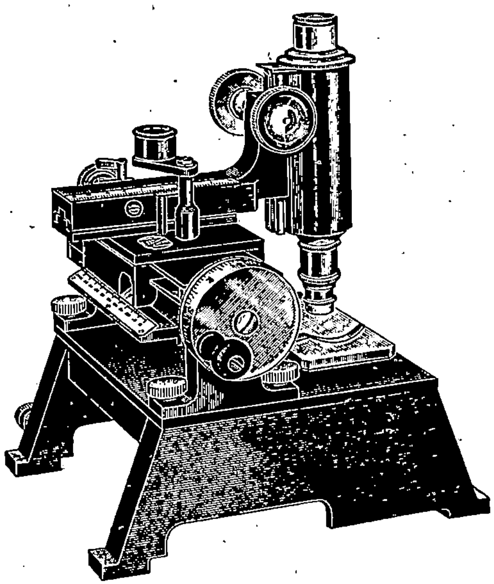

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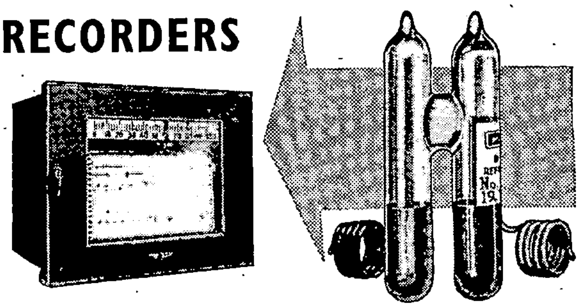

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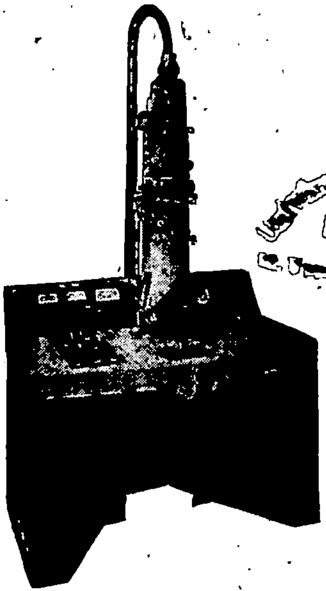

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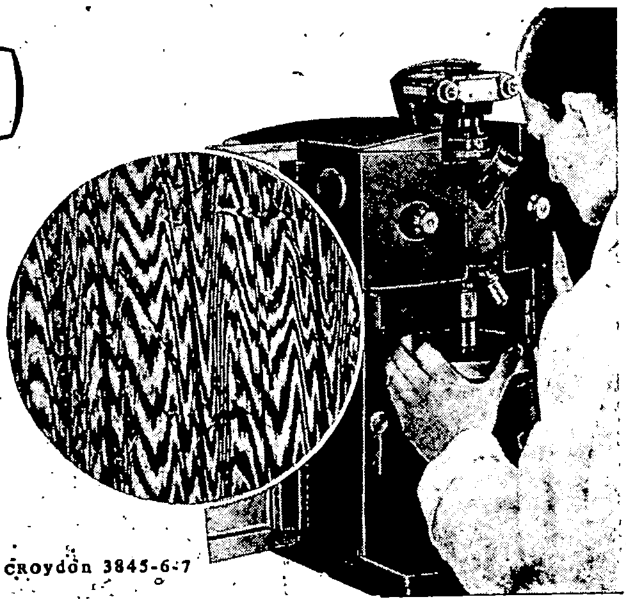

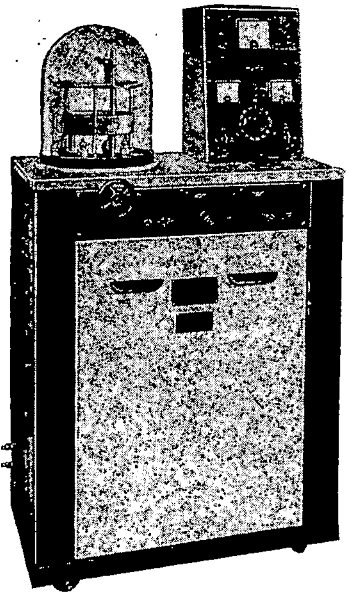

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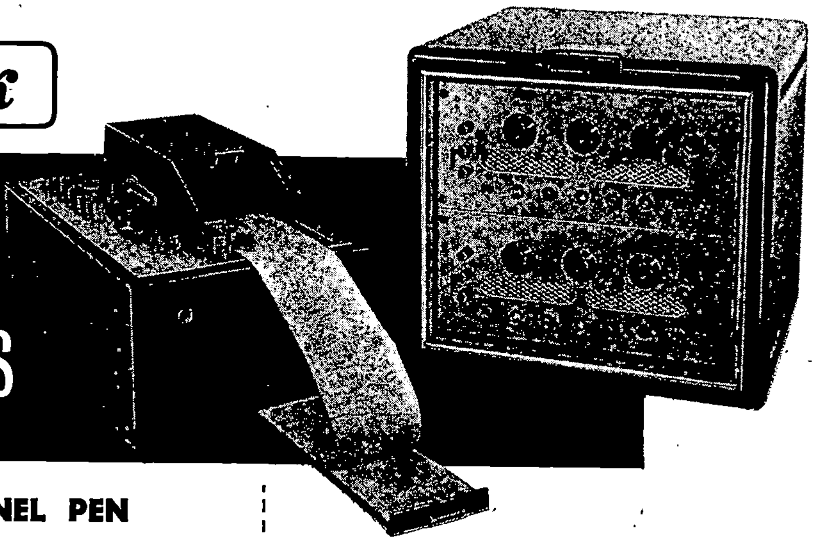

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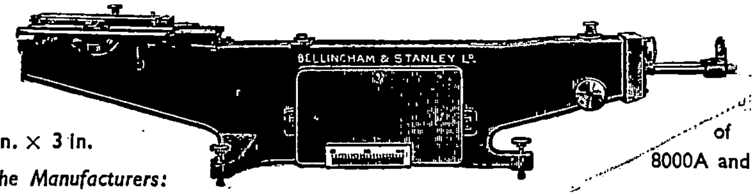

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ADMINISTRATION AND DEFENCE IN A TECHNICAL AGE

"WAR, even in or especially in an atomic age, is too serious a matter to be left almost exclusively to professionals, professionals trained in an ancient art rather than in the spirit of modern science." Thus, Prof. D. W. Brogan concludes his essay on civilian and military power in the United States in "Soldiers and Governments: Nine Studies in Civil–Military Relations", edited by M. Howard (pp. 192. London: Eyre and Spottiswoode, 1957). In this essay, Prof. Brogan suggests that no aspect of American government in this age requires rethinking more urgently than the problem of the relation between the Defence Department and the American political system, and that the days are long past in which the Service departments could be left to decide and to provide for the technical needs of the defence of the United States. The technological revolution which began on the New Mexican proving grounds of Los Alamos, argues Prof. Brogan, made the constitutional conceptions of the American system largely irrelevant, and it also brought out certain weaknesses in the administrative methods of the American Service departments which are no longer tolerable and are now becoming dangerous. The most interesting point which Prof. Brogan makes in this essay, however, is in regard to education. The central power house of American offence and defence, he asserts, is no longer in the Springfield Arsenal or even in the New London Navy Yard, but in the Atomic Energy Committee. "The higher Civil servants in England who staffed the Admiralty and the War Office might not have received an adequate technical education to discuss these questions, but they knew far better than did the military bureaucrats of the Pentagon how the physicists should be handled. Oxford and Cambridge provided a better education for this function than did Annapolis or West Point."

Clearly, President Eisenhower will need to delve deep into educational issues if he is to have any permanent and far-reaching result in the attempt to secure more effective co-ordination between the three Services foreshadowed in his Budget message and give real meaning to the office of Secretary of Defence. Mr. R. Blake's essay on Great Britain in this same volume, however, should discourage any complacency over this tribute to either British organization or methods, and Mr. M. Howard's introductory essay takes us to the root of the problems which are raised both for soldiers and for governments. The dialectic between freedom and security lies at the basis of all political society, and though, as indeed in the Bermuda discussions between President Eisenhower and Mr. Macmillan, the forms of that problem may change, the problem itself is likely to be with us until society itself is dissolved.

As Mr. Blake shows in his introduction to the volume, the issues to-day are immensely more complicated—not simply the decision as to what proportion of the national income should be spent on the Armed Forces, but also what form our defences should take and, most difficult of all, what proportion of defence expenditure should be allotted to immediate needs and what to long-term development and research. The debates in Parliament over the recent report on defence have brought out sufficiently what complications and difficulties are encountered in attempting to decide for what sort of warfare we should prepare and what part should be played by each of the three Services and, as Mr. Blake is also careful to note, these problems are debated in a climate of opinion which regards the promotion of national welfare as the highest function of the State. Indeed, it could be argued that a powerful section of opinion even puts recreational interests like television before industrial or economic development.

In such a position, we do not need to enter on those far-reaching problems of the reorganization of economic life which, as Mr. Blake points out, may be involved in defence policy, to realize the fundamental importance of educational policy at all levels. What may be remarked here, however, is that there would seem to be a *prima facie* reason for those destined for commissions in the Services to be educated side by side with those taking up civil careers, at least as far as the university-level. The clearly marked trend in the post-war entry to the Services in Britain would thus seem to be in accord with a genuine need.

There are, of course, other issues involved in the message which President Eisenhower sent to Congress early in April, though what he proposed still falls short of the unification of the three Services decreed by Congress in 1947. To the scientist in Britain, possibly the most interesting proposal in that message, and also the one which is encountering most opposition, is that which would give the Secretary of Defence complete power over research and authority to distribute appropriations among the Services to meet new situations. Quite apart from any other consideration, this suggestion is only likely to be effective and perhaps workable in the appropriate educational climate.

Much the same is true of other proposals. The Chiefs of Staff were given a chairman in 1949 and they are now to be empowered to delegate most of their Service responsibilities, with the result that the unified commands, which would themselves be created by the Joint Chiefs of Staff, would be responsible to the latter as a whole, acting in the name of the Secretary of Defence. The Secretaries of the Army, Navy and Air Force would become simply assistants to the Secretary of Defence concerned with administration, supply and training for their respective Services, but with no control over overseas or field commands. Promotion to the highest ranks, from which commands would be filled, would be at the discretion of the Joint Chiefs of Staff, and the Staff Director would be named by the Secretary of Defence.

It is the educational implications of these proposals, rather than analogy or differences with British organization for defence, that are of most interest and significance in relation to the utilization of scientific and technical man-power and technological advance to-day. To end Service rivalries in the United States by giving virtually unlimited powers to the Secretary of Defence may not of itself eliminate indecision and provide the speed and flexibility needed alike in local or global war. Even if the new authority is fully in touch with the Services themselves and their problems, co-ordination will scarcely be effective unless the understanding and co-operation of the Services are secured at junior as well as senior levels. This is partly an educational problem, of encouraging junior officers to think in overall terms of defence, to be alert to recognize even minor opportunities for inter-Service co-operation at the supply-level or in matters like pay and rations. It is a question of outlook and of a new approach to many technical matters which appropriate training could assist.

President Eisenhower's initiative should stimulate constructive thinking in Britain on a number of problems which offer wide opportunities for economy in materials and man-power and for increasing the efficiency of our defence effort. Whether those opportunities are recognized and used depend a good deal on whether sufficient receptivity to new ideas is encouraged, and this in turn on the appropriateness of the training which is given both to civilians and those in the Services, and not exclusively to officers. Defence requirements stand on all fours with the civilian needs to which such forcible expression has been given in recent months.

In his James Forrest Lecture to the Institution of Civil Engineers on March 18, for example, Sir John Cockcroft suggested that a type of engineer should be trained who had a thorough grasp of the basic principles common to all engineering, and who was not just narrowly trained in the techniques of civil, mechanical, electrical or chemical engineering. "One of the greatest problems in the rapid build-up of atomic energy," said Sir John, "has been the shortage of engineers who can take charge of the design and building up of a complete project and who can, with their scientific colleagues, speed the development of really cheap power for nuclear energy. I am sure that this will apply to other fields of engineering in future." Again, Sir Hugh Beaver, pausing in his presidential address to the Institution of Chemical Engineers on April 30 to note how small a part of our administrators and legislators have had any scientific training, ascribed to this fact some of the difficulties in obtaining adequate support and encouragement for scientific education and research in Britain. Sir Hugh urged that more should be done to produce both the attitudes of mind and the conditions which would divert an adequate proportion of our financial resources and man-power into the use of research, and this is equally true of defence as in the civil field. The two are much too interlocked for any shortcomings in this respect in one field not to be felt in the other. For example, although the expenditure of the Ministry of Supply on research is to be cut by only £6 million to £217·4 million for the coming financial year, with a further £3·3 million off the cost of work at its research establishments, since the effort put into nuclear weapons and ballistic missiles is rising, the reduction in genuine fields of research may well be severe, even if research in nuclear weapons and ballistic missiles is not exceptionally expensive.

That of itself points to the soundness of some of President Eisenhower's proposals, and further support for them and especially for the view that the key problem is education is forthcoming from the Lees Knowles Lectures, "Cabinet Government and War", given by John Ehrman last year and recently published*. Mr. Ehrman's lectures follow naturally on Lord Hankey's lectures in 1945, "Government Control in War", and although he does not include in his survey the changes made during the stress of the Second World War, he brings into clear relief the essential administrative problems of defence which confront a democratic system of government such as that of Britain. Mr. Ehrman is concerned primarily with defence organization as an aspect of Cabinet government, although he does not limit himself to that aspect, and while he does not, like Lord Hankey, enunciate specific principles, Lord Hankey's principles are implicit in much that Mr. Ehrman writes. Indeed, unless final control remains in the hands of statesmen, working in the closest co-operation with the Service chiefs, with the Prime Minister of the day alone as head and the last word even in the grand strategy, Mr. Ehrman's lectures are of academic interest only.

Mr. Ehrman notes three main developments in the Cabinet system between 1940 and 1945. The Prime Minister's exceptional political authority enabled him to make exceptional use of his professional Service advisers, so that supreme control was exercised by a professional and not by a political committee, functioning under the ægis of the Heads of Government, while within the Cabinet system the Service Ministers disappeared from the inner counsels. Second was the creation of a powerful and extensive structure of civil committees of the Cabinet, comparable with that of the Committee of Imperial Defence, and this more effective and highly articulated hierarchy left its mark on post-war practice. Third, and in consequence, the War Cabinet itself was seldom used as an agent of administration even at the highest level, and Mr. Ehrman observes that Cabinet government, bearing its traditional responsibilities to Parliament, never functioned more effectively than during those years of war.

Throughout those years and the fifty preceding years, with which he is primarily concerned, Mr.

---

* Cabinet Government and War, 1890–1940. By John Ehrman. (The Lees Knowles Lectures, 1957.) Pp. xi+138. (Cambridge: At the University Press, 1958.) 16s. net.

Ehrman believes we can recognize a continuous process and that the central organization for defence has developed in an orderly way, thereby helping to preserve the essentials of Cabinet government and also those of the Parliamentary system within which Cabinet government operates—although with powers largely alien to a happier generation. It has been, he argues, one of the factors which has enabled Britain to adjust its economy and its political institutions, without violent interruption, to the burdens of total war. Mr. Ehrman emphasizes the debt which is owed to such men as Balfour, Haldane, Lloyd George and Churchill among Ministers, and to Sydenham Clarke, Hankey and Ismay among officials, but he does not minimize the importance of the system. That in turn had its effect on the men who used it, and the achievement which Mr. Ehrman stresses in these lectures is the re-incorporation of the higher elements in the Services, from their isolation in the nineteenth century, into the structure and habits of British administration.

This achievement, as he points out, was itself part of a more extensive and notable process, namely, the re-incorporation of one of the three classic activities of government, after a long period of virtual disuse, into the framework and traditions of government as a whole; and in that concluding sentence he displays the meaning of his study for all who are concerned not simply with the effectiveness of our organization for defence, but also with the relations between science and government upon which that effectiveness largely depends. The way in which the Services have been brought back within the orbit of the Cabinet holds lessons to be pondered by all who seek to improve the relations between science and technology and government, the administration of research and development, the balance of our scientific effort and the ways in which science and technology can make their full contribution to national welfare and defence. Outstanding among those lessons is the importance of the administrator and the expert, whether Service chief or scientist or technologist, being able to speak the same language; and we are once again reminded of the over-riding importance not merely of training the scientist or technologist so that he is competent to take wide views and assume high responsibility, but also the administrator and legislator, from statesmen downward, to be competent to appraise scientific and technical factors in a situation, to appreciate the significance of expert advice and to make judgments which take full account of the facts and are not warped by prejudice. While there is much in these lectures that suggests that the general form of President Eisenhower's proposals for the re-organization of defence in the United States is fundamentally sound and incorporates the lessons of British experience, it is on these latter lessons that they should direct fresh thought. To secure flexibility and understanding and receptivity demand, above all, attention to the educational issues as a matter of urgency and outstanding importance.

LEEUWENHOEK'S CORRESPONDENCE

The Collected Letters of Antoni van Leeuwenhoek
Vol. 5. Edited, illustrated and annotated by a Committee of Dutch scientists. Pp. xi+457+36 plates. (Amsterdam: Swets and Zeitlinger, Ltd., 1957.) 145*s*.

THE first four volumes of this exhaustive and beautiful edition of the works of Leeuwenhoek were reviewed in *Nature* in 1939 (144, 956), 1946 (157, 3), 1949 (163, 192) and 1953 (172, 696). The first five volumes of the twenty or so to be published have taken more than nineteen years to produce, and unless this rate can be speeded up very few of the present generation will still be living when the last volume appears. The present volume deals with only eight letters, of which numbers 86 and 87, 1685, have not been recovered, and are known only from brief extracts incorporated in later letters. They were concerned with the biology of the cochineal insect, at first wrongly interpreted by Leeuwenhoek, but on which he made some important observations in his later work.

The following letters, all written in 1685–86, are among those examined in this volume. In letter 82 (43) —figures in brackets are those of the earlier enumeration of the letters—crystals of a variety of liquids are described and figured, and it is noted that a gastrolith is absent in the crab, but present and obvious in the lobster. A bitch was dissected, and a quantity of material was found in the genitalia, but the spermatozoa are not mentioned in the letter, although they had already been seen and described by Leeuwenhoek in 1677 and 1679. In letter 83 (44), 1685, the obsolete term 'mishmash' appears in the English translation, although George Eliot uses it, and more recently, Lewis Carroll. In his work on crystals, in which he was greatly interested, Leeuwenhoek always used impure mixtures, which are hence often difficult and even impossible to identify, and in any event the resolving power of his microscopes was not sufficient for the purpose. The impregnated uterus of a bitch was dissected and he found in it "an enormous number of living animalcules" which he assumes are the "male seed" of the dog.

In letter 84 (45), 1685, the original seventeen figures have been lost, but six figures appear in all early printed versions except one, where there are only four. This is the famous letter on generation—a subject to which Leeuwenhoek devoted so much time and thought. The two parties in the controversy were the ovists, who maintained that the embryo was developed from an egg, as Harvey believed, and the animalculists, who held with Leeuwenhoek that the spermatozoon was a microscopic undeveloped fœtus complete in all its parts, although they were too small to be demonstrated by the microscopic equipment of the time. The ovists denied that the male seed ever reached the uterus, a belief denounced in the strongest terms by Leeuwenhoek as the most foolish and crude proposition accepted among physicians. Although Leeuwenhoek rarely expresses himself in language explosive and contemptuous, he admits that he is only an amateur anatomist, but is not dismayed that there are at least seventy authors opposed to his views on the spermatozoa. He compares the spermatozoon with the tadpole of Amphibia, but recognizes that the tail of the tadpole does not drop off, although that of the sperm does.

He attempts to determine the rate of movement of the latter, but is, of course, wrong in assuming that males and females can be distinguished. In this letter Leeuwenhoek describes also the complex structure of a sheep embryo seventeen days after the parents had mated. Having discovered all its essential parts, as he thought, he was induced to support the preformation doctrine of animal development. When Leeuwenhoek refers to shagreen "leather" the editors of the present work do not consider that he had in mind the *untanned* skin of certain cartilaginous fishes, but a product of the skin of mules and horses. It is perhaps more likely that he used the term as it was understood in England before his own time. Leeuwenhoek expresses great annoyance that his embryological observations are distorted and misunderstood, and have hence been falsely described in printed versions.

Letter 85 (46), 1685, is largely botanical and deals with the structure of a number of seeds, and how the embryo of the plant arises from them. He repeats that the spermatozoon is nothing but a miniature of the animal into which it will develop, but admits that he cannot assert this "with the slightest degree of certainty", and that therefore we must await the discovery of spermatozoa large enough to demonstrate their complex structure. He rejects spontaneous generation and claims that the only function of the female sex is to provide the male seed with the substances by which it is nourished and induced to grow. He discusses the nature of hybrids and the results of crossing different species. He holds that, as regards himself, it was becoming more and more irrefutable that an animal can arise only by the development of a spermatozoon in the uterus of the female, but how this is brought about he admits he cannot imagine.

Letter 88 (47), 1685, deals largely with chemical experiments on various liquids and solids (for example, gunpowder) and includes little new biological material. The origin of the chyle or milk vessels is briefly discussed, and the fibrous structure of the optic nerves of the ox and horse is assumed to carry a new substance from the brain to the eyes for their maintenance. The scales of fishes are covered by a slimy membrane the nature of which is investigated. This induced him to examine the scales of other fishes such as the eel, bream and perch, and finally the structure of the human skin. It is characteristic of Leeuwenhoek's work in general that it is by nature comparative—having discovered an interesting feature in one type he is always tempted to examine it in other related forms.

The last letter, of 95 pages, in the volume is number 89 (48), 1686, and is concerned entirely with chemical investigations into the nature of cinnabar, gunpowder, saltpetre and "crab's eyes" (gastroliths).

The present volume of this important series is completed by 95 pages comprising a list of contributors, a bibliography with biographies of authors quoted, indexes of names and subjects, a list of the figures and illustrations, and thirty-six plates.

The Leeuwenhoek Commission is to be warmly congratulated on maintaining the very high standard of book production which characterizes this series, notwithstanding the far higher cost of this volume. In one respect the present volume is superior to its predecessors in the improvement of the English translation, in which only the following slight blemishes were detected: p. 41, note 53, for 'gluery' read 'gluey'; p. 105, line 10, for 'consnsted' read 'consisted'; p. 141, note 3, 'tot' is not used for 'to' in modern English; p. 145, last line but one, for 'my' read 'me'; p. 149, note 13, read 'which'; p. 169, de Graaf's name wrongly spelt; p. 185, for 'unsearchable' read 'difficult'; p. 291, note 12, line 1, add 'neither' before 'head'.

F. J. COLE

ISAMBARD KINGDOM BRUNEL

Isambard Kingdom Brunel

A Biography. By L. T. C. Rolt. Pp. xii + 345 + 17 plates. (London and New York: Longmans, Green and Co., Ltd., 1957.) 25*s.* net.

THIS eminently attractive and readable book traces a career that abounds in both technical and dramatic interest. Mr. Rolt, as a trained engineer, writes with understanding of the technical problems which Brunel had to face. He is seen here at the age of twenty, as engineer-in-charge of the Thames tunnel workings, where he narrowly escaped death in a sudden inundation. There is the building of the Great Western Railway, the South Devon 'atmospheric' railway fiasco, and the construction of the great Saltash bridge. Mr. Rolt then turns to Brunel's steamship ventures: the P. S. *Great Western* and her pioneer crossing of the Atlantic under sustained steam power; the *Great Britain*, first iron-hulled and first screw-propelled Atlantic steamer; and, finally, the monstrous *Great Eastern*, an over-ambitious project, forty years in advance of its time.

That a man of such impact should have made enemies is almost inevitable. For example, Arthur J. Maginnis in his book "The Atlantic Ferry", published in 1892, wrote with reference to the *Great Eastern* that she "was eventually broken up at New Ferry, on the banks of the Mersey, almost in the same year (1890) that the *Great Britain* ended her career at the Falkland Islands, representing with the broad gauge on the railway, now also doomed, the last of the costly and bitter memories of the engineer Brunel, who, unfortunately for many, had more influence with great capitalists than other far more capable and less fanciful engineers".

After the turn of the century, however, the bitterness of such attacks had moderated; and in 1910 *The Engineer* said of him: "In all that constitutes an engineer in the highest, fullest and best sense, Brunel had no contemporary, no predecessor. If he has no successor, let it be remembered that . . . the conditions which call such men into being no longer have any existence".

Now in 1958, the centenary year, John Scott Russell's original model for the *Great Eastern* is still on exhibition to the public at the Science Museum in London, while his huge working model for the oscillating paddle engines, the largest of their kind ever constructed, revolves majestically in the background. In contemplating these authentic relics, one feels a certain grandeur rising above the sordid history of disappointment, failure and recrimination, which was directly responsible for Brunel's premature death.

In the preface to his book, Mr. Rolt mentions that he was at first inspired by curiosity as to Brunel's personality, rather than hero-worship; but one suspects that hero-worship must have come later. Mr. Rolt is an experienced writer, with a vivid and eloquent pen, and the reader may well be caught up in his enthusiasm. However, Mr. Rolt's is also a disciplined pen; he gives us a balanced and therefore convincing portrait of Brunel, as a man of exceptional talent and courage, the over-ambitious author of the broad-gauge railway and the premature giant steamship of the nineteenth century, a man whose outstanding achievements and failures alike bore the stamp of greatness.

H. P. SPRATT

COMPUTERS

Digital Computer Components and Circuits

By Dr. R. K. Richards. Pp. vii+511. (Princeton, N.J., D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1957.) 64*s*.

Digital Computer Programming

By D. D. McCracken. (General Electric Series.) Pp. viii+253. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 62*s*. net.

Mathematics and Computers

By George R. Stibitz and Prof. Jules A. Larrivee. Pp. viii+228. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 37*s*. 6*d*.

THE above books, although all relating to digital computers, are very different in subject-matter and interest. "Digital Computer Components and Circuits" is a companion to a well-known book by the same author, entitled "Arithmetic Operations in Digital Computers", which deals with the logical design of the switching circuits used for various purposes in digital computers. The new book covers a much wider field, and the treatment is sufficiently detailed and comprehensive to make the book useful to engineers established in the field as well as to newcomers. It is notoriously difficult to write a good book on electronic circuits but the author has succeeded in doing so. He has brought together a great deal of design information otherwise only obtainable from scattered papers and has included much original discussion and comment. Subjects treated in the various chapters are as follows: switching circuits using diodes, vacuum tubes, transistors, and magnetic cores; magnetic and other forms of storage; circuits and tubes for decimal counting; analogue-digital conversion.

The second book is intended to provide a basic course in digital computer programming, and is of interest in that it is based on a hypothetical machine with an order code so chosen that all the basic techniques used in programming for any machine of the single-address type can be illustrated. The use of such an order code enables some of the stumbling blocks inherent in programming for a real machine to be avoided. No one, of course, can become a qualified programmer without experience in the practical running of problems, but the book is realistic in its approach, and should be useful to those who do not have access to a machine or who wish to make a preliminary study of programming before beginning work in earnest with a particular machine.

The third book, by Stibitz and Larrivee, is addressed to laymen. The authors set out "to present the computers as sober, unintelligent, but useful tools in the increasingly important applications of mathematics to science, technology, and business, and not as the weird and superhuman intelligence of science fiction, the popular press and, less forgivably, of some scientific writers who should know better". In this they have succeeded, although the technical level of the book is uneven, and in places the approach to the subject strikes one as being dated. The treatment of programming for modern digital computers is weak, and suggests that the authors have had little experience in this field. In the years just before and during the War, Dr. Stibitz was at the Bell Telephone Laboratories, and was a pioneer in the design of digital computers using telephone relays. Some sections of the book reflect his experience although, as is to be expected in a book intended for laymen, the information given does not add anything to what is obtainable elsewhere. Although the authors have, in general, been cautious about what they say, in their short section on language translation they may convey to some readers the idea that the use of digital computers in this field is more advanced than it actually is.

M. V. WILKES

FOUNDATIONS OF THERMODYNAMICS

Elements of Classical Thermodynamics for Advanced Students of Physics

By Dr. A. B. Pippard. Pp. vii+165. (Cambridge: At the University Press, 1957.) 25*s*. net. Clothbound; 15*s*. net. Paper covers.

THE first introduction of the fundamentals of thermodynamics to a student is necessarily of a brief and dogmatic nature and often he has attained no more than a facility for manipulating thermodynamic relations before he is diverted to other studies. Thus the re-examination of the fundamentals in the light of greater knowledge does not take place, and there is a growing need for this deficiency to be supplied. It is therefore a pleasure to welcome Dr. Pippard's book, which is concerned with the task of propagating a firm understanding of the bases of thermodynamics among students with a moderate acquaintance of the structure.

The first four chapters are devoted to establishing the zeroth, first and second laws of thermodynamics. While familiar enough in outline, the argument is very detailed, and every likely cause of confusion or ambiguity is carefully exposed and discussed. In most cases, the argument is presented in several different ways; thus reversible work is considered in detail not only in the standard case of a fluid under pressure, but also in the case of a body in a magnetic field; while the second law is developed both by consideration of Carnot cycles and of Carathéodory's law, the complementary nature of the two arguments being clearly brought out. The following chapters introduce the temperature scale, the thermodynamic functions and their derivatives, and their applications to simple systems. There follows a discussion of the thermodynamic inequalities in which the relations between entropy, availability, and energy functions are carefully explored and lead to the conditions for equilibrium. The consideration of phase equilibria in a simple substance follows, the last example, superconductivity, leading into the final chapter on high-order transitions, where order is introduced into this rather confused subject with a firm hand.

The book forms a nodal point, at which is drawn together the basic ideas the final-year student may be expected to know, their validity and limitations studied, and the way in which these ideas are used pointed out. At no time does the author content himself with dogmatic statement, and if an argument should lead too far from the main stream of this book the conclusion always gives the source in which the next stage of information can be found. Clarity is not sacrificed to brevity, and the writing flows smoothly from logical step to step.

There can be no hesitation in recommending this book to all undergraduates and postgraduates interested in thermodynamics, and many users of more advanced thermodynamics might well find pleasure in a study of this well-written account. The production of the book is of the usual standard of the Cambridge University Press, and, bearing in mind the preferred reader, it is good to see that an edition is available in paper covers at a substantial reduction in price. S. ANGUS

DISEASES OF BIRDS

Tratado de Doencas das Aves

Por J. Reis e P. Nóbrega, com a colaboração de A. S. Reis, R. C. Bueno e M. Giovannoni. Vol. 1: Pp. 391. Vol. 2: Pp. 416. Vol. 3: Pp. 318. Vol. 4: Pp. 428. 2a Edição, revista e ampliada. (São Paulo: Ed.ções Melhoramentos.) n.p.

TO undertake the compilation of a comprehensive work on a subject so enormous and ramifying as the diseases of birds requires courage. To complete such a work and present it in a manner that makes it of the greatest use, to both veterinary practitioners and students, is an achievement that does credit to the painstaking care and ability of the authors.

The "Treatise on the Diseases of Birds" by J. Reis and P. Nóbrega is now published in its second edition. The work was originally published in four volumes but in the new edition Vols. 1 and 2 and Vols. 3 and 4 are bound together to form two books only.

It is natural that the main bias of the work is toward the diseases of domestic poultry since it is in this field that the majority of work has been carried out, but information on matters of academic interest concerning wild birds is also included. The bibliography has been brought up to 1952 and, in some cases, more recent references are included. This fact alone will make the work useful even to those unable to read the Portuguese text.

The diseases are classified under their causative organisms. Thus, Part 1 is concerned with virus diseases, Part 2 with bacterial and fungal infections, Part 3 with diseases caused by Protozoa and parasitic arthropods and the last part deals with helminths and nutritional disorders. In Part 4, there are also sections on the pathological lesions of the organ systems, poisons, abnormalities of development, hygiene and a brief summary of surgical and general therapeutic measures.

In the parts dealing with virus and bacterial diseases the arrangement of the work is similar: the diseases are considered separately and a chapter is devoted to each. These chapters are in the nature of a complete account of the disease concerned. They begin with a synonymy of the common names of the disease in many languages, followed by a brief historical introduction and sections on geographical distribution, etiology, pathogenicity, symptoms, pathology, etc. At the end of each chapter is a bibliography of papers relevant to the disease under consideration.

The arrangement in Vols. 3 and 4 is slightly different in that the subject-matter is parasitological and each group of parasites is introduced by a brief general systematic account. The protozoan species recorded from birds are tabulated according to their hosts and are then discussed in groups with subsections dealing with the diseases in individual hosts. A somewhat similar arrangement has been used for the parasitic arthropods, but no keys for identification are given, and the whole group is dealt with from a systematic point of view, rather than by hosts. In the final volume the treatment of the various helminth groups is different. The nematodes are considered in groups according to the organs of the hosts in which they are found; the majority of the section on trematodes is devoted to lists of species found in both domestic and wild birds, again separated according to their site in the hosts; and the cestodes are dealt with in a similar manner except, of course, that position within the host is of little importance so far as the adult worms are concerned.

Vol. 4 closes with a general bibliography, eight coloured plates of pathological conditions and a comprehensive and most useful index.

It is realized that this account of the work does little to evaluate its merit in detail and, indeed, this would be a difficult task in view of the enormous field covered. The value of the inclusion of so much systematic detail in the helminthological sections is, perhaps, doubtful, since these groups are dealt with by many specialized works in a rather more satisfactory manner than is possible in this type of publication. In making this criticism I am undoubtedly biased by my own field of work.

In conclusion, it is perhaps best to summarize by suggesting that an English translation of the treatise would prove of great use to many people.

C. A. WRIGHT

ENTOMOLOGY IN REVIEW

Annual Review of Entomology

Vol. 3. Edited by Edward A. Steinhaus, in association with Ray F. Smith. Pp. vii+519. (Palo Alto, Calif.: Annual Reviews, Inc., 1958. Published in co-operation with the Entomological Society of America.) 7 dollars.

THE editors of scientific reviews have two main tasks; one is to ensure they get authoritative articles of current interest covering a wide range in the specialized field, and the other is to maintain a high scientific and literary standard in these articles. The reviewer of reviews may also consider these two aspects of policy and practice, and when the first two volumes of the "Annual Review of Entomology" were noticed in *Nature* (179, 1150; 1957) certain criticisms of the general policy were made, the main point being the disproportionately large number of articles devoted to the chemical control of insects. In the third volume, just issued, the balance is somewhat redressed, only 21 per cent of the space being devoted to insecticide work as against 35 per cent in both the preceding volumes.

The result is a book of better balance and much wider general appeal than hitherto, and it is clear from the preface of the work that the editorial committee is alive to its responsibilities in this respect. It points out, with justification, that the "Review" is not a one-volume work, the implication being that judgment should be suspended until a number of volumes are available. But if policy is still to a certain degree fluid it is now that constructive criticism would be most valuable.

One thing which is not yet clear is whether the editors want to make this review international, both from the point of view of contributors and consumers. That the one depends on the other to a certain extent cannot have escaped their notice, and yet in all three volumes more than 60 per cent of the contributors have been American. It is, no doubt, easier for the editors to maintain liaison with American authors and thus uphold the generally high standard of papers; but the dangers of excessive insularity appear not only in the choice of writers but also in their papers, several of which contain bibliographies which make it appear that their author is unaware that entomological research is also carried on outside the United States.

The useful practice of carrying articles on the same subject in successive volumes, by various authors of differing viewpoint, is again in evidence with the third article on the "Dynamics of Insect Populations", the current one being by A. J. Nicholson, who restates the evidence and replies to the criticisms in previous articles of the theory of density-dependent factors. Such a valuable series of papers underlines the advantage of a continuing, as against a one-volume, review. Insect physiology is well represented in the present volume by papers on the nervous system by K. D. Roeder, the uses of sounds in insects by H. and M. Frings, two papers on the nutritional requirements of insects by W. G. Friend and J. M. Legay, and perhaps above all by a short but most valuable paper by E. S. Hodgson on "Chemoreception in Arthropods" in which the author describes the new methods recently developed by himself and his colleagues, which have at last made it possible to determine in certain cases the responses of single chemoreceptors to a variety of stimulants. The essential unity and interdependence of all research are emphasized by the fact that this work has immediate relevance to at least four other papers in the same volume.

Papers on the chemical control of insects have a depressing tendency to turn into lists of neat little recipes for specific complaints, but the paper by R. E. Balch on "Control of Forest Insects" is an excellent antidote, giving as it does consideration to all the factors—not only chemical—relevant to insect control. Papers on biology and behaviour include two which reiterate the importance of background knowledge in control work: "The Feeding Habits of Biting Flies and their Significance in Classification", by J. A. Downes, and "Hybridization and Speciation in Mosquitoes", by L. E. Rozeboom. It is a little difficult to see the justification for including a paper on the "Biology of Scarabaeidae" (P. O. Richter), a subject so much narrower in scope than any other in the work.

The standard of the papers is high, the presentation good, and the index ample. Uniform bibliographies, in alphabetical order, might be considered as an improvement for the future. This volume is a definite advance on the previous ones in balance and appeal, and without doubt deserves to find a wide and appreciative public.

P. T. HASKELL

UNIVERSITY OF BOMBAY

A History of the University of Bombay, 1857-1957

By S. R. Dongerkery. Pp. vii+313. (Bombay: The University, 1957.) Rs. 15.

THE year 1857 was a sad year for the British administration in India, for the violence of the Sepoy Mutiny imposed a severe strain on Indo-British relationships. It is all the more remarkable, therefore, that at such a time there were men who pressed forward with measures to give form and substance to the concept of higher education in India by founding a university. Indeed, three universities, those of Calcutta, Bombay and Madras, were all founded within a few months of one another; later—on the occasion of the laying of the foundation stone of the University of Bombay in 1863—the Governor of the Province described these foundations as among the last, but not least, glorious deeds of the East India Company.

All the three universities were constituted on the model of the University of London, at that time a chartered body concerned only with examining and conferring degrees upon students trained in affiliated colleges. The defects of the affiliating system were realized later when London was reconstituted in 1900 as a teaching university after two Royal Commissions had reported in 1889 and 1894 respectively.

The corresponding activity in India culminated in the Indian Universities Act of 1904, but controversy there raged loud and long. A Committee on University Reform reporting in 1925 said that except in a loose and indirect sense, prior to 1912, the University of Bombay was not a teaching university, and since that date had only made a very partial approximation to the ideal. The Committee felt that it had been entrusted with the task of suggesting how that approximation could be made more complete.

Then came the Bombay University Act of 1928 which was a great advance and brought the work of the University into direct touch with the leaders of industry and the civic life of a large community. It focused the attention of the University on the conduct of postgraduate teaching and research as a direct responsibility and upon technology.

The reorganization of the Indian Union largely on a linguistic basis has resulted in the emergence of the University of Bombay (1953) as a city university, teaching in federal relationship with its constituent colleges and other recognized institutions. Unfortunately, the battle of the languages is not yet ended, and the future of the medium of instruction has still to be decided. The University has, however, been wise in adopting a cautious approach to this question.

The present volume, which is an extremely readable account of the growth of the University, also marks the centenary of its existence. It has had a chequered history, but it has been fortunate in commanding the devoted service over the years of men of eminence, erudition and foresight. On the whole, perhaps, things have turned out not as well as some hoped and not as bad as others feared.

The author, a versatile scholar intimately connected with the University administration for many years and as the Rector, was clearly well-placed to write this book, and he has provided a pleasing volume giving a fair and full picture of the development of the University and of the dedicated men, both British and Indian, who have shaped its course.

L. A. JORDAN

A School Course of Biology

With Suggestions for Experimental and Field Work. By L. J. F. Brimble. Fourth edition, entirely re-written and enlarged in collaboration with Dr. L. M. J. Kramer. Pp. xv+558. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1957.) 18*s*. net.

THE transformation of a school text-book, which has been in steady demand since 1940, into what is virtually a new volume should endow it with a fresh lease of useful life. It is not a cram manual streamlined to fit the requirements of some examination syllabus: instead, it sets out bravely to present a representative picture of all forms of living matter as they exist now and have originated in the past, and to describe their structure, functions, organization and inter-relationships, including those with man himself.

The chapters on evolution and heredity, living things and their environment, and man in relation to other living organisms are particularly welcome. In these respects the book merits comparison with the attractive readers put out for use in American high schools; and one hopes that some copies will find their way across the Atlantic. For British teaching practice it covers the ground for the General Certificate of Education (Ordinary Level), in many directions extending far beyond it, for it contains a large amount of miscellaneous information on such topics as the speed of animals, the life-history of the eel, parasitic and saprophytic plants.

The treatment is comparative. Directions given at the end of each chapter for individual and class observations and experiments are more than adequate. Among the many well-chosen illustrations, the drawings by the senior author deserve special commendation for their number, clarity and artistic form. The book contains one or two slips in phrasing, and a few minor errors of fact, which merely serve to show that it is impossible for a single author to be fully informed on every topic receiving mention. By the same token, the boys and girls who will study it should not be expected to remember all the knowledge it contains. R. WEATHERALL

Analytical Microscopy

Its Aims and Methods in Relation to Foods, Water, Spices and Drugs. By Dr. T. E. Wallis. Second edition. Pp. viii+215. (London: J. and A. Churchill, Ltd., 1957.) 25*s*. net.

REVISED for the first time since its publication more than thirty years ago, this book is virtually new, owing to the accumulation of fresh information and the introduction of new methods.

An account is given of the methods of preparing material for microscopical examination and is illustrated by examples selected almost entirely from problems which have arisen during the career of the author. Analytical microscopy, its aims and methods in relation to food, water, spices and drugs, clearly indicates the unequalled experience of an analyst known to many in industry and medicine.

The immensely practical nature of this work is shown by the varied use of the microscope for solving problems which cannot be successfully tackled by purely chemical means.

The introductory chapter deals with general arrangements for the proper use of the microscope and its accessories, followed by a chapter giving details of preliminary operations which are necessary for the examination of foreign matter (including insects) in poultry and bird food. The use of surface preparations is described with reference to the microscopical characters of culinary herbs, and the method of sedimentation is illustrated by investigations of water deposits. The process of kneading is explained in connexion with the analysis of flour and other starchy powders, while other chapters deal with elutriation for preserves and the reagents used for the clarification of specimens. Additional preliminary treatment of material is described by some information on 'crude fibre' in connexion with coffee and chicory. Chemical treatments used prior to the examination of pests, occurring as fragments in flour and other commodities, are mentioned. Chemomicroscopy, the micromorphology of various substances including sulphur, the techniques of sublimation and precipitation—all indicate the extensive scope of this handy volume.

For those wishing to use microscopical measurements, numerical values and quantitative microscopy, the author gives a concise account of the meticulous approach to these subjects. Accurate, well-labelled drawings are a great feature of this book, while valuable numerical data, reagent formulæ and an adequate bibliography complete the store of information available to anyone engaged in analytical work using the microscope. S. B. CHALLEN

The Amphibia of Ceylon

By P. Kirtisinghe. Pp. xiii+112+1 plate. (Colombo: P. Kirtisinghe, 2 Charles Circus, 1957.) n.p.

THE Ceylonese Amphibia are presented here in the form of a taxonomic survey, the general subjects of habits, life-history and ecology being almost completely disregarded. This is a disappointing omission in a book with as definitive a title as "The Amphibia of Ceylon" and in one which would have provided scope for speculative treatment of zoogeography, speciation and other aspects of amphibiology. None of these subjects has been given the attention that is required, perhaps because no research in these fields has been attempted by the author. Instead, Mr. Kirtisinghe has restricted himself to a taxonomic treatment. However, it is a compact and nicely produced book and makes a very useful manual for the museum laboratory worker as well as a reliable field book for the collector.

Preceding the main taxonomic section is a historical account of the study of Ceylonese Amphibia in which the author has collated the faunal lists which have been published by earlier devotees to Ceylon's amphibians. In the light of Mr. Kirtisinghe's experience, which has accrued from his position as lecturer in zoology at the University of Ceylon, from his personal collections and from the year spent in England when he devoted a great deal of time to the study of the Ceylon amphibians in the British Museum collections, he concludes that the composition of Ceylon's amphibians can be reduced from the 37 species recognized by Boulenger to 32, with 12 species believed to be endemic. Although his reasons for synonymizing these and other species may be based on sound judgment, they are not always divulged and the reader is kept guessing.

The same style is adhered to throughout the systematic section—division into families with keys to the genera and species, and within each species account there is, first, a synonymy, followed by a figure and detailed description of the adult, and of the larva also where it is known, and range. The illustrations are well executed by competent artists.

A. G. C. GRANDISON

SOME EFFECTS OF THE FINE STRUCTURE OF THE IONOSPHERE ON TRANSMISSIONS RECEIVED FROM THE RUSSIAN EARTH SATELLITE 1958δ

By F. A. KITCHEN and W. R. R. JOY

Royal Naval Scientific Service

A SERIES of simultaneous direction-finding and Doppler frequency-shift measurements has been made on the radio transmissions from the Russian satellite 1958δ, on a frequency of 20·005 Mc./s., with the initial object of determining the parameters of local tracks, and hence those of the orbit. As previously discussed[1], these techniques enable the following parameters to be derived, in principle, from observations made during one local transit: velocity, plan and slant ranges (hence the height of the satellite), and bearing of the sub-satellite point at the instant of closest approach (hence track-heading of the satellite at this point). During the course of precise observations on 1958δ, however, some interesting anomalies were observed in the Doppler measurements. These confirmed the existence of similar effects previously noted in the case of observations on 1957α and 1957β, when less-accurate measuring techniques were available. In the system at present in use, all information on bearing, Doppler frequency and time is recorded synchronously on separate channels of a multi-channel tape recorder. An Essen ring quartz-crystal oscillator operating at 100 kc./s. with a frequency drift of less than + 2 parts in 10^{10} per day was used to provide the time reference throughout the system. It was also used to drive a precise frequency synthesizer to generate a local reference signal for comparison with the signal received from the satellite, at radio-frequency. Errors in the frequency measurements originating within the receivers were thus eliminated. Some samples of track parameters deduced for 1958δ are given in Table 1.

Table 1. LOCAL TRACK PARAMETERS DEDUCED FOR 1958δ, ASSUMING A FLAT EARTH AND REFERRED TO PORTSDOWN (lat. 01° 06′ 53″ W., long. 50° 51′ 30″ N.)

Date	Revolution No.	Velocity (km./sec.)	Min. plan-range (km.)	Min. slant-range (km.)	Height (km.)	Track heading at closest approach (deg. true)	Inclination of orbit to equator (deg.)
16.5.58	17	8·16	15·8	258	257	040	62
20.5.58	71	8·11	129	318	291	043	64
21.5.58	85	8·12	722	766	290	043	65
22.5.58	98	8·12	230	370	290	040	65

The average period of the orbit between revolutions Nos. 71–98 was 105 min. 53·8 ± 0·1 sec.

One of the anomalies detected in the Doppler observations is a time displacement of the apparent instant of closest approach of the satellite, relative to that deduced from direction-finder observations. Evidence of the reality of this time difference was obtained during revolution No. 71 from south-west to north-east, on May 20, when the normal direction-finding and Doppler frequency-shift observations were supplemented by direction-finding measurements at a remote station about 300 km. distant. Observations from this latter station were recorded synchronously with the results being obtained locally, on the multichannel recording equipment. The times of closest approach to the two stations derived from the simultaneous direction-finding measurements were mutually consistent, and in agreement with the known parameters of the track involved, whereas the corresponding instant deduced from the Doppler observations at Portsdown was 6 sec. earlier than indicated by the associated direction-finder results. This is shown in the graphical transcription reproduced in Fig. 1. The time discrepancy is much greater than would be expected from the inclination of the track relative to the surface of the Earth, particularly since the local track is very near perigee. The phenomenon is considered to be due to the influence of the ionosphere, and it may be explained by refraction of the radiation from the satellite transmitter through part of the *F*-region having a tilted lower boundary, of the type reported by Bramley and Ross[2].

It has been shown[3,4] that refraction of satellite transmissions by the ionosphere will result in a virtual source displaced from the actual source, the displacement increasing with increasing range. In addition to the influence on Doppler records, the effect of this

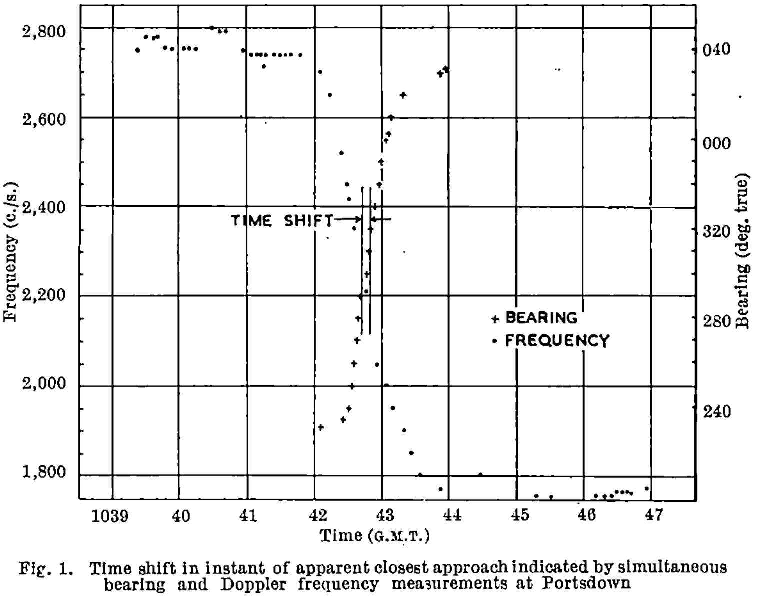

Fig. 1. Time shift in instant of apparent closest approach indicated by simultaneous bearing and Doppler frequency measurements at Portsdown

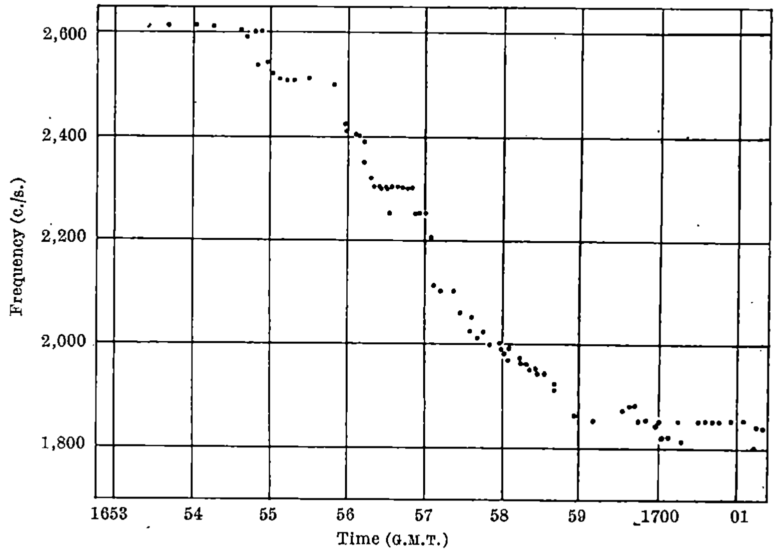

Fig. 3. Examples of discontinuities in a Doppler frequency record

refraction would also be expected to give rise to associated changes in direction-finding, but the resulting errors will be small in the case of local tracks. In the case where the ionosphere is concentric with the surface of the Earth, the refraction would result in an error in estimation of slant-range from the Doppler measurements, but not in the time of closest approach.

Fig. 2 is a simplified illustration to show how a tilted lower boundary on the $F2$-region of the ionosphere produces the time shift in the instant of closest approach deduced from the Doppler observations. The diagram depicts the case of a satellite moving above a tilted lower boundary of an ionosphere of constant refractive index on a track concentric with the Earth's surface, and over the observing point. The virtual sources are shown, as for example, 2′ corresponding to the true position 2. Again, the effects on Doppler frequency will be expected to be more marked than the corresponding effect on direction-finding observations. In the practical case where the point of observation does not lie in the sub-satellite path, the effects due to refraction will be correspondingly increased.

It is thus expected that refraction by the ionosphere will cause significant errors in the estimation of slant-range and hence height of satellite. Further, that tilts in the lower boundary of the ionosphere will increase these errors, and simultaneously introduce a shift in time of apparent closest approach of several seconds, in a sense depending on the orientation of the lower boundary at that time.

Occasionally time differences of as much as 20 sec. have been measured, in which time the satellite travels a distance comparable to the height and range. It appears unlikely that such large time-shifts are due entirely to ionospheric tilts.

Referring to Table 1, it will be seen that there is a spread in the apparent heights of 1958δ. However, for revolution $N = 17$, when the satellite passed nearly over the observing point, the ionospheric effects were minimized, and the deduced height shows nearer agreement with that obtained by the Royal Aircraft Establishment[5] using an interferometer at 40 Mc./s. The greater apparent heights quoted for subsequent revolutions are due to variations in the refractive effects described.

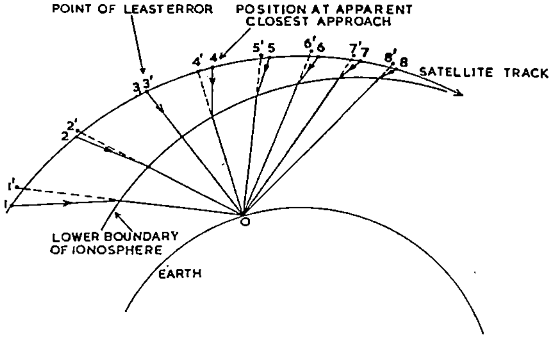
POINT OF LEAST ERROR
POSITION AT APPARENT CLOSEST APPROACH
SATELLITE TRACK
1'
1
2'
2
3
3'
4'
4
5'
5
6'
6
7'
7
8'
8
O
LOWER BOUNDARY OF IONOSPHERE
EARTH

Fig. 2. Effects of refraction in an ionosphere with tilted lower boundary (schematic, not to scale)

Fig. 3 illustrates the marked discontinuities in the Doppler frequency which occur at irregular intervals. This is a typical phenomenon for most of the observations on 1958δ, whether the satellite was approaching or receding from the apex, but was more pronounced in the latter case when the satellite was at greater heights. The magnitudes of the discontinuities in the frequency record are usually too great to be accounted for by alternate reception of ordinary and extra-wave magneto–ionic components of the transmission. It appears more likely that the discontinuities arise from the existence[6] of smaller-scale irregularities in the tilted lower boundary of the F-region, the whole of which is in effective random motion. Similar effects were not observed in the direction-finding bearing records.

It is of interest to note that if the Doppler readings are made sufficiently accurately, and at frequent enough intervals, then in many cases the irregularities observed make it impossible to process the results in the manner described by Hampton[7].

Arising from this work, it appears practicable to make a detailed study of the fine structure of the lower boundary of the F-region of the ionosphere, by analysis of the detailed character of the Doppler frequency discontinuities in conjunction with accurately known orbit parameters. Attention is now being given to this aspect of ionospheric research. The fact that wide variations of direction-finding observations have not occurred in this work leads to the assumption that the influence of sporadic E-ionization has been insignificant.

Other effects of the ionosphere on the Doppler frequency-shift recordings arise due to : (a) a change in the electrical length of the path from the satellite to the receiver ; (b) in general, a change in the velocity of propagation of the radio signals in the vicinity of the satellite.

The contributions these phenomena would be expected to make to the observed Doppler frequency-shift have been estimated, and found to be small. For example, if the satellite is above the maximum of the $F2$-region ionization, the effect of (a) is to increase the apparent height by about 9 km. for an assumed total electron content of 10^{13} per cm. column. When the satellite is in the vicinity of the $F2$-region maximum, the effect of (*b*) is merely to change the received frequency by not more than a few cycles per sec.

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EFFECT OF AIR DRAG ON THE ORBIT OF THE RUSSIAN EARTH SATELLITE 1957β: COMPARISON OF THEORY AND OBSERVATION

By D. G. KING-HELE and Dr. D. C. M. LESLIE
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IF the orbit of an Earth satellite has an eccentricity greater than about 0·02, most of the air drag is encountered near perigee. Consequently, there is a retardation near perigee and a reduction in height at the next apogee, but very little decrease in perigee height. Thus the orbit contracts and becomes more nearly circular, while the orbital period decreases because the major axis is diminishing.

The equations of motion can be solved analytically if certain simplifying assumptions are made, and the most useful solutions appear to be those obtained under the following assumptions: (1) The Earth and the atmosphere are spherically symmetrical; (2) the density ρ of the atmosphere at a given height is constant from day to day; (3) ρ varies exponentially with distance from the Earth's centre r: ρ is proportional to $\exp(-r/H)$, where H, the 'scale height', is assumed constant; (4) the aerodynamic force acting on the satellite is taken as $\rho v^2 S$ tangential to the path, where v is its velocity and S is a constant which may be interpreted as the effective cross-sectional area of the satellite; (5) the eccentricity e of the orbit is small, so that high powers of e may be ignored; (6) the presence of air drag changes the orbit during any one revolution by only a small amount, the square of which can be neglected.

Under these assumptions, the relevant orbital elements can best be written in the forms given below. If the eccentricity e is sufficiently small for terms of $0(e^2)$ to be neglected, the orbital period T can be expressed as a function of time t in the form:

$$\frac{T}{T_0} = 1 - \frac{3H}{2a_0}\left\{\ln I_1\left(\frac{a_0 e_0}{H}\right) - \ln\sqrt{1-\frac{t}{t_L}}\, I_1\left(\frac{a_0 e_0}{H}\sqrt{1-\frac{t}{t_L}}\right)\right\} + 0(e_0^2) \qquad (1)$$

where a is the semi-major axis, suffix 0 refers to initial conditions, and I_1 is the Bessel function of the first kind of imaginary argument and order one. t_L may, for brevity, be called the life-time, though it is slightly greater than the true life-time, because it gives the time at which T drops not to the lowest practical value (say, 87 min.) but to minus infinity. For *Sputnik* 2, t_L was about 0·6 per cent greater than the true life-time.

Equation 1 has the virtue that it is valid up to the last revolution of the satellite, but for most practical purposes it is preferable to have a formula which includes terms of $0(e^2)$ and avoids Bessel functions. The appropriate form is:

$$\frac{T}{T_0} = 1 - \frac{3}{2}e_0\left(1-\frac{5}{3}e_0\right)\left(1-\sqrt{1-\frac{t}{t_L}}\right) - \frac{17}{8}e_0^2\frac{t}{t_L} + 0(e_0^3) + \frac{3H}{8a_0}\ln\left(1-\frac{t}{t_L}\right) + 0\left(\frac{H^2}{a^2}\right) \qquad (2)$$

The growth of error in (2) as t approaches t_L declares itself plainly, for the term in H/a_0 becomes large, so that the $0(H^2/a^2)$ term can no longer be neglected. By differentiating (2), t_L can be expressed as:

$$t_L = \frac{3}{4}\frac{e_0 T_0}{(-\mathrm{d}T/\mathrm{d}t)_0} \times \left\{1 + \frac{7}{6}e_0 + 0(e_0^2) + \frac{H}{2a_0 e_0} + 0\left(\frac{H^2}{a_0^2 e_0^2}\right)\right\} \qquad (3)$$

When e_0 is very small, say less than 0·02, equation 3 becomes inaccurate, and the appropriate form is that obtained from (1):

$$t_L = \frac{3}{4}\frac{e_0 T_0}{(-\mathrm{d}T/\mathrm{d}t)_0}\frac{I_0(a_0 e_0/H)}{I_1(a_0 e_0/H)} \qquad (4)$$

where I_0 is the Bessel function of the first kind of imaginary argument and order zero. Leslie[1] gave a limiting form of (4), under the assumption that $a_0 e_0/H$ was not too small; Groves[2] derived a version of (3); and Parkyn[3] gave (2) without the $0(e^2)$ terms.

The distance of perigee from the Earth's centre, r_p, is given by:

$$r_p = r_{p_0} + k_0 - k + H\ln\frac{k\, I_1(k/H)}{k_0\, I_1(k_0/H)} + 0\left(\frac{H^2}{r_p}\right) \qquad (5)$$

where $k = er_p/(1+e)$. If e is greater than 0·01, equation 5 can be expressed as:

$$r_p = \left\{r_{p_0} - \frac{H}{2}\ln\frac{e_0(1+e)}{e(1+e_0)}\right\} \times \left\{1 + 0(e_0^3) + 0\left(\frac{H^2}{a^2}\right)\right\} \qquad (6)$$

from which it follows that the relation between T and e is of the form:

$$\frac{T}{T_0} = \left(\frac{1-e_0}{1-e}\right)^{3/2}\left\{1 - \frac{3H}{4a_0}\ln\frac{(1+e)\,e_0}{(1+e_0)\,e} + 0\left(\frac{H^2}{a^2}\right) + 0\left(\frac{H}{a}e\right)\right\} \qquad (7)$$

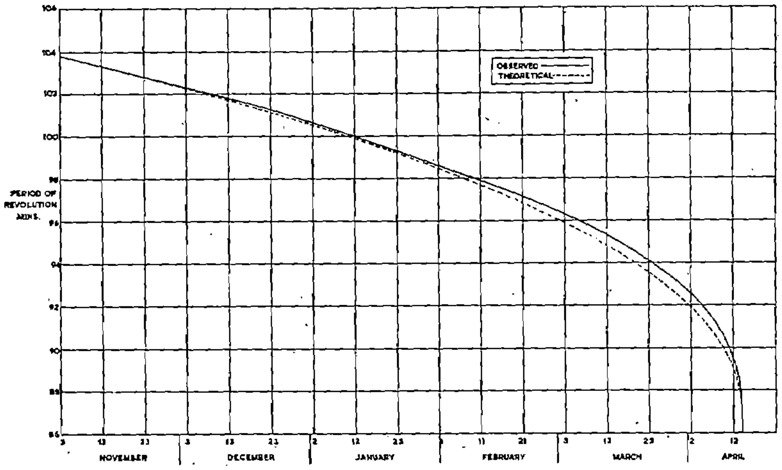

Fig. 1. Period of revolution of *Sputnik* 2 between November 1957 and April 1958. (*Crown copyright reserved*)

Once the initial values e_0 and T_0 are known, equation 7 should provide a good indirect method of finding e. The variation of eccentricity with time is given by:

$$\frac{e}{e_0} = \sqrt{1 - \frac{t}{t_L}}\left[1 - \frac{e_0}{6}\left(1 - \sqrt{1 - \frac{t}{t_L}}\right) + 0(e_0{}^2) + 0\left\{\frac{H}{a}\ln\left(1 - \frac{t}{t_L}\right)\right\}\right. \qquad (8)$$

Equation 8 shows that the variation of e^2 with time is nearly linear, so long as the terms in e_0 and H/a_0 remain small.

The observational values of T and dT/dt for *Sputnik* 2, which are given in Figs. 1 and 2, are based on the analysis of some four hundred observations received at the Royal Aircraft Establishment in the course of the prediction service which was provided from January until April 1958. Most of the observations were accurate to ± 1° in direction and ± 2 sec. in time, though some were much more accurate. Each observation was used to estimate the time at which the satellite passed through apex, the point of maximum latitude north, and the root-mean-square error in determining apex time was usually not more than about 3 sec. From two apex times approximately a day apart, the mean nodal period of revolution T in the interval could be determined with root-mean-square error usually not more than 0·3 sec., or 1 part in 20,000. The series of values of T was then differenced, at intervals Δt, to give values of $\Delta T/\Delta t$ for comparison with the theoretical dT/dt. The value of $\Delta T/\Delta t$ could be obtained with a root-mean-square error usually not more than $0{\cdot}4/\Delta t$ sec./day, where Δt is in days. Except in the last four days of the life of the satellite, a lower limit of 0·8 day was set for Δt, to avoid large errors. Sometimes, through lack of observations, Δt had to be taken as high as 10 days. It would be possible to produce an improved version of Fig. 2 by determining the apex times more accurately and by a proper

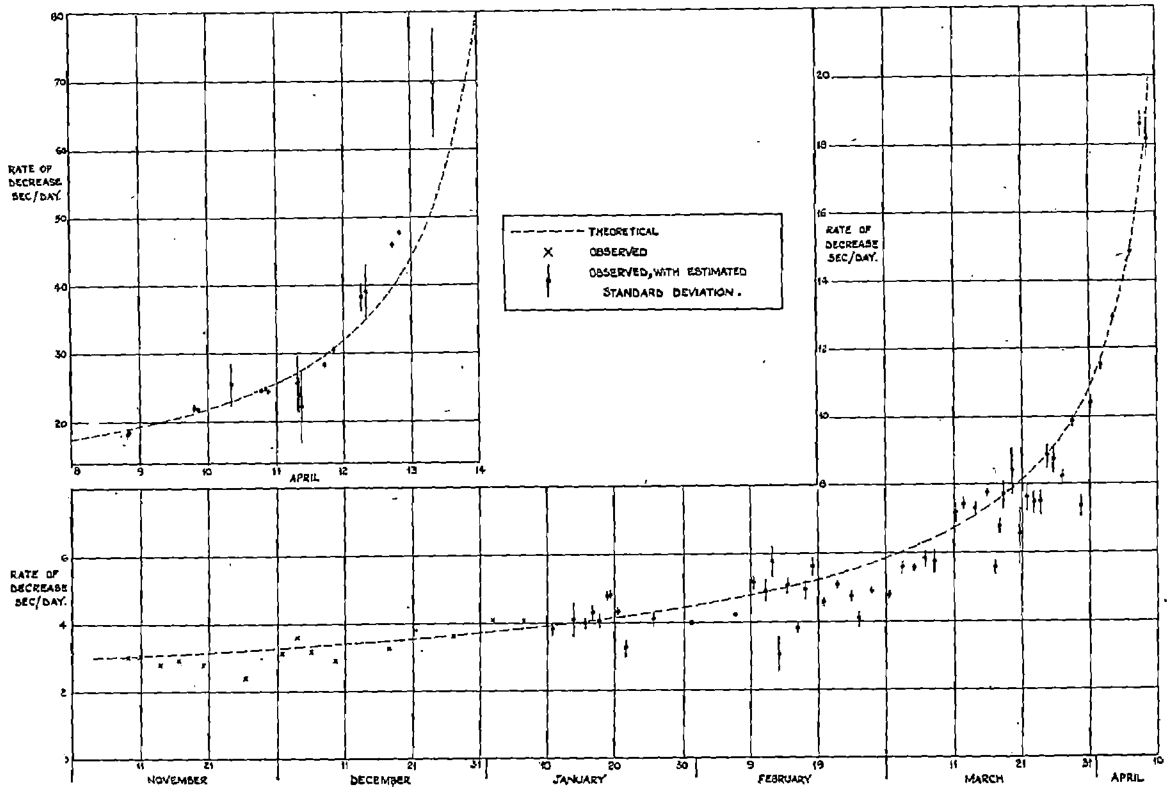

Fig. 2. Rate of change of period for *Sputnik* 2 between November 1957 and April 1958. (*Crown copyright reserved*)

Table 1. ORBITAL DATA FOR *Sputnik* 2 (NOVEMBER 1957–APRIL 1958)

Date (00 hr. G.M.T.)	November 4	January 4	February 21	March 25	April 9	
Orbital period (min.)	103·760	100·505	97·105	93·785	90·780	± 0·005
Semi-major axis (nautical miles)	3,947·1	3,863·7	3,776·1	3,689·9	3,610·7	± 0·2
Eccentricity	0·0987	0·0802	0·0605	0·0400	0·0212	± 0·0006
Perigee distance (nautical miles)	3,557	3,554	3,549	3,542	3,531	± 2
Angle from apex to perigee	− 31°	− 55°	− 76°	− 91°	− 98°	± 1°

Initial inclination of orbital plane to equator, 65·3°. Last column gives root-mean-square errors.

statistical treatment of the results, to decide, for example, the optimum value of Δt. However, the labour required scarcely seems worth while, when independent results from other countries will no doubt soon be available and will show whether there are any spurious values in Fig. 2.

The theoretical curve drawn for comparison in Fig. 1 is that obtained from equation 1, with November 4·0 as initial point, $t_L = 162 \cdot 0$ days and $H = 30$ nautical miles. The agreement between observation and theory is fairly good. But it is by no means perfect, and this is scarcely surprising in view of the irregularities in Fig. 2.

There are two contrasting features of interest in Fig. 2. First, it appears that the theoretical curve provides a reasonable mean value of dT/dt, suggesting that the effective cross-sectional area S underwent no great and irreversible change. This conclusion is consistent with observation, for until April 12 the brightness of the satellite fluctuated widely when it was between the observer and the Sun, and the period of these fluctuations was usually between 1½ and 2 min. These regular changes suggest that, until April 12, the satellite may have been rotating at a roughly constant rate, and that the mode of rotation, for example, a tumble or a barrel roll, may have remained the same. If so, the mean effective area S would be expected to remain constant. The second interesting feature of Fig. 2 is that the observed values depart significantly from the theoretical. Anyone who tried to predict the transits of the satellite will confirm that these oscillations in dT/dt are real, and not due to errors of observation or analysis. Taking theory instead of observation for January 20–February 9, for example, would have led to an error of about ½ hr. in the predicted times. It seems probable that the fluctuations in dT/dt are caused by day-to-day fluctuations in the properties of the atmosphere at perigee, either by changes in the number of particles per unit volume or in their electrical state. Though there is no obvious pattern in the fluctuations of Fig. 2, an oscillation of period about 25 days is faintly discernible, and this has provoked speculation that the tide-raising force of the Moon may play some part. There are many other possible sources for the irregularities, however, and it would be premature to attempt any detailed discussion of them here.

The value of H, the scale height, can in principle be obtained from the orbital data of Table 1, by means of equation 6 or equation 7; but since H depends on the small difference between two large quantities, considerable errors are inevitable. If the initial values are taken as those in the first column of Table 1, and H is determined from (7), using each of the other four columns in turn and giving each equal weight, the value obtained for H is 38 ± 13 nautical miles, almost all the error arising from the error of 0·0006 in e. The errors can be minimized by taking only the last of the four columns. It is then found that $H = 35 \pm 4$ nautical miles from either (6) or (7). Though the error is smaller, the result should still be received sceptically, for several reasons. First, because of the Earth's oblateness the value of H obtained is not the scale height as customarily defined, relative to height above the Earth's surface; when oblateness is taken into account, H is increased by about 25 per cent. Secondly, the irregularities in dT/dt violate one of the assumptions of the theory. Thirdly, H varies with both latitude and height, thus violating two more assumptions. Fourthly, electrical effects may be important and, if so, ρ is not the true air density. For these reasons it is obvious that much further study is required before a reliable value of H can be derived.

We wish to thank the many independent observers who provided the observations for Figs. 1 and 2, and Miss D. M. C. Gilmore, who analysed the observations and prepared the graphs.

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THE BIOGEOGRAPHY OF AUSTRALIA

By PROF. RONALD GOOD

University of Hull

IT has been suggested[1,2] that the biogeographical problems of Australia become less perplexing if it is assumed that Australia and New Guinea, instead of being parts of one and the same primeval land mass, have attained their present proximity in comparatively recent geological times, by some relative movement which has gradually diminished the distance between them. Such a diminution might be caused by an active drift of Australia in an easterly or northerly direction; or to an active drift of the Melanesian–New Zealand arc westwards; or to some combination of these; but at present it is simplest to speak of the drift of Australia towards New Guinea, remembering, nevertheless, that this may be only a relative description.

A theory of this kind must depend largely on circumstantial evidence and the field in which this may be sought is wide, since there is scarcely a cognate science which cannot contribute to it. It seems justifiable, therefore, in order to indicate where this is likely to be most valuable, to suggest in rather more detail, and particularly in botanical terms, one course which events may have taken.

To begin with, plant geographers have long remarked the considerable affinity between the floras of Australia and South Africa, an affinity typified most familiarly by the families Proteaceae and Restionaceae, and by the Ericales, but seen also in many other plant groups. There seems no doubt that this is a true genealogical affinity, and we may therefore postulate that at some earlier period Australia, as we now call it, was much closer to (perhaps actually in contact with) what we now call South Africa, and therefore that its relative movement has been, in general, eastwards.

When, accepting this premiss, we consider the possible direction of movement more closely, an important point at once emerges. If we assume that the drift was directly eastward, then Australia would have remained within the same range of latitude throughout its journey ; but if, on the other hand, the drift was to some degree north-eastward, then Australia would, in the course of it, gradually have altered its position in respect of the poles, which for the moment we may regard as retaining their positions. The difference between the two from the botanical point of view is great. In the first case we should expect the original flora of Australia to continue unembarrassed by serious climatic change and to alter no more than might be expected from the prolonged passage of time alone. In the second case, the flora would be under continued and increasing stress through the gradual movement from one climatic condition to another.

In other words, Australia, unless it maintained a true latitudinal course, is likely to have moved so that it came to fall more and more within the warmer and drier conditions of the southern high-pressure belt or horse latitudes, and less and less within the cooler and wetter conditions of the south-temperate low-pressure belt of the roaring forties and north-westerlies. If this movement was considerable, then Australia would even have moved entirely out of one major climatic zone into another.

To-day there are in the Australian flora, in addition to what we may call the basic 'Afro-Australian' element already mentioned, two other great floristic elements, the 'south circumpolar' rain-forest element found now in south-east Australia and particularly in Tasmania (as well as in New Zealand and South America), and the 'Melanesian' rain-forest element of eastern Queensland and north-eastern New South Wales. The presence of the former (of which there is no counterpart in the present South African flora) suggests strongly that Australia was at one time in continuity with a general southern-temperate rain-forest flora and, thus, that its original position was somewhat to the south of Africa and, perhaps, even between that continent and what is now Antarctica. In this position we should expect its flora to consist of two main elements—one in the north having much in common with the nearby South African flora, and a temperate circumpolar element in the south.

From this position we may picture Australia as having drifted at least east-north-east, and it may be almost north-east, and the change in latitude involved as amounting to as much as 20°. Such a move would be likely to cause great floristic changes. In an original position of, let us say, 30° to 60° S., Australia would have lain with only its most northerly portion in a comparatively dry zone and with most of its area in a cooler and much wetter zone. In its present position between 10° and 40° S. it is almost wholly in a dry zone, and only some of its more southerly parts have a wetter and cooler climate. There are, indeed, only two, adjacent, parts of the continent in which rain-forest occurs to-day, namely, the south-east corner with Tasmania, where there is a circumpolar type, and along the warmer east coast, where here and there a more Melanesian type of rain-forest occurs.

Now let us view this supposed drift of Australia from another aspect. At first the movement would have been mainly one of gradual separation from its neighbours, but this would soon amount to a considerable measure of isolation. Moreover, if the relative positions of the other land masses were, and remained, as we know them to-day, then this isolation would not only increase but also would persist for most of the journey, diminishing again only in the later stages as Melanesia was approached. Hence, for much of the time, which may have been a very long period, not only would Australia have been isolated from other lands but also it would have been moving gradually from one climatic zone to another.

In such circumstances it would seem almost inevitable that the flora must have been affected profoundly. On one hand the major area of temperate rain-forest would have become more and more restricted to the south, and on the other, increasingly wide aridity would probably have greatly changed the distribution of the Afro-Australian element. Most important of all, the isolation of Australia from other land masses would have hindered any replenishment of the flora from elsewhere. We should therefore expect that as drift continued the general character of the flora of Australia gradually became changed and probably more drought-resistant, in any event over much of the continent. It may be highly relevant in this connexion that despite the assumption of close prior association with southern Africa, Australia has, unlike South Africa, practically no specialized desert flora to-day, although its arid areas are now at least as extensive. This suggests that at its time of separation from Africa it lacked either the stock from which the African desert flora has or had come, or the appropriate climatic conditions.

Because of these circumstances, a most interesting situation would have arisen as Australia gradually came within population distance of Melanesia. In the first place, it would have arrived in a floristically unsaturated condition ready to be replenished easily at the first opportunity. In the second place, it would have reached a point geographically at which certain local parts of it on the east would have been particularly capable of sustaining tropical rain-forest but of which there would have been no available sources in Australia. It would therefore not be surprising if there was a very rich and rapid invasion of plants from Melanesia as soon as diminishing distance permitted, not only, though perhaps primarily, in the form of rain-forest down the east coast, but also more generally in the form of potentially more drought-resistant elements. Australia may indeed have afforded something like a partial floristic vacuum into which plants from Melanesia would have flowed quickly and easily.

If this was indeed the course of events, we should expect to find, in the present Australian flora, certain prominent features. We should expect to find some remnant of the old temperate rain-forest flora which once covered most of the continent, because the south-east is still as far from the equator as 40° S., and this we see plainly in the flora of much of Tasmania and parts of the adjacent mainland.

We should expect to find in the remaining less-arid parts the general occurrence of the old Afro-Australian flora, and this we do very conspicuously, for it still provides much of the most typical Australian plant life. We should expect a relative absence of specialized desert types because the conditions for their development came after the separation of Australia from areas with such types now, and this, of course, is true. Finally, we should expect to find a strong infiltration of Melanesian types, mostly tropical rain-forest plants, in the north and east wherever the rainfall is sufficient, and the presence of this kind of vegetation in the high rainfall areas of the north-east is familiar and conspicuous.

Hence the sequence of events outlined provides a reasonable explanation of the major features of the present Australian flora without recourse to former land connexions of any kind, except in so far, of course, as the present Torres Straits have almost certainly been dry land on occasion during the very recent geological past, that is to say, on the present hypothesis, since Australia reached New Guinea.

It will be clear now that two very important aspects of the circumstantial evidence mentioned earlier will be the palæontological and the palæoclimatic, and it may therefore be reiterated that according to my hypothesis I should expect the Angiosperm fossil record of much of Australia to show in sequence, first a fairly widespread flora predominantly of a temperate rain-forest kind; secondly, a contraction of this and a spread of an 'Afro-Australian' flora (such as is exemplified by acacias, Proteaceae, Restionaceae, Ericales and various Monocotyledons); thirdly, more widespread evidence of aridity accompanied or closely followed by a great increase in such plants as *Casuarina* and *Eucalyptus*, together with the appearance of some development of tropical rain-forest in the north-east and east; and fourthly, one or more short-term extensions of the more mesophytic kinds of vegetation during the pluvial stages of the Pleistocene.

There is not yet much to guide us in dating these successive phases, but there are one or two pointers. In the larger plant groups, particularly families, there is, with one particular exception to be mentioned, good agreement between the present floras of South Africa and Australia, and it seems clear from this that if the two regions have indeed drifted apart then the process must have begun after the general differentiation of the Angiosperms, that is to say, not earlier than the later Cretaceous or the earliest Tertiary. On the other hand, it may, so far as the plants are concerned, have started at almost any later time, the more recent the start the shorter, of course, being the duration of the movement. Again, whether drift has been going on slowly for a long time or has taken place wholly within a comparatively short time, we do not know. At the nearer end of the time-scale the considerable size of the Melanesian element in the Australian flora to-day (together with the much smaller selection of Australian plants in New Guinea) suggests that an appreciable time has elapsed since these two became close enough together to populate one another, and this in turn may merit the speculation that their approximation was during or at the end of the Pliocene.

On one point the fossil record may be of special importance. The underlying affinity of the floras of South Africa and Australia has been stressed more than once and it should therefore be made plain that there are also puzzling differences between the two. This is notably the case with two of what are now characteristic Australian types, *Casuarina* and the Myrtaceae, especially, of course, *Eucalyptus*. Neither of these is prominent in Africa; the Myrtaceae are very poorly represented there even in the tropics, and *Casuarina* does not occur native at all. Yet both are well-developed and characteristic features of the Melanesian tropical flora. Several species of *Eucalyptus* itself occur there, one of which at least is generally regarded as among the least specialized. May it not be, then, that these two genera, doubtless among others, are not in fact Australian types in origin, despite their prominence there to-day, but among the most conspicuous examples of that filling of a partial vacuum, mentioned earlier, by appropriate stocks from Melanesia?

Finally, it must not be forgotten that the sequence of events outlined above presupposes the present latitudinal distribution of climate, which arises from the position of the poles, to have remained unchanged throughout. To have incorporated the possibility that there was at the same time polar movement would have complicated the picture too much, but it must always be remembered that if, as there seems reason to believe, there may have been some such contemporary changes in the positions of the poles, these could have had one of three effects. They could have intensified the climatic changes suggested; they could have reversed them; or they could even have prevented them. They could scarcely, however, have affected the movement of Australia in itself.

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[1] Good, R., *Nature*, 179, 926 (1957).

[2] Good, R., *Austral. J. Sci.*, 20, 41 (1957).

OBITUARIES

Dr. Emil Abel

Dr. Emil Abel died in London on April 3 in his eighty-third year, after a short illness. He had studied in Vienna and then under Nernst. In 1905 he established himself as *Privatdozent* at the Technische Hochschule in Vienna, and when a chair of physical chemistry was created he was appointed professor and head of the institute attached to the chair. He held this position until the Anschluss in 1938, when he was dismissed under the Nuremberg laws. With his family he found refuge in England; during the War, and for several years after, until his retirement, he was in charge of the research laboratory of the Ever Ready Co., Ltd.

Though he contributed to many branches of physical chemistry, his main interest was chemical kinetics. His early work was devoted to homogeneous catalysis, and he showed in a series of brilliant papers that the role of the catalyst is the creation of additional reaction paths from the reactants to the products. He used to insist firmly that "it is reactions that catalyse, not substances".

After the First World War he turned his attention to the reaction complex of the acids and oxides of nitrogen and sulphur, and contributed a number of papers on the mechanism of the reactions in the lead chamber process for the production of sulphuric acid. He also continued his work on the mechanism of oxidation-reduction reactions and studied the isotope effect in kinetics. During the Second World War he worked on industrial problems of national importance and projected a study of the basic mechanism of the dry cell; he worked on this until his retirement. Even afterwards he did not remain idle: he considered different kinetic mechanisms from a unified point of view in which electron transfer reactions play a central part.

Abel had established a large and vigorous school in Vienna, and his institute produced work on many branches of physical chemistry. He had a peculiar, racy style of lecturing, which was appreciated more by the élite than the average student.

He took little active part in matters outside science, but had by no means the narrow outlook of the specialist; those who had the pleasure of hearing his talks to the Austrian Club in London can testify to this. He had an uncomplicated, pleasant nature; though he continued to live in London after the War, he always had a great love for Austria. His eightieth birthday was the occasion for special celebrations by the Academy of Sciences in Vienna and the Bunsengesellschaft.

His two children of his first marriage, and his second wife, survive him. H. TOMPA

Dr. J. S. Farquharson

THE meteorological service of Great Britain lost a well-known and senior member of its staff, when Dr. James Strachan Farquharson lost his life in a fatal motoring accident on January 31. Dr. Farquharson was born on June 30, 1904, and joined the Meteorological Office in July 1925 after graduation in the University of Aberdeen. He served in various divisions of the Meteorological Office, mainly those concerned with meeting the requirements of civil aviation and the Royal Air Force, both at home and overseas. In June 1954, Dr. Farquharson was appointed as assistant director for public services and, in this capacity, did much to develop both the television and weather broadcasts and the automatic telephone weather service in Britain.

The death of Dr. Farquharson was also a sad loss to the Royal Meteorological Society, of which he had been a Fellow since 1934. As honorary treasurer of the Society, he succeeded in introducing a modification of the old-established policy of investing in gilt-edged securities—a change which he firmly believed will prove of considerable value to the Society. His contributions to the Society's *Quarterly Journal* included two studies related to the development of Empire air routes, namely, "Haboobs and Instability in the Sudan" and "The Diurnal Variation of Wind over Tropical Africa".

The death of Dr. Farquharson has brought to an untimely end an experienced and energetic personality with a wide comprehension of, and original ideas for meeting, the meteorological requirements of the community. R. G. VERYARD

Mr. F. J. Welch

THE death on May 7 of Mr. F. J. Welch, for forty-six years an assistant in the George Holt Physics Laboratory of the University of Liverpool, has severed one of the few remaining links of personal association with Sir Oliver Lodge, Lyon Jones professor of physics in 1900. Mr. Welch was then only in his early twenties, but his recollections of the great man—and his wireless aerial—were very vivid.

Prof. Wilberforce followed Sir Oliver and held the chair for thirty-five years, and Mr. Welch became senior laboratory steward during this period. Those were the days when popular lectures were delivered on "Liquid Air", and also when medical as well as science students attended lectures and demonstrations in physics, which brought them all into intimate contact, not only with the teaching staff, but also with Mr. Welch, who acted as demonstrator. Many physicists, medical men, dentists and school teachers now scattered all over Britain will have happy recollections of the kind and helpful way he always had with them at these classes.

Sir James Chadwick became professor of physics in 1935, and until he retired in 1946, Mr. Welch was in the Department and experienced the period of secrecy which followed the splitting of the atom; and he had close contact with other well-known physicists, such as Prof. J. Rotblat and Prof. O. R. Frisch.

It is interesting to note that his eldest son, E. A. Welch, who received his early training in the George Holt Physics Department, is now senior technician in the Department of Physics, University College of North Wales, Bangor. W. J. PIERCE

Mr. G. A. Cook

MR. GEORGE ALFRED COOK died suddenly in Melbourne on January 4. He had enjoyed a comparatively brief retirement from the Commonwealth Scientific and Industrial Research Organization, of which he had been secretary during 1944–52. Before the First World War, Cook was an outstanding student at Ormond College in the University of Melbourne and graduated with first-class honours as master of science and bachelor of mining engineering. During the War he was commissioned in the Second Australian Tunnellers, in which unit he gave distinguished service in France and was awarded the Military Cross.

After the War he spent several years in research work in the mining industry, and in 1922 joined the Institute of Science and Industry as a scientific abstractor. The Institute was replaced by the Council for Scientific and Industrial Research, which in turn was succeeded by the Commonwealth Scientific and Industrial Research Organization, and Cook's service with these bodies was continuous. When he joined the Institute in 1922 there were only two people with scientific training on the staff. When he retired as secretary of the Organization, there was a total staff of more than three thousand, of whom one thousand held professional qualifications. Cook, during his early years with the Organization, took a particular interest in making the results of scientific research available to industry, both as an editor of scientific publications and as a writer of non-technical accounts for the general reader.

NEWS and VIEWS

Sir Macfarlane Burnet, O.M., F.R.S.

THE award of the Order of Merit to Frank Macfarlane Burnet will delight scientific workers generally and particularly those who labour in Burnet's chosen fields of virology and immunology. Australians will, of course, especially appreciate that this high honour has fallen to one of themselves. For most of his life Burnet has worked in Melbourne, at the Walter and Eliza Hall Institute, and he has been its director since 1944. With his increasing scientific distinction he has had many temptations to accept important positions outside Australia. Perhaps he likes Australia ; in any event, he has resisted all blandishments and his decision to stay there has been of benefit not only to Australia but, indirectly, to the world at large, for he has founded in Melbourne a school which has attracted many students from distant parts. His contributions to knowledge mostly concern fundamental principles in biology ; but others have dealt with problems which have an important Australian aspect to them—*Q*-fever, psittacosis, Murray valley fever and myxomatosis are examples. Burnet is best known for his work on viruses, especially influenza. He and his co-workers have been able to throw important light on the mechanisms whereby viruses become attached to and infect cells. More recently, he has been interested in the nature of antibodies, their mode of formation and of action. Above all, Burnet is an all-round biologist, a master of the 'magnificent generalization'. When men with such rare gifts turn up, they well deserve the highest of honours.

Theoretical Atomic Physics in Copenhagen :

Prof. L. Rosenfeld

PROF. LEON ROSENFELD, who has occupied the chair in theoretical physics in the University of Manchester since 1947, is now leaving to become professor in the new Nordik Institute for Theoretical Atomic Physics at Copenhagen. Prof. Rosenfeld is perhaps now most widely known for his contributions to nuclear physics, where his wide interests are well typified by his book, "Nuclear Forces" (1948), which was one of the first authoritative and comprehensive works in the field of nuclear physics, and for his work as editor of *Nuclear Physics*—the first journal devoted entirely to this field. However, his interests have not been limited to this single branch of physics, nor has his influence been confined to Manchester alone. His earlier work with Niels Bohr on the interpretation of quantum mechanics has been followed by many publications dealing with basic problems in physics, their history and their philosophical implications. His views and influence have been made felt in many parts of the world, not only by his published work, but also by his lectures and personal contacts. For Prof. Rosenfeld, physics, and science generally, is part of a mature, scholarly and cultural outlook, an outlook which was conveyed to, and was appreciated by, audiences in many countries. Prof. Rosenfeld's views and ideas were part of the culture of the civilized world, and although the centre from which they are disseminated will now move from Manchester to Copenhagen, their influence will no doubt be as widespread as ever. In Manchester, as elsewhere, one may hope still to continue to enjoy them.

Theoretical Physics in Manchester :

Dr. B. H. Flowers

DR. BRIAN H. FLOWERS has been appointed to the chair of theoretical physics in Manchester, from which Prof. Rosenfeld resigns this year. Dr. Flowers took the Natural Science Tripos at Cambridge, and then worked at the Atomic Energy Laboratory in Montreal, and after the Second World War joined the newly established Atomic Energy Research Establishment at Harwell. For a time he worked in Prof. Peierls's Department of Mathematical Physics, University of Birmingham, and was awarded a D.Sc. degree by that University. In 1952 he was appointed, at a remarkably early age, to be head of the Theoretical Physics Division at the Atomic Energy Research Establishment, Harwell, and since then he has continued to occupy this very responsible post. Dr. Flowers is widely known for his many outstanding contributions to the theory of nuclear structure and the application of group-theoretical methods to these problems. In his work at Harwell, Dr. Flowers has contributed to many important problems which have arisen in the extensive range of activities covered by nuclear science and atomic energy. His intellectual gifts, his great energy, his wide experience of physical problems and, through his early work, his first-hand appreciation of the problems of experimental physics, will, in addition to his expert knowledge of nuclear physics, all be greatly appreciated at Manchester. Manchester has a long and distinguished tradition in theoretical physics, a tradition which includes Bohr, Eddington, Hartree, Milne and Schuster, as well as Dr. Flowers's immediate predecessor. Dr. Flowers will, without doubt, further enhance this great tradition.

Dr. J. Glasspoole, I.S.O.

DR. J. GLASSPOOLE, a principal scientific officer in the Meteorological Office and well known to all those requiring information regarding the distribution of rainfall in the British Isles, retired at the end of last year after nearly thirty-eight years service. Dr. Glasspoole began his career in the British Rainfall Organization, which was taken over by the Meteorological Office in 1919. Thereafter he was continuously employed on climatological work, especially the study of one particular element, rainfall. He wrote a large number of papers on the subject and became a recognized authority on the incidence and distribution of rainfall in the British Isles. In recognition of his services, he was appointed a Companion of the Imperial Service Order, and the Institution of Water Engineers made him an honorary member of the Institution.

The Scientific American

IN January 1948, the editing and publishing of *The Scientific American* (415 Madison Avenue, New York, 17), one of the oldest of America's scientific journals (founded in 1845), was taken over by Mr. Gerard Piel and his two partners, Mr. Dennis Flanagan and Mr. Donald H. Miller, jun. At that time, the journal was being far from successful, since only about two thousand copies of each issue were paid for in cash, and advertising revenue was quite negligible. During the past ten years, however, *The Scientific American* has undergone a metamorphosis which may be described as staggering, for now it has more than two hundred thousand monthly subscribers on its books. Mr. Piel, publisher, and his colleagues are to be congratulated on this great achievement, especially since, through sound policy, good editing and attractive presentation this journal has won the high regard of scientists and laymen alike for its excellent interpretation of scientific discoveries and advancement.

All the articles which appear in *The Scientific American* are authoritative, being written by men of science directly concerned with the work being reported —usually leading authorities themselves. In the past, these have included Einstein, Karl Compton, Robert Oppenheimer and Hans Bethe. But these articles are rigorously edited with the view of clarification, not simplification. The journal is lavish with its illustrations—photographs, drawings, charts and diagrams, many of which are coloured. But the editors make sure that the text shall not become a mere vehicle for attractive pictures. The aim of the latter is to give the reader a vivid grasp of what the article is about and to develop the relationships between variables which so often defy exposition by the written word. So fine, rather than commercial, artists are employed because, as the publisher claims, "The creative artist, when he turns his interest to science, tends to come up with really original solutions to the problems presented by the text".

In connexion with *The Scientific American*, ten paper-backed topical 'anthologies' have also been published, and the aim is to issue about five of these every eighteen months. These 'anthologies' have already been translated into a dozen languages.

Here is a very successful venture into scientific literature for which all scientific workers and especially non-scientific readers must be very grateful. To mark the tenth year of publication under its new direction, a "Cumulative Index" (author, title and subject) of all the issues of this magazine from its first issue (May 1948) to 1957 is now available. We take this opportunity of congratulating the board of editors, including Mr. Gerard Piel (publisher), Mr. Dennis Flanagan (editor) and Mr. Leon Svirsky ; the art director, Mr. James Grunbaum ; the general manager, Mr. Donald Miller, jun. ; and the advertising manager, Mr. Martin M. Davidson, on their magnificent achievement. They are making a first-class and essential contribution to the advancement of science.

Medical Colour Television

On June 4 the first mobile medical colour television unit to be designed and manufactured in Great Britain was handed over by the Marconi's Wireless Telegraph Co., Ltd., to Smith, Kline and French Laboratories, pharmaceutical manufacturers, who ordered the equipment. The vehicle weighs 6 tons, and the television apparatus accounts for a further 2 tons. The available space has been divided into three sections. The rear compartment is staffed by one maintenance engineer to service the apparatus, which combines the red, green and blue signals for transmission via land-line or microwave link. The technical director, the vision mixer, the sound mixer and two camera-control operators work in the centre compartment under the control of the producer. This room houses a colour monitor for each camera, and a third one acts as a line monitor. These are fixed to a monorail, so that they can be moved to either of the other two sections for maintenance or repair. The driver's compartment is also used as a servicing area. The cameras are direct descendants of those supplied to the British Broadcasting Corporation a few years ago. The display unit is a Marconi Colour Television Projection Unit, which can provide a picture 8 ft. × 6 ft., which is said to be adequate for viewing by an audience of up to 300. This equipment will be made available, without charge, to conferences and congresses, so that large audiences can obtain a close-up view of operations or clinical demonstrations. A two-way radio link is provided to facilitate discussion between the surgeon or demonstrator and the audience.

Smoking and Lung Cancer

Following the decision of the Ministry of Health to accept the Medical Research Council's findings as establishing a causal relationship between smoking and lung cancer, local authorities were asked to promote appropriate educational campaigns. The Central Council for Health Education was recommended as a suitable agency. To help local authorities, Dr. John Burton, director of the Central Council for Health Education, has produced a summary of the relevant medical and ethical issues which should be considered by local authorities before launching its campaign. It includes the essential facts about lung cancer ; criticism of the facts ; other factors involved for which there is some evidence ; facts about smoking ; reasons for and attitudes to smoking ; giving up smoking ; policy on presentation of the case against smoking ; aims and methods of presenting the facts ; and the questions people ask. The summary is a clear, objective, factual account of the relationship between smoking and lung cancer and should give local authorities the kind of lead for which so many of them have been asking.

Language and Speech

Interest in the problems of language and speech has grown rapidly in recent years. In this, the biggest single factor is undoubtedly modern communications engineering and its impact upon the biological sciences. New electro-acoustic techniques have thrown much light on the physical basis of speech and are being increasingly applied to the study of fundamental problems in experimental psychology. The theory of information, as developed by Shannon and others, would appear to have important application to biological systems, not excluding the field of human behaviour. Furthermore, recent developments in statistical technique have given promise of a new and more genuinely scientific approach to linguistics. In view of these considerations, any serious attempt to bring together the many and diverse approaches to the study of speech deserves a warm welcome. *Language and Speech* is a new quarterly edited by Dr. D. B. Fry, of the Department of Phonetics, University College, London (annual subscription : 80*s*. ; 11.50 dollars. Single issues : 25*s*. ; 4 dollars. Teddington, Middlesex : Robert Draper, Ltd., 1958). Its avowed purpose is ". . . to furnish a medium for publications in which the fundamental problems of speech and language form the centre of interest". It is to offer space not only for reports of experimental findings but also for discussion of theoretical issues arising from, or relevant to, experiment. The fields covered include language structure, the transmission and reception of speech, mechanical translation, synthetic speech, and abnormalities of speech and language. Of particular interest in the first number (1, Part 1; January–March 1958. Pp. ii+78) is a paper on brain disorders and language analysis by Prof. A. R. Luria, of the University of Moscow.

A Folk-lore Survey

IN the *Museums Journal* of May, Mr. J. M. Dodgson describes in detail the procedure adopted in connexion with a survey of English folk-lore which he is carrying out from University College, London. The object of the survey is a classified index of English folk-traditions, comparable with that of Swedish folk-lore in Sweden or of Irish and Scottish folk-lore in Dublin and Edinburgh. The survey is being conducted in a scholarly and critical manner and is an attempt to reduce to methodical order a subject which up to the present has not been dealt with on a scientific basis. The co-operation of museum curators is invited, and Mr. Dodgson looks forward to the time when every district of England will possess a well-ordered folk museum.

Federation of British Industries

THE forty-first annual report of the Federation of British Industries, covering the year ended December 31, 1957 (pp. vi+43. London: Federation of British Industries, 1958), displays the wide range of the Federation's interests. During 1957 the Federation continued to be greatly interested in the problems involved in Britain's possible entry into a European Free Trade Area, and its studies of the implications of this proposal led to a general survey for industrialists and a joint report, with the Association of British Chemical Manufacturers and the National Union of Manufacturers, to the Government on the kind of convention it should seek in the negotiations for a Free Trade Area, and a study of comparative taxation in European countries. In November the Grand Council of the Federation finally recorded its opinion as being, on balance, in favour of the Government's policy, provided certain safeguards and conditions were secured. Evidence was submitted to the Radcliffe Committee inquiring into the working of the monetary and credit system, and to the Trade Effluents Sub-Committee of the Central Advisory Water Committee, which is considering the law affecting the disposal from trade premises of liquid effluents; much statistical information was collected for another sub-committee considering the growing demands for water, and the Federation pioneered a scheme whereby the Department of Scientific and Industrial Research will undertake, on behalf of industry, research on the fundamental problems of the treatment and disposal of trade wastes and the purity of rivers. In education, links with the universities, technical colleges and schools were further consolidated, and a memorandum submitted to the Minister of Education in August supported particularly the proposal of the Willis Jackson Committee for a staff college for senior teaching staffs in technical colleges. Among topics considered by the Industrial Research Committee were the establishment of a National Lending Library for Science and Technology and British official overseas scientific representation.

Scaling-up of Chemical Plant

THE Institution of Chemical Engineers, in co-operation with the Chemical Engineering Group of the Society for Chemical Industry and two similar Dutch organizations, arranged a two-day symposium in London in May 1957 on "The Scaling-up of Chemical Plant and Processes". Previously, the literature on the subject had been very scanty, but the recent text-book by Johnstone and Thring (see *Nature*, 181, 1094; 1958) and the proceedings of the symposium (pp. 136. London: Institution of Chemical Engineers, 1958. 60*s*.) together form a sound basis for a study of the subject. One of the major decisions to be taken in developing a new process is whether or not to carry out pilot-plant tests and how best to interpret the information so obtained. The papers presented at the symposium cover a wide field and illustrate many of the problems involved. The first session was devoted to fundamental aspects: introductory ideas on scaling-up and the principles of similarity are discussed, together with the design of reactors, with special reference to the economics of batch, tubular and continuously stirred tank reactors. The first session ended with a discussion on the relation between the cost and the size of plant. The following three sessions were devoted to scaling problems related to specific processes and equipment, including the rotating-disk contactor, cyclones, air-separation plant, continuous-filtration equipment, and solvent extraction and gas absorption. The discussion at the end of each session is also reported. About 60 per cent of the papers were from England and 40 per cent from Holland.

Pharmacopœias, Dispensatories and Formularies

HUMAN societies, as it seems, have long had an inherent urge towards the possession of a *materia medica*. In this connexion, the biological journal, *Lloydia* (20, 1; 1957. Lloyd Library and Museum, Cincinnati, Ohio), contains an article of somewhat unusual interest, namely, "A Catalogue of the Pharmacopœias, Dispensatories, Formularies, and Allied Publications (1493–1957) in Lloyd Library". As the authors explain, John Uri Lloyd, who founded the library in 1864, began to collect these literary materials in the same year. This effort has evidently been continued with zeal, so that the collection now contains more than 1,000 titles, dating from 1493 to the present time, from all parts of the world. The arrangement of the catalogue is alphabetical by countries and chronological by dates of publication. Among the illustrations, one may note reproductions of the title pages of such works as "Pharmacopœa Dogmaticorum Restituta" (Paris, 1607) and "Pharmacopœa Persica" (Paris, 1681).

Metabolism of Marine Flagellates

THE products of photosynthesis of two marine flagellates have been examined and compared with those of *Chlorella pyrenoidosa* with the use of radioactive carbon and chromatographic techniques by R. G. S. Bidwell (*Canad. J. Bot.*, 35, 945; 1957). The alcohol-soluble products were different in each alga, many of the compounds produced by the marine forms being unidentified. The principal soluble product of photosynthesis of a member of the Heterokontae, *Olisthodiscus* sp., was identified as *d*-mannitol. Those of a dinoflagellate, *Amphidinium carteri*, include glycosides of glucose and mannitol. The main insoluble carbohydrate produced by all three organisms gave rise to glucose on hydrolysis; this only contained about 10 per cent of the total fixed carbon. The radioactive compounds released from the alcohol-insoluble residues by acid hydrolysis were similar in the three algae and consisted mainly of amino-acids.

Electron Density Profiles in the Ionosphere

In many parts of the world during the past twenty years, regular measurements have been made of the maximum electron density (N_m) and the approximate true height (h_m) of the various layers in the ionosphere. Both these parameters can be obtained fairly easily from the $h'(f)$ curves (ionograms) which are produced by automatic pulse-sounding equipment. On the other hand, very little accurate information is available on $N(h)$ profiles, the distribution of electron density with height in the ionosphere, and how these profiles vary with time, season and geographical location. Correspondingly, little is known about the variation of electron density with time at a constant height (the $N(t)$ curve). The ionograms contain all this information, but the mathematical procedure for deriving it explicitly is very laborious, especially if the effect of the geomagnetic field is taken into account. The electronic computers now available have opened up a new era in this field since they can readily be used to compute $N(h)$ profiles from ionograms.

A programme of such computations has been organized by the Radio Research Station of the Department of Scientific and Industrial Research, at Slough, as part of the United Kingdom programme of observations during the International Geophysical Year. The $N(h)$ profiles are being produced by Ferranti, Ltd., on a "Pegasus" automatic digital computer using $h'(f)$ data obtained at four observatories, namely, Slough, Ibadan, Singapore, and Port Stanley. For each observatory profiles are being calculated for each hour of the day for about four days a month beginning in July 1957. When the ionograms are suitable, Regular World Days are selected for analysis; when this is not practicable, other days are substituted. This programme will be continued until December 1958 when the possibility of extending the work will be considered. The analysis is carried out according to a method recently described by Thomas, Haselgrove and Robbins (*J. Atmos. Terr. Phys.*, 13, 46; 1958), which makes no *a priori* assumptions about the variation of electron density with height except that it increases monotonically. It can be applied to $h'(f)$ curves from any observatory merely by changing the geomagnetic dip angle and the gyro-frequency, both of which are taken into account in the calculations.

The Association of Universities of the British Commonwealth

The report for 1956–57 of the Executive Council of the Association of Universities of the British Commonwealth (pp. 25. London, 1958), to which are appended a note on the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom (which met eleven times during the year) and the accounts of the Association, records expenditure of £24,797 and an income of only £26,980 compared with £27,860 for 1955–56. Lists of names and other particulars of overseas students continued to be collected from all universities and university colleges in the United Kingdom and a statistical analysis of this material has been printed as an appendix to the Commonwealth Universities Year Book for 1958. These lists are available for consultation by accredited inquirers and the Association also maintains a collection of up-to-date issues of official publications of Commonwealth universities, which are available in the office for reference by inquirers. During the year the Association acted in connexion with 408 appointments in member universities outside the United Kingdom, compared with 394 in 1955–56, and handled 2,871 inquiries in relation to specific vacancies, compared with 2,962 in 1955–56. A list of posts in respect of which the Association was requested to take action is included. The Association has also assisted in the administration of the Marshall Scholarships, the Beaverbrook Scholarships, the Commonwealth University Interchange and in the award of British Memorial Scholarships for study in Australia and Imperial Relations Trust Fellowships.

European Interchange Scheme for Postgraduate Students

The Department of Scientific and Industrial Research is encouraging the interchange of research students between the United Kingdom and certain European countries, and has set aside a number of its research studentships for this purpose. Those awarded such studentships for study in Europe will receive maintenance allowances, second-class rail fare and fees; in addition, a cost-of-living allowance will be paid for certain countries. The award is tax-free. The duration of the award, and other conditions, are the same as those for ordinary Department of Scientific and Industrial Research studentships. Applications for these awards must be made through heads of departments of science and technology in universities and colleges before July 1.

Grants to Students

The National Union of Students has published a Grants Year Book (pp. 107. London: National Union of Students, 1958. 3*s*.) giving details of awards to students by nearly all the local education authorities of Great Britain. Besides information about the scale of awards, allowances for vacations and dependants, the book also provides details of how awards are made, the policies of local education authorities to students who fail examinations and other relevant items. A copy of the Ministry of Education Regulations for State Scholarships is also included; this sets out the income scale for assessing parental contributions. The book should be of practical value to all students and their parents or guardians.

The Salters' Institute of Industrial Chemistry

The Worshipful Company of Salters, through its Institute of Industrial Chemistry, has since the foundation of the Institute in 1918 devoted its resources mainly to the award of postgraduate research grants. Ninety-eight research students have been awarded fellowships and most of them have had distinguished careers in industry and the universities. In 1951 the award of a research scholarship was instituted, and twenty-eight students have since been elected, including three to scholarships reserved for students from the Commonwealth. A considerable number of smaller grants have also been awarded each year to part-time students of chemistry in London, and many of the chemical engineering departments of universities throughout Britain have received substantial grants for the purchase of equipment or similar purposes. Arrangements have now been made with the Royal Institution for the Company to sponsor lectures to school-children in some of the interesting branches of chemistry, on the lines of the lectures on physics which have been given there with such success in recent years. The Institute has also decided to make grants to headmasters of selected public schools from which Salters' Exhibitions may be awarded to able boys who might otherwise be unable to complete a scientific education. By these new developments, the Institute hopes that the study of science in schools may be enlivened and encouraged and that indirectly the flow of scientists of high calibre to the universities and eventually to industry and other fields may be increased.

Royal Netherlands Geographical Society : Honorary Members

The following have been elected to honorary membership of the Royal Netherlands Geographical Society: Prof. J. Büdel, University of Würzberg, distinguished for his researches on peri-glacial phenomena and on the morphology of the humid tropics; Prof. H. C. Darby, University of London, author of "A Historical Geography of England" and "Medieval Fenland and the Draining of the Fens"; G. J. A. Mulder, Netherlands, author of various text-books on geography including "Geography of the Mediterranean Region" and editor-in-chief of the "Manual of Geography of the Netherlands".

The Manchester Literary and Philosophical Society: Officers

At the recent annual general meeting of the Manchester Literary and Philosophical Society the following officers were elected: *President*, Mr. C. E. Young; *Vice-Presidents*, Miss A. C. Alexander, Mr. A. H. Goulty, Sir Geoffrey Jefferson, Dr. F. C. Toy; *Hon. Secretaries*, Dr. G. T. Ashley, Dr. L. Cohen; *Hon. Treasurer*, Mr. H. Hayhurst; *Hon. Librarians*, Mr. L. L. Ardern, Dr. W. H. Brindley; *Hon. Curator*, Mr. N. G. C. Pearson.

The Night Sky in July

Full moon occurs on July 1d. 06h. 04m. U.T., new moon on July 16d. 18h. 33m. and full moon on July 30d. 16h. 47m. The following conjunctions with the Moon take place: July 9d. 15h., Mars 3° S.; July 14d. 06h., Venus 3° N.; July 23d. 04h., Jupiter 2° N.; July 27d. 03h., Saturn 3° S. In addition to these conjunctions with the Moon, Mercury is in conjunction with Pollux on July 1d. 11h., Mercury being 4·9° S., Venus with Aldebaran on July 5d. 06h., Venus being 4·0° N., and Mercury with Regulus on July 26d. 05h., Mercury being 1·6° S. Mercury is an evening star, setting about an hour after the Sun, but conditions are not favourable for observation. Venus is a morning star, visible low in the south-east before sunrise. It rises at 1h. 55m., 1h. 50m. and 2h. 10m. on July 1, 15 and 31, respectively; its stellar magnitude is −3·3. During the month its distance from the Earth increases from 120 to 137 million miles and the visible portion of the apparent disk from 0·812 to 0·890. Mars rises at 0h. 10m., 23h. 30m. and 22h. 50m. at the beginning, middle and end of the month, respectively; conditions for observation are rapidly becoming more favourable. Its stellar magnitude increases during the month from +0·3 to −0·1, its distance from the Earth decreasing from 101 to 86 million miles. Mars continues to move eastwards among the stars, passing from Pisces to Aries on July 26. Jupiter sets at 0h. 10m., 23h. 15m. and 22h. 10m. on July 1, 15 and 31, respectively; it is near Spica. The stellar magnitude of Jupiter is −1·6, its distance from the Earth on July 15 being 500 million miles. Saturn sets at 2h. 45m., 1h. 45m. and 0h. 35m. at the beginning, middle and end of the month, respectively; it is near θ Ophiuchi. It has a stellar magnitude of +0·4 and a distance of 850 million miles from the Earth on July 15. There is one occultation of a star brighter than magnitude 6 visible at Greenwich: July 24d. 21h. 05·8m., ν Lib. (disappearance). The Earth is at aphelion on July 5, its distance from the Sun being 94·6 million miles.

Announcements

The British Overseas Mining Association Educational Trust has been established by the Association to provide scholarships tenable at mining schools and universities in the United Kingdom for courses in mining engineering and related subjects. Further information can be obtained from the Secretary of the Association, 8 Great Winchester Street, London, E.C.2.

The Oliver Memorial Fund is offering an award of £50 to a British subject for original work or services in connexion with the research, organization or donor aspects of blood transfusion. Applications or information on possible candidates for the award should be sent to the honorary secretary, Mrs. F. E. Bedborough, 105 New Park Avenue, London, N.13.

The thirteenth annual exhibition and convention organized by the Northern Division of the Institution of Electronics will be held at the Manchester College of Science and Technology during July 10–16 (excluding Sunday, July 13). It will include the largest British display of electronic devices held outside London.

A one-day meeting of the Polarographic Society will be held at Ardeer, Ayrshire, on September 26, by kind permission of Imperial Chemical Industries, Ltd. Further information can be obtained from Mr. A. F. Williams, Research Department, Imperial Chemical Industries, Ltd., Nobel Division, Stevenston, Ayrshire.

A conference on Mass Spectrometry is being organized by the Mass Spectrometry Panel of the Institute of Petroleum Hydrocarbon Research Group and Committee *E*-14 of the American Society for Testing Materials. It will be held in the Beveridge Hall, Senate House, University of London, Gower Street, London, W.C.1, during September 24–26. Further information can be obtained from Dr. R. R. Gordon, National Coal Board, Coal Research Establishment, Stoke Orchard, Cheltenham, Gloucestershire.

The seventh Conference on Hot Laboratories and Equipment is to be held in Cleveland, Ohio, during April 1959. Abstracts of papers to be presented at the Conference should be sent to the programme chairman, L. G. Stang, jun., Brookhaven National Laboratory, Upton, New York, before September 15. Papers are invited on all phases of hot laboratories and equipment for handling radioactive material, including design, construction, operation, maintenance, decontamination, remodelling, shielding calculations, costs, etc.

Erratum. In the communication entitled "Passage of Phosphate through the Human Tooth", by Dr. P. Pincus, in *Nature* of March 22, p. 844, paragraphs 5 and 6, for "inorganic phosphate" and "inorganic form" read "organic phosphate" and "organic form".

INDUSTRIAL PSYCHOLOGY

AN outline of the history and work of the Medical Research Council's Industrial Psychology Research Group, since its origin (under another name) in 1918, has recently been provided by R. Marriott, assistant director of the Group (*Occupational Psychology*, 32, No. 1; January 1958).

Between 1918 and 1947 more than a hundred reports and many papers were published. Broadly speaking, the wide range of subjects covered could be classified under the general headings of environmental conditions (lighting, vision, heating and ventilation), the effect of industrial solvents, industrial disease, sickness and absence, hours of work, repetitive work, human relations, vocational psychology, time and motion study, accidents, skill and machine design.

After the Second World War it was decided to bring the existing teams into line with other units or groups of the Medical Research Council by making them self-contained and directly responsible to the Council for their activities. Two of these teams had been mainly responsible for most of the psychological investigations. One, the Applied Psychology Unit at Cambridge, had done much work on accidents, environmental conditions, skill and machine design. The other team, under the direction of Dr. S. Wyatt, had been mostly concerned with such problems as absence from work, motivation and incentives, interest and boredom in work, and satisfaction and discontent in the working situation. This team became the Industrial Psychology Research Group with Dr. Wyatt as its first director. In 1952 the Group was transferred to University College, London, under the honorary direction of Prof. R. W. Russell and Mr. J. W. Whitfield, of the Department of Psychology.

During 1946–52 the Group's two teams, with from four to six investigators in each, were mostly occupied with comparative studies of the nature, extent and causes of satisfaction and discontent in various types of large industrial organizations. The published papers show, for example, clear-cut relationships between working efficiency and size of group and between satisfaction and size of group. They also demonstrate that workers' satisfaction is correlated with the amount of mechanization in the layout. Thus, those on mechanized layouts are less satisfied and express more boredom than those on non-conveyor-line work; individual workers are the most satisfied and least bored. Satisfaction with earnings was related to family responsibilities, and general satisfaction to various factors such as hours of work, shift systems and management policy.

Since 1953 most of the research done by the Group has been concerned with three general problems—absence in heavy industry, communication within industrial firms, and incentive payment systems. Final reports on these projects have not yet been published, but some papers and abstracts bearing on the investigations are available. The following are brief outlines of the methods used and the main conclusions.

A survey was made of the absences of three thousand men in one engineering and two large iron and steel works. Absence from all causes was compared for such factors as age, family responsibilities, length of service, wages, hours of work and physical conditions.

It was found, in general, that absence was least from men with two dependants and higher for those with fewer or more—the curve was U-shaped; higher paid men lost more time due mainly to sickness but partly to absence without permission; absence was associated with heaviness of work, the trend being more pronounced for short absences and among men on continuous work. Continuous work also appeared to cause more absence among men more than forty-five years of age; on three-shift systems about three-quarters of the absence without permission occurred on the early morning shift, due, it was thought, to the 6 a.m. start.

Three studies were made under the heading of communication in industry, one in the laboratory and two in factories.

The experimental study sought to compare the relative understanding and retention of salient points in a prose passage (uncompressed information) and in a précis of it (compressed information). Pilot studies showed that recall, not recognition, of the material was the most successful method of discriminating between the two kinds of information.

Studies in four engineering firms were made, by interviews, observation and the analysis of records, of the differences in formal communication structures in planning and production control, and in particular of their effects on the estimating of delivery dates to customer firms. Differences between the firms in these respects were mainly in the degree of integration between planning and control. On this depends the adequacy and accuracy of the estimator's knowledge of the results of his decisions. It was found that more accurate estimates were made and greater satisfaction was expressed where there was unity of planning and control; the opposite was true where these two functions were divided.

Another inquiry showed that, in general, delivery time was twice as long as the time allowed for production; only 2 per cent of the orders took less than the expected time; 80 per cent of the delay occurred during normal production and 20 per cent in rectification work. The 80 per cent normal production delay was analysed as 9 per cent in supplying materials, 9 per cent in routing between departments, 30 per cent in a capacity block in one department, 15 per cent in the planning and pre-production departments and 17 per cent in other production departments.

Though the analysis of the results is still incomplete, it can be stated tentatively that production control failure, not technical breakdown, was mainly responsible for the total delay.

Recent research into incentive payment systems has taken the form of four separate studies which, although conceived as parts of the whole, were carried out to a large extent independently of each other, as well as a review of research and opinion on incentive payment systems.

Two of these studies were general field surveys relating to workers' understanding of incentive payment systems and to the aims associated with the introduction of such systems. The other two studies concerned the effects of changes in incentive payment systems in a factory and a repair works. All the studies showed the importance of considering the total factory situation, the relevance of the incentive payment system to the nature and organization of the work, and the social effects produced by these systems.

Satisfaction with a system appeared to be related to the understanding of it, and this depended on the workers' ability to explain it to themselves.

In the two studies of changes in payment systems it was found that improved morale and satisfaction followed the change, but it was not possible to attribute this to the alteration alone. There was evidence that improved output may accompany increased satisfaction, but different performances by comparable working groups were attributed more to the size and stability of the groups. Social conflicts arose in group systems if there was equal regard for unequal effort.

In addition to these investigations, essential incidental studies have been carried out on methodological problems in order to facilitate work in this field. Among these are a study of the dangers of using crude absence-rates available in industry; examinations of the use of linear and verbal self-assessment scales in the assessment of attitude; consideration of possible extensions of the paired comparison technique in measurement of opinion and in measurement of agreement of opinion; a study of the different methods of measuring understanding and remembering of verbal material and the development of rank correlation methods.

Papers have also been published on accidents in industry, and on the effects on skill and performance of machine design, environment and technological change.

CONTACT STRESSES

So many engineering devices, such as toothed gears, rolling bearings and the wheel itself, operate by the transmission of large forces between surfaces in contact over a relatively small area that a knowledge of the local stresses set up in the region of such contacts is obviously of wide interest. Yet the symposium, organized by the Stress Analysis Group and held at the Institute of Physics on May 14, appears to have been the first in Britain to be devoted specifically to the topic of "Contact Stresses". An explanation for the neglect of the subject probably lies in the mathematical difficulties involved in obtaining a theoretical solution to even the simplest problem in contact stress. Apart from the inspired, and now classical, theory of elastic contact presented by Hertz in 1881, there have been until recently very few contributions to the theoretical structure of the subject so beloved of academic investigators. In consequence, the engineering designer has been obliged to develop his own empirical rules and to conduct his own comparative tests to avoid the undesirable consequences of excessive contact stresses: pitting, scuffing, fretting or simple wear.

The past few years, however, have seen considerable advances in the theory of contact stresses. A number of solutions have been found, arising, as so often is the case, from investigations in other fields, to the problem of contact of both ideally elastic and ideally plastic solids under the action of various systems of forces. The basis for more fundamental and revealing studies of the mechanism of surface breakdown under contact loads appears to have been laid, and it is likely that more satisfactory explanations of pitting and other surface failures are not too remote. Even the study of metallic friction and wear, which has attracted scientific work of high quality over a number of years, has benefited from recent theoretical studies.

The present symposium gave encouraging evidence of this trend. The extent to which the problems are common ones was striking. Speakers whose papers arose from interests as diverse as railways, toothed gearing, ball-bearings and rubber tyres described phenomena which were basically similar and to which the academic contributions were relevant.

Contact-stress problems can be divided broadly into two categories, one of contact between surfaces having no relative movement, and the other to include contact between rolling or sliding solids. The first session was devoted to stationary contact, and naturally the papers were concerned with various extensions to the Hertz problem of two ideally elastic bodies under the action of a purely normal force. Mr. C. Storey (Constructors—John Brown, Ltd., Leatherhead) recalled Hertz's assumption that the undeformed profile of the solids in contact could be taken to be parabolic, and showed how the theory could be improved for spherical surfaces. The correction appears to be significant only where there is close conformity between the surfaces, as for a ball-ended pivot in a spherical seating.

Perhaps the most valuable recent contribution to elastic contact theory is due to Mindlin[1] and his associates, who have found the surface tractions and displacements at a contact where a tangential force and a twisting couple are applied in addition to a normal force. They have shown that in consequence some slip is inevitable at a periphery of the contact area. Explicit calculations of the internal stresses in these circumstances have not been made, so that the experimental work of Mr. E. Ollerton (Nottingham) is particularly valuable. He described a photoelastic investigation of the contact stress-field under the action of a normal and tangential force (less than the limiting friction force). The observations with a two-dimensional model as the tangential force approached its limiting value were shown to compare favourably with the theoretical analysis of Poritsky[2]. With smaller tangential forces and also with a three-dimensional model, an attempt was made to deduce the surface stresses to compare with Mindlin's theory, but at the present stage of development of the technique the comparison is rather inconclusive.

The work of Bowden and Tabor[3] on metallic friction has shown that the intimate contact of metal surfaces is to a large extent a plastic phenomenon. In the most lightly loaded contacts the surface asperities are crushed plastically so that the subsequent application of a tangential force, however small, must cause further plastic flow. Dr. D. Tabor

(Cambridge) discussed this process, referring to the experiments on adhesion carried out by McFarlane and Tabor[4] and to the measurements of initial tangential displacement by Courtney-Pratt and Eisner[5]. In both these investigations the behaviour of a single asperity was simulated by using small, heavily loaded contacts in soft metals so that their real and apparent areas of contact coincided. The application of a tangential force to a contact already stressed to the yield pressure in compression causes an immediate increase in the area of real contact. The predominant plastic deformation, therefore, initially brings the surfaces closer together, while the tangential displacements are of an elastic order of magnitude, as their agreement with Mindlin's elastic theory shows. As the tangential force is increased, the contact undergoes large, irreversible, plastic deformation in the tangential direction until, at a point determined by the cleanliness of the surfaces, the junction breaks, and complete sliding occurs. In the context of a meeting on contact stresses it is relevant to ask how the essentially plastic behaviour of individual surface asperities can be related to the overall properties of a contact in which the forces are transmitted through a large number of asperities, while the main body of the material is stressed within its elastic limit—the usual situation found in engineering practice. Is an elastic theory of any value? The experiments of Johnson[6] suggest that the deformation of the contact as a whole can be predicted very closely by an elastic theory. The explanation seems to lie in the fact that if contact is maintained through a large number of junctions their tangential plastic deformation is 'controlled' (in the sense used in plasticity theory) by the strains in the hinterland which remain elastic. Thus two solids first pressed into apparently elastic contact and then sheared undergo normal and tangential displacements given by Mindlin's theory. Over the central area of contact, where the normal pressure is high and the tangential tractions low, the solids are locked together. Towards the edges of the contact area, where Mindlin predicted slip, the asperities may be expected to shear plastically in the manner of Courtney-Pratt's model, through a displacement sufficient (yet no more than sufficient) to relieve otherwise infinite elastic stresses in the body of the material.

The second session was devoted to papers on rolling contact. Experimental investigations of the tangential stresses and relative movements at the contact surface of a rolling pneumatic tyre were reviewed by Mr. V. E. Gough (Dunlop Rubber Co., Ltd., Birmingham). The importance of tangential surface stresses was emphasized since these provide both the driving force and also the controlling forces of a wheeled vehicle. The amount of slip between the tyre and the ground determines the wear-life of the tyre. It was shown that the area of contact is divided into two regions: a forward region where there is no relative movement with the ground, and a region at the sides and trailing edge of the contact area where slip occurs. If the plane of the wheel is inclined at an angle to the direction of rolling, which would arise from the side-slip when rounding a corner, the tangential tractions at the contact surface provide a transverse 'cornering' force. In addition, due to the fact that the slip occurs at the rear of the contact area, this force exerts a self-aligning torque tending to rotate the plane of the wheel into the direction of rolling. Measurements of the cornering force and self-aligning torque as a function of the slip (or yaw) angle show that these quantities increase in proportion to the slip for small angles to a maximum value, after which they decrease gradually. The maximum value corresponds to the transition from partial slip to complete sliding of the tyre on the ground.

The similarity in behaviour of a rolling tyre and a rolling solid is striking. In a later paper, Dr. K. L. Johnson (Cambridge) showed pictures of the contact area of a solid rubber ball rolling on a 'Perspex' sheet. The patterns of slip are almost identical: slip begins at the sides and trailing edge and spreads forwards as the tangential tractions are increased. Experiments with steel balls rolling on steel tracks exhibit similar relationships between the slip motion, or 'creep' as it is frequently called, and the tangential forces and twisting moments. Conditions similar to those obtaining in the case of a tyre rounding a corner occur in angular-contact ball-bearings, where, due to rolling around a curved track, the balls have an angular velocity of 'spin' relative to the races on which they roll, and tangential forces are brought into play by virtue of the 'creep' motion. It follows that in such a bearing the steady-state rolling path of the balls lies between surfaces of the races which are not parallel at the two points of contact, a result which is contrary to the usual assumption in ball-bearing design.

Messrs. A. A. Milne and A. M. Nicholson (Mechanical Engineering Research Laboratory, Glasgow) and also Dr. A. W. Crook (Associated Electrical Industries, Ltd., Aldermaston) were indirectly interested in the life of rolling contacts—the former in rolling bearings and the latter in toothed gears—so that their papers dealt with the breakdown of the rolling surfaces under the continuous application of heavy loads. Milne and Nicholson described some experiments using a modified four-ball machine[7] in which a single rotating ball rolls on three others. The kinematics of the motion were analysed and it was shown that there is a large angular velocity of spin between the rotating and the rolling balls, in consequence of which slip occurs at the sides of the contact area. The majority of the pitting cracks are observed at the edges of the rolling track and on the slower moving surface. The conclusion that, where rolling is accompanied by sliding or even local slip, pitting is more likely to affect the slower moving surface now seems to be fairly well established. As Mr. Milne observed, the cycle of stress experienced by the slower moving surface is one of tension followed by compression, which is consistent with the theory of crack propagation by trapped lubricant proposed by Way[8].

The paper by Dr. Crook suggested that another significant mechanism might be involved. Experiments on rolling mild steel disks under loads sufficiently large to exaggerate the amount of plastic flow were described[9]. He showed that two disks rolling under a purely normal contact force produce plastic shearing of a relatively undeformed surface layer, forward, in the direction of rolling, relative to the main body of the disk. The effect is independent of the presence of a lubricant. Running the disks at different speeds introduces frictional tractions at the contact surfaces, acting in the direction of rolling on the slower surface and opposed to it on the faster one. The effect of these tractions, as might be expected, is to accentuate the plastic flow of the slower surface and restrict or reverse that of the upper surface depending upon the coefficient of friction. In any event, it appears that the slower moving surface experiences much larger plastic deformations than the faster one, which under lighter loads and with less ductile materials would be likely to lead to a shorter fatigue life.

The papers on rolling contact made it clear that stresses and distortions in rolling contact are likely to differ from those in a stationary contact under the same forces. Dr. Johnson explained this difference in terms of the different stress history of a surface element in the two cases. If either slip or plastic flow takes place, a difference in sequence of loading leads to a difference in the overall stress pattern. In particular, it was shown that slip at the contact surface begins at the trailing edge of the contact area and not at the leading edge. A method of approach to the theoretical problems of rolling contact was suggested in which the process is viewed as one of 'steady-flow' in the manner of hydrodynamics. This involves using the Eulerian co-ordinate system[10] in which the contact region appears as a stationary pattern of elastic distortion through which the material of both surfaces flows at a steady rate.

Taken as a whole, the symposium gave a valuable co-ordinated view of the present state of research into contact problems in Britain. K. L. JOHNSON

PAPERS PRESENTED AT THE SYMPOSIUM

Andrews, H. I., "Contact Stresses on Railways and Wheel and Rail Problems".

Ollerton, E., "Contact Stresses between Toroids under Radial and Tangential Loads".

Tabor, D., "Effect of Tangential Stresses on Plastically Loaded Contacts".

Storey, C., "Point Contact Effects—the Relevance of Hertz's Theory".

Gough, V. E., "Tyre to Ground Contact Stresses".

Milne, A. A., and Nicholson, A. M., "Pitting Failure—Some Studies in the Modified Four-ball Machine".

Crook, A. W., "Some Experiments upon Sub-surface Deformation in a Disk Machine".

Johnson, K. L., "The Rolling Contact of Elastic Solids viewed as a Steady-flow Process".

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THE METROPOLITAN-VICKERS IRRADIATION LABORATORY

THE opening on May 29 of the new Irradiation Laboratory at the Metropolitan-Vickers Barton works was performed by Mr. H. West, director of electrical engineering in the Company. In a short address he reminded his audience that the scientific and engineering contributions made by Metropolitan-Vickers to the development of high-vacuum equipment and particle accelerators have been prominent in keeping Britain to the forefront in this field. An inspection of the new laboratory certainly gave strong support to his claim.

The principal item of equipment in the laboratory is the 4-MeV. linear accelerator, which produces the beam of irradiating electrons. There is nothing fundamentally new about this unit; it has been adapted from the accelerator developed by the Company for its 4-MeV. X-ray machines which are already installed in several hospitals in Britain. The electrons, bunched together into small clusters and travelling in a hollow 'corrugated' wave-guide, are accelerated by a radio-frequency field which is produced by the propagation of radio-frequency power of short wave-length (usually 10 cm.) along the wave-guide. The design of the wave-guide is such that the velocity of propagation of the radio-frequency field matches that of the accelerating electrons, so maintaining the phase relationship between field and beam and ensuring the continuous acceleration of the electrons along the whole length of the wave-guide. A radio-frequency feedback system is used to increase the energy of the beam, which is released in pulses of 2 μsec. duration at a rate of between 50 and 500 pulses per sec. The power of the beam is of the order of 500 watts, corresponding to a mean beam current of 125 μamp. At the output end of the accelerator an alternating field fans out the electrons so that they scan an area of 12 in. × ¾ in. as they emerge from an aluminium foil window.

The construction of the laboratory itself leaves nothing to chance in the matter of safety. A system of interlocked doors ensures that access to the treatment room (surrounded by massive concrete walls with 4-in. steel plates at strategic locations) or to the accelerator room automatically renders the apparatus harmless. All the control equipment is centralized and is well clear of any radiation or high-voltage hazard. Articles to be irradiated may be mounted either on a variable-speed continuous conveyor belt or a specially designed work-table, both of which are operated by remote control.

The property which makes irradiation a useful process is the disruption which it causes, particularly in large molecules. When biological systems are irradiated, three types of change may occur. Slight irradiation will lead to no obvious damage to the organism, but through the agency of gene mutation may promote the evolution of new genetic types. This offers the interesting possibility that, by exposing quantities of seed to radiation, the probability of producing mutations and of occasionally finding some improved plant strain may be greatly increased. Greater doses of radiation may render sterile the irradiated organism. A suggested application of this property is the improvement of the storage properties of some vegetables, such as potatoes, by preventing them from sprouting.

However, the most fascinating possibilities seem to arise from the utilization of the lethal effects of very large doses of radiation as a bacteriocide. Foodstuffs which normally deteriorate through bacterial infection have their keeping properties much improved by irradiation; unfortunately, the dosage required to exterminate the bacteria sometimes renders the food unpalatable, a difficulty which has still to be overcome. An even more attractive application is in the sterilization of certain types of pharmaceutical products; due to chemical instability or unfavourable physical properties, it may not be possible to use the usual high-temperature methods of sterilization, and irradiation may be used with a temperature rise of a few degrees only. In addition, the product may often be treated in its finally packaged state, ready for distribution.

The irradiation of polymeric substances frequently results in useful changes of their properties. These changes may be roughly classified into two types. In the first of these C—H bonds are ruptured to give a hydrogen atom and a free polymer radical. Two radicals combine to give a larger molecule, a process known as cross-linking, and a molecule of hydrogen is liberated. If the irradiation dosage is large, so many cross-linkages may be formed that the whole specimen becomes virtually a single huge molecule which is extremely inert chemically and insoluble in most solvents. The other type of change which may occur is known as degradation. The polymer is broken down into simpler hydrocarbons, some of which are gaseous and held in the substance under high pressure. Subsequent heating of the polymer softens it and allows this gas to expand, thus producing a foamed material the low density and other characteristic properties of which have found useful applications.

The new laboratory has been set up by Metropolitan-Vickers to provide an irradiation service for other industrial firms and organizations. In doing so the Company has demonstrated a degree of initiative which one hopes will be matched by its potential customers. It is pleasant to witness an industrial enterprise which is not content merely to keep abreast of current scientific advance but which also itself makes a noteworthy contribution to scientific progress.

THE PROGRESS OF WORLD HEALTH

On April 7 the World Health Organization marked its tenth anniversary by sponsoring the celebration, on that date, of a World Health Day in London. As its director-general, Dr. M. G. Candau, said, there have been, during the past ten years, great scientific advances—new drugs, new vaccines, new and better insecticides, more effective methods of fighting or preventing disease. Governments have learnt to take responsibility for the health of their peoples and to provide not only hospitals and health institutions, but also better food and better care for mothers and the young; and eighty-eight countries are now members of the World Health Organization.

How much has been achieved was outlined by Dr. H. van Zile Hyde, chief of the United States Division of International Health. Infectious disease has handicapped man throughout his history. History has, in fact, often been changed by diseases such as typhus, influenza, plague and malaria. But in limited areas of the world in which it has been possible to apply the knowledge acquired by medical science, the epidemics of the past—cholera, smallpox, plague and yellow fever—are no longer feared. Malaria, prevalent in regions in which three-fourths of mankind live, has been conquered to such an extent that whereas, in 1948, 300 million people had malaria each year and 3 million died of it, these figures have to-day been cut by 30 per cent. This disease is still one of the most formidable menaces, but its eradication, already achieved in certain areas, is now possible almost everywhere in the world. It is likely that it will, in a few years, be controlled in the United States, and no new infections with it are expected in the U.S.S.R. after 1960. In the eastern Mediterranean, a traditional reservoir of the disease, great progress in its control has been made. The most serious problem is presented by Africa south of the Sahara, but here also much has been achieved.

The list of other scourges controlled is long and encouraging. Respiratory diseases, such as pneumonia, the common cold and influenza, still flourish; but whooping cough, though it still resists, is in retreat. The international spread of epidemic diseases, formerly controlled by quarantine regulations which imposed great hardships and delays in travel and commerce, is now reduced, in spite of increased possibilities of spread of these diseases by the aeroplane, to the relatively easy conditions of the International Sanitary Regulations designed by the World Health Organization and adopted in 1951.

Many diseases formerly feared, such as cholera, typhus, smallpox, yellow fever, tuberculosis, and those menaces of childhood, scarlet fever, measles and diphtheria, are now virtually under control and, if they occur and are properly handled, they rarely kill. The decline of mortality is, in fact, one of the most significant features of the health record of the world, but it creates new problems that are serious. More elderly people must be fed and housed and given work; the diseases of later life, such as cancer, diabetes and heart disease, are commoner. The stress of modern life is also taking its toll, and great quantities of drugs are manufactured to counter this stress. Whereas infectious and parasitic diseases have been reduced by half, accidents, especially among the young, are leading causes of death. For the very young, on the other hand, and for the mothers who bear them, there is much greater chance of health and happy life.

Thus people born nowadays may expect, apart from accidents, a safer, longer and happier life than earlier generations could. They owe this, of course, primarily to the work of men and women of all nations who have provided the knowledge on which this remarkable progress has been based, and also to the work of the World Health Organization and kindred organizations which have integrated and correlated the work done by individuals and teams in various parts of the world. A major problem of the future would seem to be the diseases of later life, such as cancer, diabetes and arteriosclerosis. If so much has been done in a decade, there is every hope that these diseases also will soon be added to the list of scourges that man has overcome.

G. Lapage

EAST AFRICAN VIRUS RESEARCH INSTITUTE

THE annual report* of the East African Virus Research Institute, Entebbe, for 1956–57, which includes a list of papers published during the year and a list of scientific and technical staff as at June 30, 1957, records that the mechanism of transmission and maintenance in Nature of the arthropod-borne viruses continue to be the main interest of the Institute. A systematic programme was commenced to identify the viruses concerned in the causation of fever in man in Uganda. Rabies were recorded in the Entebbe area for the first time and the Institute was largely responsible for identifying the agent. Studies on *Arvicanthis abyssinicus*, a common rodent in Uganda, indicated that it may be important as a host in maintaining Rift Valley fever virus in Nature. Two strains of Zika virus were isolated from *Aedes africanus* mosquitoes collected in forest near Entebbe.

Much attention continued to be given to yellow fever. Some modifications were made in yellow fever neutralization test methods. A more detailed analysis of the sera collected in Northern Rhodesia in 1950–52 indicates that in the four districts mainly involved both sexes are exposed to infection, but rates are generally higher in males than in females; in males infection-rates generally increase with age. In several tribes or localities this is true of females only up to about twenty-four years of age. Twenty-five monkey sera from Tanganyika were all non-immune, but five immune individuals were found among thirteen Brazza's monkeys (*Cercopithecus neglectus*), and laboratory studies indicated that this monkey was likely to be an efficient host for yellow fever virus in Nature. No antibody could be detected in the study of the hæmagglutination inhibition antibody reaction of a bush-baby (*Galago crassicaudatus*) on infection with yellow fever virus.

In the entomological field most attention has been devoted to mosquitoes, especially *Aedes* (*Stegomyia*) spp. The intermittent trap for sampling insects attracted to live bait continued to give encouraging results. Studies are reported of the oviposition cycle in *Aedes aegypti*, *A. africanus* and *Taeniorhynchus fuscopennatus* and of the hormonal mechanisms involved in the reproductive cycle of mosquitoes. Extensive studies of *Aedes aegypti* both in Entebbe and on the Kenya coast, to determine whether the population of this species is made up of 'races' differing biologically, indicate that man is an important host both in Uganda and on the Kenya coast. The hosts of some other mosquitoes have been determined: *A. simpsoni* feeds mainly on man; *Taeniorhynchus fuscopennatus* feeds mainly on mammals and the other *Taeniorhynchus* spp. attack mainly birds.

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* East Africa High Commission. East African Virus Research Institute Report, July 1956–June 1957. Pp. iv+61. (Nairobi: Government Printer, 1957.) Sh. 5.

ARIZONA METEORITE CRATER

DURING the summer of 1956 the Smithsonian Astrophysical Observatory sent an expedition to investigate the distribution of pieces of meteoritic material that are scattered through the mantle of soil surrounding the Arizona Meteorite Crater, the object being to determine more accurately the mass of the meteorite that made the crater and also the direction of its flight. J. S. Rinehart has now published the results of this survey (*Smithsonian Contributions to Astrophysics*, 2, No. 7: "Distribution of Meteoritic Debris about the Arizona Meteorite Crater". Pp. ii+145–160. Washington, D.C.: Government Printing Office, 1958. 20 cents). Niniger had previously worked on the same subject and had published his results in 1956 with his method for extracting the meteoritic material from the soil surrounding the crater, but Rinehart's method was different. He developed a special magnetic separator consisting basically of a vibrating hopper and a slanted trough down which the soil moves under the combined action of gravity and vibration. Above the trough were suspended three strong 'Alnico' magnets to which the magnetic material flies up and adheres as the soil moves downwards. Many precautions were necessary to secure reliable results and these are described very fully.

Estimates of the total mass of finely divided meteoritic material around the crater suggested that this is about 12,000 tons, but this figure is subject to some uncertainty. It is believed that about one-fourth of this mass may be terrestrial oxygen that combined with the meteoric iron after its encounter with the Earth. In addition, there does not appear to be any way for ascertaining accurately the amount of contaminating material present. After taking into consideration a number of uncertain factors, it is believed that the computed mass of 12,000 tons may have to be reduced by about 10–20 per cent.

It is suggested that the meteorite approached the Earth from a south-westerly direction, and after the collision threw forward large quantities of meteoritic material to the position where it now rests. As no piece more massive than 2,000 lb. has ever been found, while thousands of pieces weighing a few ounces or less have been recovered, it is believed that the meteorite was shattered into fragments when it struck the Earth, melting and evaporation accompanying this disintegration. The results so far provide no indication as to whether a large mass of meteoritic material lies buried in the crater. If we accept the low estimates of 10,000–15,000 tons for the mass needed to form the crater, then no large mass could remain in the crater. If, on the other hand, the estimates of Öpik and of Rostoker are nearer the true value, then the amount of meteoritic debris so far recovered is insignificant, and a large mass may be buried underneath. Dr. F. L. Whipple, in a personal communication to the author, expresses the view that a most reasonable mass is that given recently by Hill and Gilvarry, namely, between 80,000 and 400,000 tons.

MEANING OF DENSITY-DEPENDENCE AND RELATED TERMS IN POPULATION DYNAMICS

ONE of the most familiar concepts of population dynamics is the idea of the regulation of abundance by density-dependent factors, which operate more severely at high density than at low density, per individual of a population. But there has been some variation in the meaning and scope of 'density-dependent' and related terms as used by different authors, and in recent years this tendency has increased. This has led to some confusion, and poses the question how the application of these terms can be stabilized. Varley[1-3] has argued that the meaning and scope of such a term should be determined strictly according to its author's definition, and that on this basis insect parasites, predators and disease organisms should be excluded from the density-dependent category. Discussion of this matter with Prof. Varley has not altered my opinion that it is too late to attempt to make a change so contrary to the intentions of the originator of this term, and to subsequent common usage, but has led to various improvements in the present article.

In order to deal with a number of points which are closely inter-related, it is proposed : (1) to look back to the origins of the terms concerned, then (2) to give a brief account, similar in some respects to that given by Varley[3], of the variations in the use of these terms by various authors, and of a number of synonyms, and finally (3) to discuss various proposals for clarifying the position.

(1) Howard and Fiske[4], discussing the natural control of insects with special reference to defoliating caterpillars, wrote that for natural control, or balance, to exist "it is necessary that among the factors which work together in restricting the multiplication of the species there shall be at least one, if not more, which is what is here termed facultative . . ., and which, by exerting a restraining influence which is relatively more effective when other conditions favour undue increase, serves to prevent it". The chief of such facultative factors was stated to be parasitism, "which in the majority of instances, though not in all, is truly 'facultative' ".

They considered disease as a type of facultative factor which, in their experience, became effective chiefly at a very high level of abundance, and starvation as operating only at the extreme limit. Generally, insects would be controlled at a low level of density "only through parasites and predators, the numerical increase of which is directly affected by the numerical increase of the insect upon which they prey".

Secondly : "A very large proportion of the controlling agencies, such as the destruction wrought by storm, low or high temperature, or other climatic conditions, is to be classed as catastrophic, since they are wholly independent in their activities upon whether the insect which incidentally suffers is rare or abundant. . . . The average percentage of destruction remains the same. . . ."

Thirdly : "Destruction through certain other agencies, notably by birds and other predators, works in a radically different manner . . . it may be considered that they average to destroy a certain gross number of individuals each year, and . . . this destruction . . . would most probably represent a heavier percentage when that insect was scarce than when it was common. In other words, they work in a manner which is the opposite of 'facultative' as here understood."

In short, Howard and Fiske recognized three types of factors : (*a*) 'catastrophic' ; (*b*) 'facultative' and a third type which was later called (*c*) 'inverse'[5]. Later, Thompson[6] divided controlling factors into two classes. One, which he named 'general', was the same as Howard and Fiske's catastrophic type. The other comprised "those *individualized* factors whose destructive capacity depends in some way on the numerical value of the host population" ; this definition takes in two of Howard and Fiske's categories, the facultative and the inverse factors ; it is clear from this paper and from Thompson's later writings[7] that he means chiefly parasites, but he considers that, because of their limited reproductive capacities, they generally act as inverse factors.

It was H. S. Smith[8] who introduced the new terms 'density-independent' and 'density-dependent' for Howard and Fiske's catastrophic and facultative categories. He made the mistake of identifying the facultative or density-dependent class with Thompson's individualized category ; but his designation, "destroying a percentage which increased when the numbers of the host increased", shows that he did not mean to include inverse factors ; indeed, he followed Howard and Fiske in recognizing them as a distinct third category, again citing "many insectivorous birds and mammals" as examples. His examples of density-independent agents included climatic factors, 'intrinsic' mortality, and malnutrition due to unsuitable food. Examples of density-dependent factors were, primarily, entomophagous insects, then certain infectious and contagious diseases, quantity of food and competition for nesting sites or protective niches ; the last-mentioned process, it was suggested, was a medium through which climatic factors could have a density-dependent action.

Thus Smith and Howard and Fiske agreed in designating facultative or density-dependent factors as those having a greater proportionate influence at high than at low population density, and also in regarding insect parasites, or entomophagous insects (Smith), certain pathogens, and food shortage as examples ; Smith added intra-specific competition, and hence (in his view) certain climatic factors. Varley[1-3] has insisted that the definition and the examples are at variance, inasmuch as theoretically constructed parasite-host oscillations show a relationship which, owing to the delayed response of parasite numbers to changes in host numbers, is alternately density-dependent and inverse. It may be added that interactions broadly similar to the theoretical ones have been demonstrated in laboratory experiments and in a fragmentary form in certain field populations, though not in others. Nevertheless, the great majority of writers on the subject have accepted Smith's ideas and terms, presented as they were without formal definition, and have been content to use them in a not too precise way; in particular, most writers have accepted all those insect parasites and predators exerting a regulating influence upon a population as density-dependent factors; whether or not their response to host density might be so delayed as to prevent any consistent and straightforward density-dependence has been little considered.

(2) There have, however, been a number of variations in the application of Smith's terms, and various new terms have been used by authors wishing to avoid confusion. The term 'density-independent' has suffered relatively little misuse. But in his text-book, Odum[9] refers to a type of inverse factor as density-independent, and uses a new term, 'density-proportional', for one type of density-independent factor.

With respect to the term 'density-dependent', a major source of confusion is that some authors have taken it to include inverse factors, which Smith specifically excluded. Allee[10] and Allee *et al.*[11] did this, and then separated 'direct density-dependent' from 'inverse density-dependent' factors. Haldane[12] did likewise, but called these two subdivisions 'negative' and 'positive density-dependent'. Thompson[7] writes that Smith proposed the new term 'density-dependent' for Thompson's individualized category. This, as already noted, was an error on the part of Smith[8]; for, like Howard and Fiske[4], he explicitly separated the inverse type of factor into a separate category.

Milne[13] makes a distinction between 'perfectly' and 'imperfectly' density-dependent factors: "Perfection here means an *exact* linear (or curvilinear) relationship between increasing action of the factor and increasing density of the species". The only perfectly density-dependent factor is said to be competition between members of the population. I do not believe that factors perfectly dependent on density exist except at a high level of abstraction. In Nature, the actions of all factors are presumably variable and inexact.

Varley[1,2], in separating parasites, predators and pathogens from the density-dependent category, called them 'delayed density dependent' factors. Lack[14] has treated this new category as a subdivision of the density-dependent class.

Some synonyms of density-dependent are 'facultative'[4], 'controlling'[15], 'concurrent'[5] and 'density-governing'[16].

'Inverse' factors of various types have been called 'density-disturbing'[16], 'inverse density-dependent'[10,11], and 'positive density-dependent'[12]. Odum[9] refers to one sort of inverse action as an inverse type of density-dependence, and to another sort as density-independent. The terms positive or inverse density-dependent, as we have seen, extend the density-dependent category beyond the limits laid down by its originator.

There is, of course, an important characteristic held in common by density-dependent and inverse factors: the action of both is related to population density, though in opposite senses. Terms (other than density-dependent) which have been used for including both these types of factors together are 'individualized'[6], 'density-related'[5] and 'reactive'[16].

(3) Turning now to the question how to standardize the use of the term density-dependent and reduce the confusion which has beset it in the past, there are three main possibilities:

(*a*) The first is to follow the course advocated by Varley[2,3], and place a strict interpretation on the explanations (scarcely formal definitions) given by Howard and Fiske[4] and by Smith[8]. What the result of this would be depends upon whether or not many insect parasites and predators do in fact maintain an oscillatory relationship, of the type seen in mathematical theories, with the populations of their hosts or prey. If Varley's[2] expectations are correct, parasites and predators would generally be excluded from the density-dependent category of which Smith took them to be the prime exemplars. Besides running counter to the intentions of the originator of the term, this would give density-dependence a far narrower meaning than it has been given throughout the extensive literature in which it has been used over the past two decades. (The only exceptions to this, so far as I am aware, are papers by Varley[1-3].) I believe such a restriction of the scope of this familiar term would be unlikely to find general acceptance, and that after such a long period it would cause a great deal of further confusion if it were adopted.

(*b*) The second possibility is to follow the example of Allee[10], Allee *et al.*[11], and Thompson[7], and take the density-dependent category to include, not only all the types of factors attributed to it by Smith, but also the inverse factors, which he excluded. In support of this course, it may be said that it has been fairly widely favoured, and that it interprets density-dependent in the literal sense of "acting in a way which is dependent on density". But I doubt whether it accords with a majority viewpoint, and am opposed to it because it gives the term density-dependent a quite different scope from that laid down by its originator.

(*c*) The third possibility is to follow the intentions of Smith as closely as possible, by including, along with intraspecific competition and other straightforward density-dependent factors, those parasites, predators and pathogens which respond to changes in host population density in such a way as tends to limit these changes (even if the response is delayed as in the theoretical parasite/host oscillations), and by excluding only those factors the action of which wholly or predominantly maintains an inverse relationship with density, and those which are independent of density. Many writers have explicitly or implicitly adopted a similar interpretation. I suggest that, in so far as the term 'density-dependent' continues in use, this is the way in which it should properly be applied.

Whichever course is followed, one major difficulty is inescapable for the present: there are very few ecological situations which are well enough known for particular biological factors to be placed with confidence in any one of Smith's three categories. Still less can we say in general what proportion of insect parasites and predators act as density-dependent, or inverse, or density-independent factors.

The writer on this subject may often prefer to avoid using the term 'density-dependent'. One alternative is to use Nicholson's term 'density-governing'. Nicholson[16] writes that "its meaning is precisely that of 'density-dependent factor' according to definition (Smith, 1935)", and, like Smith, he puts inverse factors in a separate category (density-disturbing). A possible objection to the term 'density-governing' is the implication that all density-dependent factors have a governing influence upon density, which seems unlikely.

As a means of avoiding the various difficulties associated with the use of 'density-dependent', and at the same time recognizing the special features of the factors Varley[1] called 'delayed density dependent', the following classification may be useful. It sets out some types of relation which the unfavourable action of factors upon a population may bear to the density of that population, the action being measured as an effect upon mortality, the reproductive rate, or the net rate of increase or decrease, and expressed in proportionate terms such as percentage.

(1) 'Directly density-related': showing a positive correlation between adverse action and density.

(2) 'Inversely density-related' (or 'inverse'): showing a negative correlation between adverse action and density.

(3) 'Alternately density-related' (or 'alternating'): where a lagging response to changes in density leads to a regular succession of directly and inversely related phases.

This last category is distinguished from the density-independent (or non-reactive[16]) relationship, where the correlation between action and density would generally vary (in successive short runs of observations) in an irregular manner between positive, zero and negative, with a long-run correlation not differing significantly from zero.

A single factor might fall in different categories in different circumstances, or at different levels of abundance or (as pointed out to me by Dr. R. F. Morris, of Canada) within a single generation as compared with a series of generations.

Upon such questions as what sort of ecological causes may lie behind the correlations observed, which factors may be found to fall in which category under various conditions, and what may be their function in natural control, this classification is deliberately left non-committal.

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[1] Varley, G. C., *J. Anim. Ecol.*, **16**, 139 (1947).
[2] Varley, G. C., Trans. Ninth Int. Congr. Entom., 2, 210 (1953).
[3] Varley, G. C., *J. Ecol.*, **45**, 639 (1957); *J. Anim. Ecol.*, **26**, 251 (1957).
[4] Howard, L. O., and Fiske, W. F., *Bull. U.S. Bur. Ent.*, No. 91 (1911).
[5] Solomon, M. E., *J. Anim. Ecol.*, **18**. 1 (1949).
[6] Thompson, W. R., *Parasitol.*, **20**, 90 (1928).
[7] Thompson, W. R., *Canad. Entom.*, **87**, 264 (1965).
[8] Smith, H. S., *J. Econ. Entom.*, **28**, 873 (1935).
[9] Odum, E. P., "Fundamentals of Ecology" (W. B. Saunders Co., Philadelphia and London, 1953).
[10] Allee, W. C., *Amer. Nat.*, **75**, 473 (1941).
[11] Allee, W. C., Emerson, A. E., Park, O., Park, T., and Schmidt, K. P., "Principles of Animal Ecology" (W. B. Saunders Co., Philadelphia and London, 1949).
[12] Haldane, J. B. S., "New Biology", No. 15, 9 (Penguin Books, Ltd., London, 1953).
[13] Milne, A., *Canad. Entom.*, **89**, 193 (1957).
[14] Lack, D., "The Natural Regulation of Animal Numbers" (Clarendon Press, Oxford, 1954).
[15] Nicholson, A. J., *J. Anim. Ecol.*, **2**, 132 (1933).
[16] Nicholson, A. J., *Austr. J. Zool.*, **2**, 9 (1954).

MR. SOLOMON directs attention to a serious state of affairs which is making the study of population dynamics unnecessarily confusing. While agreeing with his analysis of the past use and misuse of the terms, I think that the reasons for the confusion require closer study, and I also disagree with his recommendations. This disagreement involves the principles on which scientific terminology should be based, and it would be interesting to have the views of workers in other fields of science, where there are comparable difficulties.

Here the issue in question concerns the way in which animal populations are stabilized, and there are at least two quite different models which may be used for explaining such stability, and mortality relationships appropriate to each require different terms if confusion is to be avoided. The first and simplest is that of Verhulst, Pearl and others which considers one species only, and assumes that its relative rate of increase is reduced by rising population density. There is a single population density at which the rate of increase is zero. Whether the population density is initially above or below this it will rapidly approach this equilibrium position. In my opinion a mortality factor which stabilizes a population in this way fits best with Smith's term 'density-dependent'.

The second model is more complex and concerns the interaction between two species, predator and prey, or parasite and host. It has been studied mathematically by Lotka, Volterra and in a special form by Nicholson and Bailey. On this model populations show oscillations, and mortality in the prey or host species does not show a simple relationship to its own population density. Actually, the maximum mortality lags a quarter of a cycle behind the population density. Hence my term 'delayed density-dependent factor' (Varley, 1947). Similarly, the maximum rate of increase of the predator or parasite is a quarter of a cycle after its own population minimum, so that the effect is delayed, being density-dependent for two quarters of the cycle, and inverse for the other two.

From the beginning there has been confusion between these two models. Howard and Fiske's explanation (*l.c.*, p. 107) of their term facultative has been quoted in part by Solomon, but the phrase "when other conditions favour undue increase" is vague; they also say (p. 108) that facultative agencies "effect the destruction of a greater proportionate number of individuals as the insect in question increases in abundance", which is consistent with model one. They did not seem to appreciate that model two was basically different. They realized that parasites and predators had a regulatory influence on populations, and cited them as examples to which their term applied. There is, however, no evidence from studies of parasite behaviour to warrant this citation.

Nicholson (1933) likewise seems to confuse the models. Having given examples of balance of populations of *Tribolium*, etc., *in vitro*, he says (*l.c.*, p. 135) that "for the production of population balance, it is essential that the controlling factor should act more severely against an average individual when the population density is high, and less severely when the population is low". Such a controlling factor clearly agrees only with model one, and the examples he had just considered have often been fitted by the Verhulst–Pearl equation. Nicholson then proceeds to elaborate his theory of population balance by parasites, which is a form of model two. He does not point out that according to his theory the host's mortality due to parasitism reaches its maximum not when host density is maximal, but when it is half-way down to its minimum again. Hence parasites, according to his theory, do not fit his definition of controlling factors which I have quoted. Nor does Nicholson seem to recognize the distinctive nature of model two even in his 1954 paper.

A second cause of confusion, as rightly pointed out by Mr. Solomon, is that certain workers have interpreted the term 'density-dependent' literally, and divorced it from its original restricted definition. This I consider to be deplorable, and contrary to general scientific practice. Thus biologists do not apply the term 'chromosome' to any coloured body.

Thirdly, as seen from Solomon's review, various workers have re-defined and used the term 'density-dependent' in different or even in opposite senses from that originally defined. This raises the question whether scientists should adopt rules for the purpose of conserving the meaning of terms.

Mr. Solomon considers three ways of treating Smith's term 'density-dependent', and favours the last, (*c*), which is to sanction the application of the term to parasites and predators. This puts more weight on Smith's examples than on the definition or explanation of Howard and Fiske to which Smith referred. Further, this course probably involves the rejection of the original definition of the term, and therefore the provision of a new definition. Since Thompson and Nicholson have entirely different ideas about the ways in which parasites react to host population changes, and observations are as yet inadequate to give a clear decision[1], an agreed definition cannot be given at the present time if parasites are to be an example of the term's correct application. Is it not wiser for the present to refer to these animals simply as parasites or predators, and avoid being committed to any particular hypothesis concerning their influence on populations ?

The second solution (*b*) which Solomon rejects would also require a formal change in the definition of the term 'density-dependent'. Although various authors have used the term in senses different from that originally defined, I agree with Solomon that there seems to be no valid reason for following any of them. The consequences of permitting scientific terms to be altered in such a way are serious.

I am convinced that the best course, though Solomon rejects it, is to accept a precise definition of 'density-dependent' in accordance with model one, which I believe to be what the original authors had in mind, and it is in this sense that I have interpreted the term in the papers cited. This, it is true, means that parasites and predators are excluded as examples, but as already stressed, their action probably conforms more to model two. While Solomon claims that to narrow the scope of the term in this way is confusing, I think that distinctive terms are required for mortality relationships in the two models, and that this will help to clarify the issues involved.

Possibly there is a case for rejecting all these old terms simply on the grounds that they have been perverted and inverted by various authors ; but on balance I prefer to use them and to retain their original definitions. I can see little advantage in adopting Solomon's three new terms, although they provide a good logical system, since they are synonyms of terms already in use. If these new terms come to be misused in the future, must they be cast aside in turn ?

I am grateful to Dr. D. Lack for discussing a draft of this reply, and helping to remove some ambiguities.

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[1] Varley, G. C., and Edwards, R. L., *J. Anim. Ecol.*, 26, 469 (1957).

BITING BEHAVIOUR OF MATED AND UNMATED FEMALES OF AN AFRICAN STRAIN OF *AEDES AEGYPTI*

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IN the course of extensive studies on the biting behaviour of an African strain of *Aedes aegypti*, which has been maintained in the Liverpool School of Tropical Medicine since 1938, it was observed that the mated and unmated females behaved differently. Gillett[1-3] has studied the development of the oocytes and the oviposition habits of several African strains of the same species of mosquito and has provided evidence for the presence of an ovarian development hormone and suggested the existence of an ovulation hormone, the production of which appears to be usually dependent on previous mating. While the investigations being undertaken in Liverpool are not directly concerned with a study of these hormones, the experiments described in this preliminary communication may throw some further light on the hormonal control of gonadotrophic activity in the mosquito.

In each of the experiments in which the biting behaviour of fertilized and unfertilized mosquitoes was compared, the adult insects were obtained from the same 'crop' of pupæ so that both populations were exactly comparable. The mosquitoes were kept in organdy cages in an insectary, the temperature of which varied between 75° and 85° F. and the relative humidity between 70 and 82 per cent ; illumination was provided only during the day, by means of neon lamps. Feeding on a sensitized human volunteer was begun on the second day after emergence when a high proportion of the mosquitoes were likely to feed[4], and the flies were afterwards offered a meal on the same volunteer for exactly 5 min. daily.

The results of the experiments, which were carried out in the summer of 1957, showed that the numbers of fertilized mosquitoes which fed decreased markedly in the first few days, the lowest level of feeding corresponding with the onset of the oviposition-cycle. Feeding in the fertilized mosquitoes then showed a cyclical pattern with the intervals corresponding to those of the oviposition-cycle. On the other hand, in the case of the unfertilized mosquitoes, biting was maintained at a high level from the onset of feeding, while the egg output was very low ; in its oviposition habits the Liverpool strain of *A. aegypti* appears to behave similarly to the Newala strain described by Gillett[1]. There was a slight variation in the various experiments carried out, but the basic pattern as illustrated in Fig. 1 was repeated, particularly in the

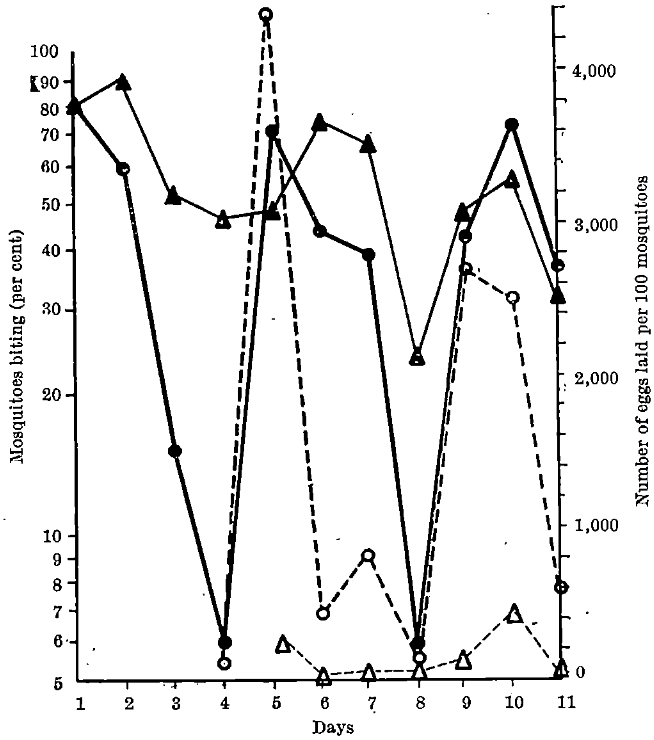

Fig. 1. Graph showing the relationship between the biting and oviposition curves of a group of 52 fertilized *Aedes aegypti* and the relationship between the biting and oviposition curves of a comparable group of 52 unfertilized *A. aegypti*. The biting curves are plotted on semi-logarithmic co-ordinates and the oviposition curves are plotted on arithmetical co-ordinates. The experiments were started on July 2
●, Fertilized biting curve; ▲, unfertilized biting curve; ○, fertilized oviposition curve; △, unfertilized oviposition curve

first few weeks of each experiment. As the populations aged the picture was not quite so clear cut, due to a number of complicating factors, the nature of which will be discussed when a full account of these results is published.

Dissections of a control group of fertilized mosquitoes belonging to the experiment illustrated in Fig. 1 showed that biting fell off sharply after the oocytes had reached the third stage, and that mosquitoes which fed at the late third or fourth stage of oocyte development generally took smaller meals than mosquitoes with oocytes of an earlier age. In a group of 55 fertilized mosquitoes, only 2 out of 23 flies which had fifth-stage oocytes had taken a blood meal and both presented abnormal features; in one individual only the right ovary contained fifth-stage oocytes, while in the other mosquito each ovary contained only a few fifth-stage oocytes. On the other hand, dissections of a comparable control group of unfertilized mosquitoes, carried out on the fifth day, revealed that all the mosquitoes possessed oocytes at the fifth stage of development although biting was proceeding at a high level. These results are of great interest when compared with those of field workers such as Teesdale[5] and Macdonald[6].

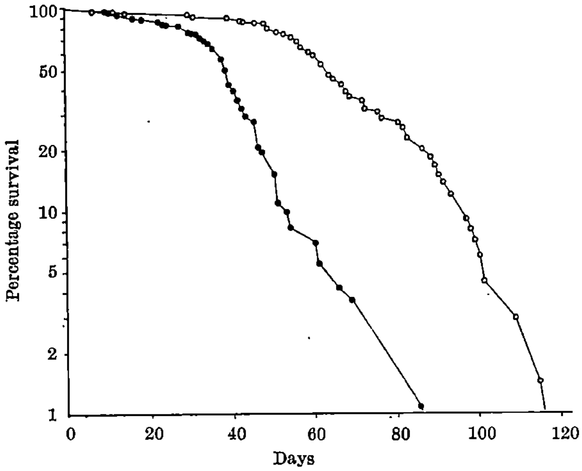

Fig. 2. Survival curves for comparable groups of fertilized ○ and unfertilized ● *Aedes aegypti* which had been offered a blood meal daily, plotted on semi-logarithmic co-ordinates

The explanation of the sharp reduction in the biting activity of the fertilized females, as the oocytes developed, is not clear. It is certainly not due to a pressure effect, since unfertilized females with retained and pigmented eggs, and with an extensive fat body, readily took up blood. It therefore appears probable that avidity for blood is under hormonal control and closely associated with events in the gonadotrophic cycle of the ovipositing mosquito. While it is manifestly dangerous at the present stage of our knowledge to speculate too freely about the mechanisms controlling cyclical feeding, it is tempting to suggest that the production of increasing amounts of ovulation hormone in the gravid fertilized mosquito inhibits the mechanisms by which the mosquito is induced to feed and that this inhibitory effect is very rapidly removed following oviposition. Whatever the final answer to the problem, it probably will not prove to have a simple solution.

Studies on the survival of fertilized and unfertilized populations of *Aedes aegypti* which were offered a blood meal daily showed that the rate of death of unfertilized females was greatly increased when compared to that of fertilized females (Fig. 2). That the increased rate of death of the unfertilized females was not due directly to the effect of feeding but to some factor or factors associated with the retention of the ova was shown by the fact that two curves plotted for unfertilized populations, one of which was offered a blood meal daily and the other every 10 days, coincided almost exactly.

Finally, it should be noted that the term 'biting cycle' is used in this context to describe the type of cyclical biting activity shown in Fig. 1 in accordance with Kleitman's[7] nomenclature. This is not to be confused with the nycthemeral biting curve which is usually referred to as the 'biting cycle' and which appears to be controlled by factors other than those discussed in this paper. While it may be necessary in the future to reconsider carefully the nomenclature of cyclic, rhythmic and periodic phenomena in mosquito biology, it is my feeling that this can only be done profitably when more is known about the mechanisms which control the vital activities of the insect.

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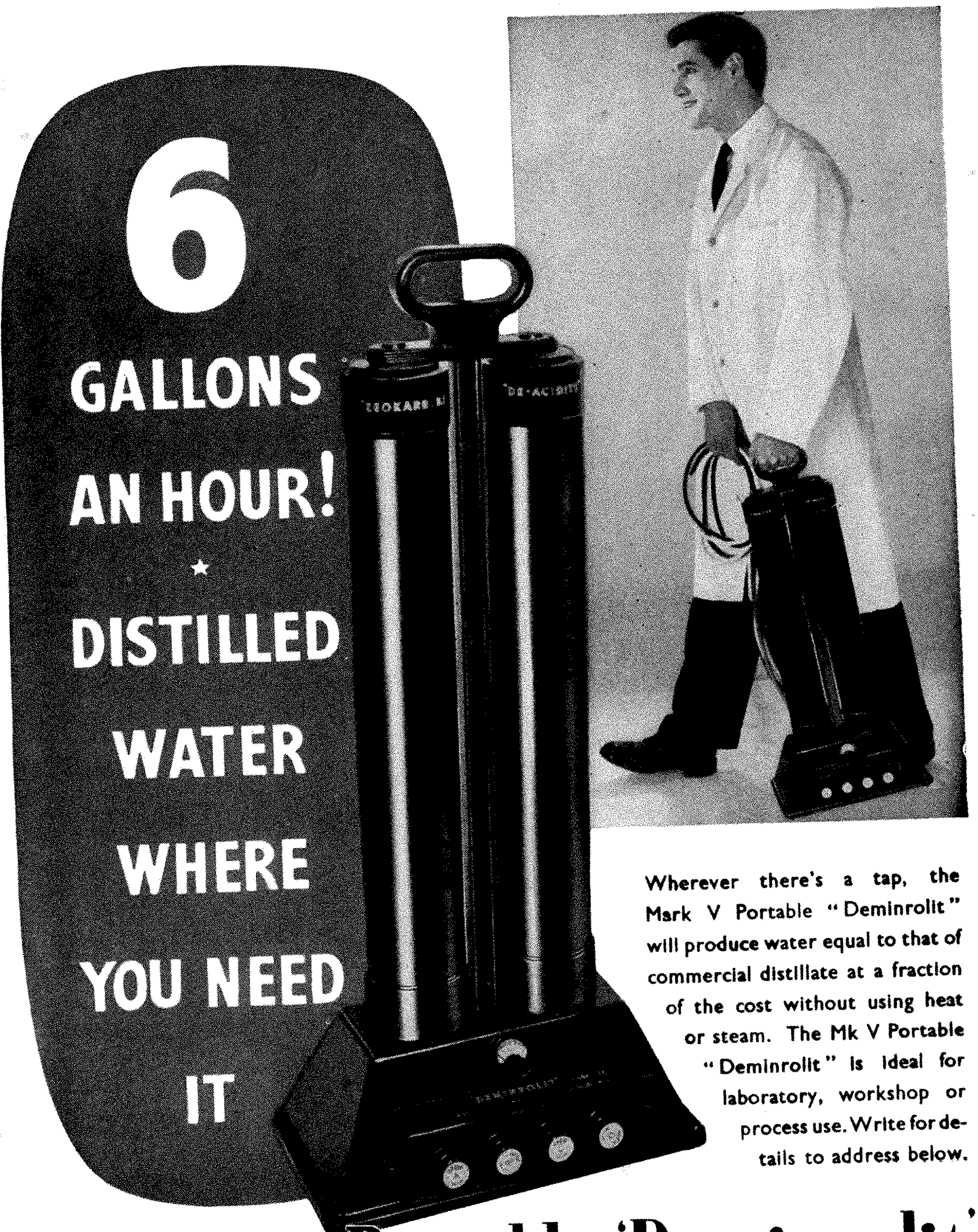

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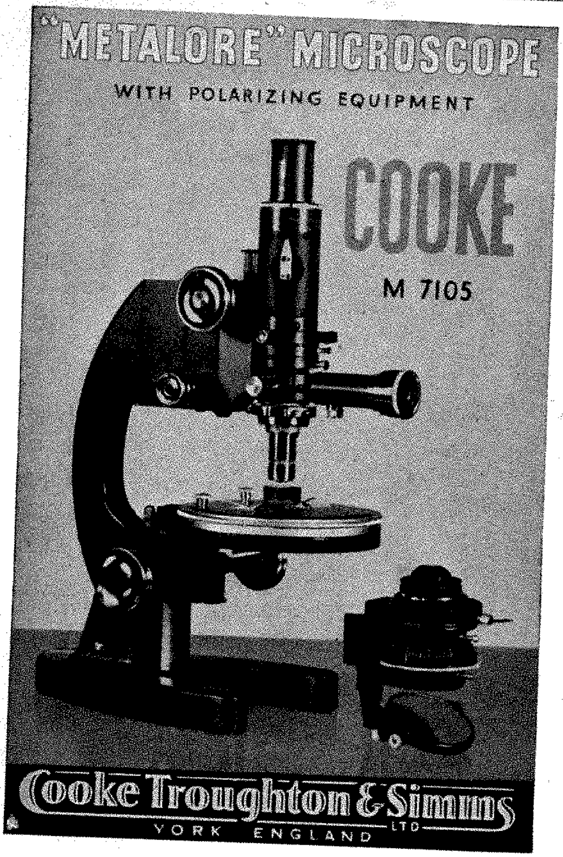

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DEVELOPMENT OF LYSOZYME-RESISTANCE IN *MICROCOCCUS LYSODIEKTICUS* AND ITS ASSOCIATION WITH AN INCREASED O-ACETYL CONTENT OF THE CELL WALL

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FROM a typical lysozyme-sensitive strain of *Micrococcus lysodiekticus*, resistant variants have been obtained by serial subculture on nutrient agar containing increasing amounts of lysozyme[1]. The most resistant of these variants, strain 250, grows on nutrient agar containing 4,000 μgm./ml. lysozyme, whereas the parent strain *L2* (N.C.T.C. 2665) fails to grow on nutrient agar containing 0·1 μgm./ml. of the enzyme. Cell walls prepared from the two strains show marked differences in their sensitivity to lysozyme action as measured either turbidimetrically or by release of N-acetyl hexosamine[2] as shown in Table 1. In this experiment the cells of strain 250 from which the walls were obtained were grown on nutrient agar containing 1 μgm./ml. lysozyme to inhibit the growth of sensitive variants.

Various explanations for the lysozyme-resistance of strain 250 have been sought[1], but particular attention has been given to the possibility of a chemical alteration in the cell wall, since this structure contains the substrate of lysozyme[3]. Analysis of the cell walls of strains *L2* and 250 revealed no major differences in their sugar or amino-acid composition[1]. However, when O-acyl estimations were made by the method of Hestrin[4], a marked difference between the two strains was revealed. The results in Table 1 show that the cell walls of the resistant strain contained more than one-hundred-fold greater content of O-acyl groups than the cell walls of the sensitive strain. Similar differences were also observed with whole cells. Paper chromatography[5,6] has identified the acyl groups as being principally acetyl.

These observations suggested that the lysozyme-resistance of strain 250 might be due to the ability of this organism to acetylate certain cell wall hydroxyl groups, associated with the lysozyme substrate, which in the sensitive strain are free. On the basis of this hypothesis, we have explored the possibility of using chemical procedures to alter artificially the lysozyme-sensitivity of *M. lysodiekticus* cell walls by changing their O-acyl content. Thus we have tried to make the resistant cell walls sensitive again by removing the O-acetyl groups with sodium hydroxide and, conversely, to render the cell walls of the sensitive strain resistant by acetylation with acetic anhydride and pyridine. That these experiments were successful is shown in Table 1.

Table 1. Comparison of O-Acyl Content and Lysozyme-Sensitivity of the Cell Walls of Sensitive (*L2*) and Resistant (250) Strains of *M. lysodiekticus*, and the Effect of Previous Treatment of Cell Walls with (*a*) Sodium Hydroxide, (*b*) Acetic Anhydride and Pyridine

Strain	Treatment	O-Acyl content of cell wall (μM/gm.)	Lysozyme sensitivity*	
			Percentage reduction in O.D.	Glucosamine released (mgm. per cent cell wall)
			After 90 min. at 37°	
L2	None	3	68	3·1
250	None	433	15	0·4
250	NaOH	5	62	2·2
L2	Ac_2O/pyr.†	305	26	0·8

* In lysis tests the lysozyme concentration was 1 μgm./ml. while in estimations of glucosamine release 10 μgm./ml. was used. O.D. estimations were made on the Spekker, using grey filters.

† 80 mgm. cell walls + 20 ml. acetic anhydride + 1 ml. pyridine, 1 hr. at 37°, followed by washing at 0° in *p*H 7 phosphate buffer, first 0·2 *M* (twice), then 0·01 *M* (thrice).

Armour Laboratory crystalline egg-white lysozyme was used throughout this work.

By milder treatment it was possible to make the intact cells of strain 250 sensitive to lysozyme, but without the loss of viability that accompanied treatment with 0·01 *N* sodium hydroxide. For this purpose the cells were incubated 1 hr. at 37° in 0·1 *M* Sørensen phosphate or glycine buffers over the range *p*H 7·0–11·4, after which they were washed repeatedly in 0·01 *M* phosphate buffer *p*H 7·0 at 0°. It was found that although no significant loss of viability occurred up to *p*H 11·4, there was a progressive decrease in O-acetyl content and a corresponding increase in lysozyme sensitivity with increasing *p*H (Table 2). This increased sensitivity to lysis was associated with increased release of N-acetyl glucosamine, which is regarded as a reliable index of breakdown of lysozyme substrate[1]. Subculture of the cells rendered sensitive to lysozyme by treatment at *p*H 11·4 produced colonies the cells of which were once more lysozyme-resistant. It is therefore concluded that strain 250 differed genotypically from strain *L2* in its ability to acetylate cell wall hydroxyl groups. That at least some of these groups are located on the bacterial surface is suggested by the ease with which they can be removed without affecting cell viability. Thus in addition to natural selection, simple chemical treatment can be used to alter the susceptibility of *M. lysodiekticus* to lysozyme, except that the chemically induced changes are not transmitted.

Table 2. Exposure of a Lysozyme-resistant Strain of *M. lysodiekticus* to Alkaline Buffers: Effect on Lysozyme-sensitivity and O-Acyl Content of the Intact Cells

Treatment (*p*H)	Reduction in O-acyl content of cells (per cent)	Lysozyme sensitivity (per cent reduction in O.D.)*
7·0	0	30
8·4	8	37
9·2	11	43
10·3	31	53
11·4	39	75

* Concentration of lysozyme was 2 μgm./ml.

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* National Science Foundation Senior Post-Doctoral Fellow.

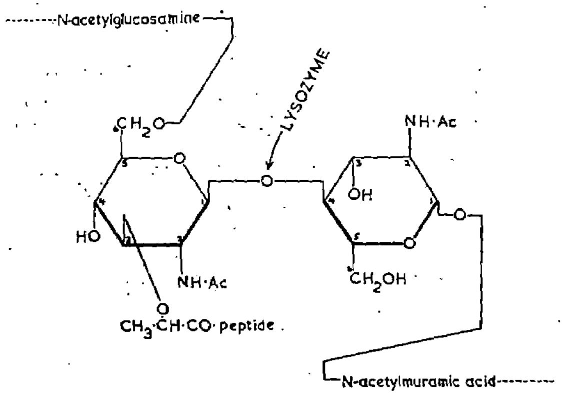

Fig. 1

These findings have led us to speculate on the possible locus of the O-acetyl groups in the cell wall and also on the nature of the bond split by lysozyme. Cell walls of Gram-positive bacteria have a remarkably similar chemical composition[7–9], being composed of three or four amino-acids and two amino-sugars: N-acetyl glucosamine and N-acetyl muramic acid. However, some of these bacteria are sensitive to lysozyme and others completely resistant. When lysozyme acts on susceptible cell walls only a few bonds in the substrate polymer are split, and large molecular weight fragments (10,000–15,000) with N-acetyl hexosamine end-groups are liberated[10]. Based on the results of a differential colour test, it appeared probable that these end-groups are all N-acetyl muramic acid[11] (although if N-acetyl glucosamine were still linked to the polymer through carbon 3, the same colour reaction would be given). The finding that only about 10 per cent of the total N-acetyl muramic acid in susceptible cell walls is made available by the action of lysozyme is in keeping with the size of molecular fragments released.

Disaccharides of N-acetyl muramic acid and N-acetyl glucosamine have been obtained following lysozyme action[10] and acid hydrolysis[12]. It is probable that this disaccharide forms the backbone of the polymer, although beyond this the structure of the mucopolysaccharide attacked by lysozyme is unknown. Assuming for the structure of the cell wall polymer repeating units of the two amino-sugars, let us now consider the possible linkages between them (Fig. 1). The colour yield of the split products in the Elson and Morgan test[13,14] following lysozyme action indicates that carbons 1 and 4 of N-acetyl muramic acid are free. Thus only carbon 6 is available for binding to the rest of the fragment, presumably to carbon 1 of N-acetyl glucosamine. On the other hand, the lysozyme-sensitive bond is probably from carbon 1 of N-acetyl muramic acid to carbons 3, 4 or 6 of N-acetyl glucosamine. It is very likely that lysozyme attacks only one of these bonds, and Berger and Weiser[15] have recently shown that chitin, which is a β 1–4 linked polymer of N-acetyl glucosamine, is slowly split by lysozyme. For this reason we propose the hypothesis that lysozyme splits a 1–4 link between N-acetyl muramic acid and N-acetyl glucosamine.

The effective inhibition of lysozyme by O-acetyl seems to require one acetyl per disaccharide unit. We have found an approximate 1 : 1 molar ratio of O-acetyl to N-acetyl muramic acid in the cell walls of our resistant strain 250. As mentioned earlier, lysozyme does not appear to split readily the bond between adjacent repeating units of the polymer, but acts preferentially on bonds about 10 units apart. From this one would predict that a fully resistant strain would become highly sensitive if only every tenth repeating unit were deacetylated, provided the deacetylated units were properly spaced. The results in Table 2 show that removal of only 40 per cent of the O-acetyl groups from the resistant organism was sufficient to confer high sensitivity to lysozyme. Abrams[16], who first observed the presence of O-acetyl in bacterial cell walls, concluded that these groups were not involved in lysozyme resistance because *Streptococcus faecalis* No. 9190, which contains O-acetyl, is sensitive to the enzyme. We would predict that this organism possesses less than one O-acetyl group per repeating unit and that resistant strains obtained by selection would possess a higher O-acetyl content.

This mechanism of resistance to lysozyme may be of general occurrence in view of the wide distribution of O-acyl in bacterial cell walls (Park, J. T., unpublished observation, and see ref. 16). However, certain cells may use sugars as the blocking agent if one accepts that the essential feature of blocking is the covering of a particular hydroxyl group on the substrate.

Certain cells are essentially resistant to lysozyme possibly because they lack the lysozyme-sensitive bond (1-N-acetyl muramic acid—4-N-acetyl glucosamine). For example, *Staphylococcus aureus* H., which contains a considerable amount of O-acyl, is still resistant to lysozyme after removal of these groups. It is of interest to note that *Staph. aureus* produces a lysozyme-like enzyme, although presumably of different specificity, which enables rapidly growing cells under certain conditions to autodigest their cell walls whereas older cells cannot[17]. It is possible that before new cell wall can be synthesized a preliminary hydrolysis of part of the existing wall, by this enzyme, is necessary. Equally necessary would be a mechanism for protecting cell wall areas remote from this site. Substituents such as O-acetyl groups introduced into the cell wall polymer could clearly fulfil this function.

Various techniques such as those of Nakamura[18] and Repaske[19] are now available for inducing lysozyme sensitivity in a wide range of bacteria which under normal testing conditions are resistant to the enzyme. Whether or not these sensitivity changes are associated with hydrolysis of cell wall O-acyl groups is at present under investigation.

We wish to thank Miss J. A. Gathercole for excellent technical assistance.

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BIOLOGICAL EFFECT OF A MAGNETIC FIELD AND THE RADIATION SYNDROME

By M. F. BARNOTHY and J. M. BARNOTHY
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As reported in a previous communication[1], when mice are kept in a homogeneous magnetic field of several thousand gauss, leucocytosis can be observed during the first weeks following the removal of the animals from the field. Both the segmented and the lymphocyte count increase and reach a maximum of 30–60 per cent in 12–14 days after removal of the animal from the magnetic field.

Based on these findings, the following working hypothesis was tested. Irradiation with X- or gamma-rays in the mid-lethal dose-range decreases the granulocyte and lymphocyte count in four or five days, to a few per cent of their normal value[2]. Since this effect of irradiation on the leucocyte count is, in its sign, opposite to that found after removal from the magnetic field, it could be expected that the bone-marrow syndrome in the radiation injury might be partly compensated, if irradiation and treatment in a magnetic field could be adjusted in a proper time sequence.

Eight-week-old virgin *RFM*-strain mice from the Roscoe B. Jackson Memorial Laboratory were used. From the 60 mice used in each experimental series, a sample of 10 or 20 of average weight distribution was selected, and placed for a period of 14 days in a magnetic field of 4,200 gauss. The maximum gradient of the field within the cage was 30 gauss/cm. The remaining mice were kept in standard plastic cages. 'Rockland mouse diet' and tap water were supplied *ad libitum* to both groups. At the end of the 2-week period the treated mice were placed for 2–3 days in standard cages, whereupon to all of them a whole-body irradiation was given in the Cobalt Therapy Unit of Cook County Hospital, at 57 r./min. intensity. All animals were deprived of food 10–12 hr. prior to irradiation to minimize intestinal syndromes[3].

In the following account the radiation dosage is always given for cobalt-60 gamma-rays; in order to convert the dosage to 250 kV. X-ray dosages of the same relative biological effectiveness, the values must be divided[4] by the factor 1·33. The expression 'controls' refers to animals irradiated but not treated in the magnetic field; and the expression 'treated' to animals which were treated in a magnetic field and irradiated.

Table 1 shows the irradiation dosage, the number and age of controls and treated mice at the time of irradiation, the mortality-rates and the probability-level in the difference of the mortality-rates.

In series *C*, the surviving 45 animals of series *B* were used again, and irradiated 44 days after their first irradiation. The same ten animals were treated anew, that is, kept for 14 days in a magnetic field prior to their (second) irradiation.

Table 1

Series	Dose	Age in days	No. of: Controls	Treated	Mortality-rate (per cent) Controls	Treated	Probability-level
A	850 r.	88	41	20	86	75	1:6
A'	850 r.	88	41	10	86	50	1:95
B	750 r.	77	50	10	30	0	1:107
C	850 r.	121	35	10	89	80	1:3·5

As it was shown by one of us, the development of young animals kept in a magnetic field is retarded. After magnetic treatment, the weight of the treated mice averaged 1–2 gm. less than that of their controls. Since, as is known, the irradiation mortality increases with decreasing body-weight, the treated animals were in a somewhat unfavourable situation. In series *A*, 10 of the heaviest mice from the 20 treated were marked. Their average weight was the same as that of the control group. The mortality-rate of this selected group is listed in Table 1 as series *A'*.

The difference in the mortality-rate between controls and treated mice is significant in series *A'* and *B*, but not significant in series *A* and *C*. It is highly significant for the pooled results of series *A*, *B* and *C* as well as for the pooled results of series *A'* and *B*.

In series *A*, blood samples were taken on the 5th, 10th, 15th, 20th and 30th post-irradiation days, from the tail veins of 6 controls and 6 treated. The segmented neutrophile and lymphocyte count dropped on the 5th day in treated and control groups to 3 and 2 per cent, respectively, of the original value. The upper part of Fig. 1 shows the change in the leucocyte count of the treated animals relative to the leucocyte count of the control group. The magnetic treatment does not compensate the leucopænia of the bone-marrow syndrome, but diminishes it by a percentage. Furthermore, it enhances the leucopænia between the 15th and 18th post-irradiation days. In view of these findings, it is not to be expected that magnetic treatment will decrease considerably the mortality-rate of the radiation injury of young mice in the high lethal range.

A significant difference is manifested in the mortality histograms. On the 9th, 10th, 11th and 12th day after irradiation, none of the treated animals

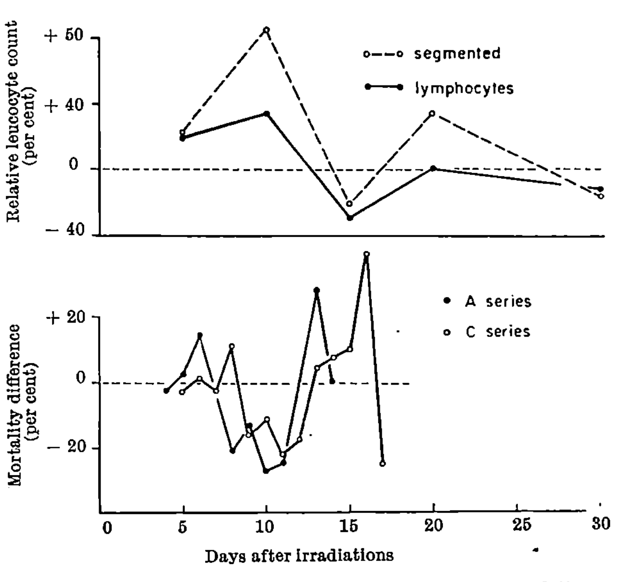

Fig. 1. Upper curves, leucocyte count of treated animals relative to controls; lower curves, mortality of treated above controls as a percentage of preceding-day survivors, for series *A* and *C*

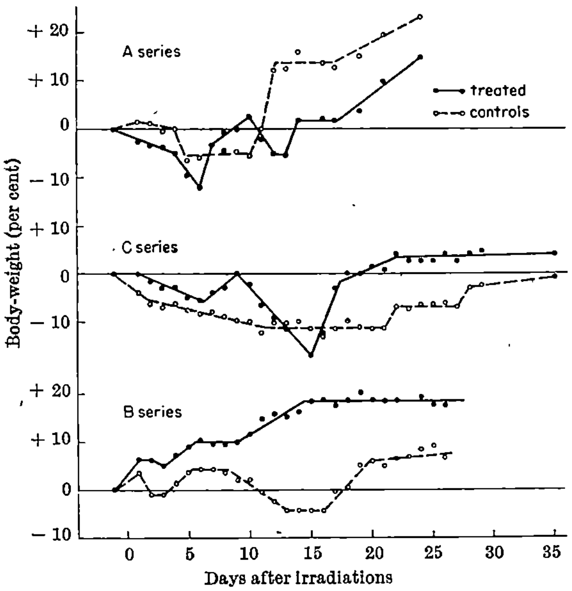

Fig. 2. Change in average body-weight relative to average body-weight on the day before irradiation for series *A*, *C* and *B*

died in either of the series *A* or *C*, although during the same period the highest toll was taken from the control groups. The lower curve in Fig. 1 shows the difference in the mortality-rate of treated and controls. This curve runs definitely anti-parallel to the relative leucocyte count (upper curves).

The body-weight of the animals was measured daily. Fig. 2 shows the change in the average body-weight for treated and controls in series *A*, *C* and *B*. The greater increase in weight after recovery in series *A* and *B* is due to the circumstance that in these series very young animals which were not fully developed were used. All three series show different behaviour of treated and controls. In both high-lethal series *A* and *C*, the weight curve of the treated shows a maximum on the 9th post-irradiation day, which coincides with the maximum in the relative leucocyte count in Fig. 1 and with the low-mortality period of the treated groups in series *A* and *C*. The weight-curves of the controls do not show such a maximum.

The weight-curve of the treated group in the low-lethal series *B*, although indicating a small minimum on the third day, increases thereafter continuously. This pattern of the weight-curves indicates that radiation injury was practically fully compensated in this low-lethal series through previous magnetic treatment. None of the treated mice died in this series.

A further effect of the magnetic treatment is indicated in the relative weight of spleens. (Spleens were removed and weighed within 2 hr. after death had occurred.) In series *A* the average spleen weight of treated and controls was the same. In series *C*, where the animals underwent a previous irradiation 44 days earlier, the spleen weight of the treated was only 57 per cent of that of the controls. The difference is significant on a probability-level less than $1/10^8$; and indicates that the treated animals were not affected by their first, low-lethal irradiation 44 days earlier and, therefore, their spleens did not pass through a transitory hyperplasia[5] as a consequence of the recovery process from leucopænia.

The hæmatological counts were made by Miss M. Walker at St. Francis Hospital, Evanston, Illinois. Acknowledgment is due to the staff of the Cook County Hospital, to Dr. I. F. Hummon, Dr. M. F. Magalotti and Miss D. Scully for their kind co-operation in the irradiation of the animals. The experiments were performed in our laboratory in Evanston, Illinois, and assisted by the Dorothy Shattuck-Stensland Foundation.

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ELECTROPHORETIC SEPARATION AND CLASSIFICATION OF BLOOD PLASMA ESTERASES

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THE specificity of cholinesterases present in the plasmata of various mammalian species is fairly well known and aliphatic esterases and lipases have also been studied, though in less detail, using simple esters and triglycerides as substrates[1–3]. For most animal species, it is still unknown whether the plasma contains, in addition to a cholinesterase, aliphatic esterases or/and lipases. The presence of an aromatic esterase in human plasma has been proposed[4] and Aldridge[5] introduced a nomenclature, a most satisfactory one as will be demonstrated below, for esterases hydrolysing *p*-nitrophenyl acetate, propionate and butyrate. The A-esterase is the enzyme which splits acetate at a higher rate than butyrate and is resistant to organophosphorus compounds; the B-esterase is inhibited by such compounds. It is not known, however, whether A- or/and B-esterases have the ability to hydrolyse aliphatic substrates or whether it is justifiable to call either A-esterase or both A- and B-esterases 'aromatic esterases'. Like the aliphatic esterases, they differ from the cholinesterases in being resistant to physostigmine.

Except for a study of the A- and B-esterases of rabbit and guinea pig plasmata[6], no attempt has been made so far to separate the various esterases electrophoretically. The object of the present investigation was to explore the usefulness of electrophoresis for such separations, to compare the esterase patterns of various vertebrate plasmata, and to propose a classification based on such patterns. The results showed that vertebrate plasmata contain three types of esterases; some plasmata contain all three types, others two and still others only one. When designating these enzymes, the nomenclature generally accepted by most authors in this field was followed so far as possible. The characteristic features of these esterases as revealed by the present study are summarized below; it will be understood that within each group there are species variations in the properties of the individual enzymes within the group.

A-esterases (arylesterases): typical aromatic esterases which hydrolyse phenyl acetate at a higher rate than phenyl butyrate: aliphatic esters are normally not attacked. They are resistant to both organophosphorus compounds and physostigmine, and have, in most cases, the greatest electrophoretic mobility of the three esterase groups, moving together with or close to the albumin components.

B-esterases (aliphatic esterases, lipases): both aliphatic and aromatic esters are hydrolysed; there exist acetyl-, propionyl- and butyryl-B-esterases, and choline esters are not hydrolysed. They are sensitive to organophosphorus compounds, but resistant to 10^{-5} *M* physostigmine; some B-esterases are sensitive to higher concentrations of the latter compound. The B-esterases move electrophoretically more slowly than the A-esterases (eel plasma is an exception), but more rapidly than the C-esterases; they are always found in the α_1-globulin fraction or a fraction close to that component.

C-esterases (cholinesterases): choline esters are split at a higher rate than both aliphatic and aromatic esters, the latter usually being hydrolysed at a lower rate than aliphatic esters or not at all; the specificity regarding the acyl group varies greatly. These esterases are sensitive to both organophosphorus compounds and physostigmine, the latter giving 100 per cent inhibition in 10^{-5} *M* or lower concentration. They have the slowest electrophoretic mobility of all plasma esterases (frog plasma is an exception), normally migrating between the α_2- and β-globulins. (It is not my intention to add a new term to all those already existing for these enzymes; 'C-esterase' is used here only for practical reasons when these esterases are discussed in relation to the A- and B-esterases, and because it is the third esterase coming out in electrophoresis.)

Plasma was prepared from heparinized blood, and was free from all cells, including thrombocytes. Aliphatic, aromatic and choline esters were tested as substrates. The substrates used were the acetyl (Ac), propionyl (Pr), butyryl (Bu) esters of the following radicals, *iso*-amyl, glycerol (for example, tributyrin), phenyl and choline; also, acetyl-β-methylcholine, benzoylcholine, succinylcholine, the carbon analogue of acetylcholine (3,3-dimethylbutylacetate), 'Tween 20' (polyoxyethylene sorbitan monolaurate), procaine hydrochloride, atropine sulphate, cocaine hydrochloride, and heroin. Choline esters were all as iodides. Eight compounds were selected as inhibitors from those frequently studied as selective enzyme inhibitors[7] in recent esterase studies: physostigmine salicylate, tetra-*iso*propylpyrophosphoramide, mipafox (*bis*-mono*iso*propylamino fluorphosphine oxide), 'Astra 1397' (10-(1-diethylaminopropionyl) phenothiazine hydrochloride), 3318*CT* (*bis*-(piperidinomethyl coumaranyl-5)ketone), 62*C*47 (1,5-*bis*(4-trimethylammoniumphenyl)pentane - 3 - one diiodide), atoxyl, and quinine sulphate. The active fractions obtained in electrophoresis were dialysed against a bicarbonate buffer prior to testing against the inhibitors.

Electrophoresis was carried out on cellulose columns[8] (3 cm. × 40 cm.) in veronal buffer (pH 8·4, $\mu = 0{\cdot}1$) at 5–11° C., using 5 ml. buffered plasma for each experiment and a current of 60 m.amp.; the duration of runs was 30 hr. The protein concentration of successive 2·8 ml. fractions of the eluate was estimated by a modified Folin method[9], and the esterase activities of the fractions estimated manometrically by the Warburg technique[7].

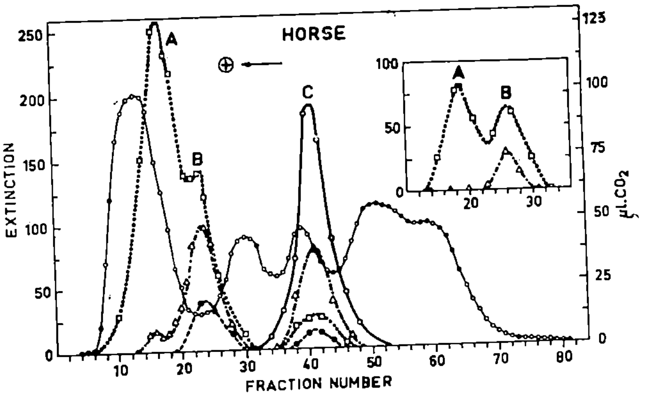

Fig. 1. Distribution of protein and esterase activity after column electrophoresis of horse plasma. The protein content (measured by the extinction at 700 mμ) and esterase activity (expressed at μl. carbon dioxide/30 min./ml. fraction) are plotted as ordinates against the fraction numbers as abscissæ. For convenience in presentation, the esterase activities have been multiplied by the factors, shown below in brackets, before plotting. ○—○, protein concentration; □ . . . □, phenyl acetate (0·05); △–.–△, phenyl butyrate (0·1), tripropionin (0·15, peak *B*; 0·3, peak *C*); ● - - - ●, tributyrin (0·1), *iso*-amyl butyrate (0·1, peak *B* only); ○–○, butyrylcholine (0·1), propionylcholine (0·16), benzoylcholine (0·8).

The insert is the electropherogram of a mixture of 3·8 ml. purified A-esterase and 8·0 ml. purified B-esterase from the peak fractions of *A* and *B*, main diagram, showing clearer resolution of A- and B-esterases. □ . . . □, phenyl acetate (0·4); △–·–△, phenyl butyrate (0·4)

Fig. 1 shows in detail the results of a single separation using horse plasma. It will be seen that, depending on the substrate, esterase activity was maximal in one or more of three clearly separated fractions. The three peaks of activity are designated *A*, *B* and *C*. It is a reasonable inference that these three peaks are due to the presence of three distinct enzymes, each with a different, and characteristic, electrophoretic mobility. The family of curves in each peak gives the substrate specificity of the enzymes responsible for it; a comparison of the esterase peaks with those of protein concentration indicates the relation of the enzyme proteins to the main protein components of the plasma and enables the specific activity of the various fractions to be estimated.

Esterases separated in this way were studied further by means of selective inhibitors and by submitting them to a second electrophoretic separation. The insert diagram in Fig. 1 shows that a mixture of A- and B-esterases can be more completely resolved by further electrophoresis and that each enzyme again travels as a single component.

Fig. 2 shows in simplified diagrams the results with nine further plasmata and Fig. 3 summarizes the plasma esterase pattern of all the species studied as revealed by combined studies of electrophoretic mobility, substrate specificity and sensitivity to inhibitors. The characteristics of the various plasmata studied will now be briefly summarized.

Horse (Fig. 1). This plasma contains all three types of esterases. The A-esterase is a typical acetylarylesterase, being resistant to all inhibitors studied. The B-esterase has a low specificity, and is a typical propionylesterase, the propionates in both the aromatic and aliphatic series of substrates being hydrolysed at a higher rate than the corresponding acetates and butyrates. It differs from most B-ester-

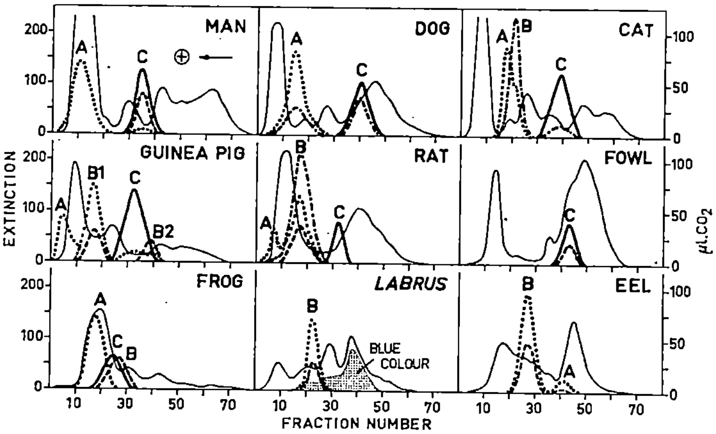

Fig. 2. Distribution of protein and esterase activity after electrophoretic separation of vertebrate plasmata. Conditions as for Fig. 1

Man: *A*, ..., phenyl acetate (0·01), phenyl butyrate (1·0). *C*, ——, butyrylcholine (0·1); – – –, tributyrin (0·4), [phenyl butyrate (0·1), benzoylcholine (0·8); ...., phenyl acetate (0·01).

Dog: *A*, ..., phenyl acetate (0·025); –·–·, phenyl butyrate (0·4). *C*, ——, butyrylcholine (0·4); propionylcholine (0·8); –·–·, phenyl butyrate (0·4).

Cat: *A*, ..., phenyl acetate (0·01). *B*, –·–·, phenyl butyrate (0·1), tripropionin (0·2); ...., phenyl acetate (0·01). *C*, ——, butyrylcholine (0·4), propionylcholine (0·65); –·–·, phenyl butyrate (0·1).

Guinea pig: *A*, ..., phenyl acetate (0·05). B_1 and B_2, ..., phenyl acetate (0·05), phenyl butyrate (0·05; N.B. –·–·); tributyrin (0·07); tripropionin (0·07); 'Tween' (0·03); – – –, *iso*-amyl butyrate (0·2), ethyl acetate (0·2; peak B_1 only). *C*, butyrylcholine (0·2), phenyl butyrate (0·2); ...., phenyl acetate (0·05), tributyrin (0·07).

Rat: *A*, ..., phenyl acetate (0·05). *B*, –.–., phenyl butyrate (0·05); ...., phenyl acetate (0·05); – – –, tripropionin (0·1), *iso*-amyl acetate (0·32), 'Tween' (0·2). *C*, ——, propionylcholine (0·8), butyrylcholine (1·0), phenyl acetate (1·0), phenyl butyrate (4·5).

Fowl: *C*, ——, propionylcholine (0·4); – – –, tripropionin (0·4), phenyl acetate (0·4), phenyl butyrate (0·4).

Frog: *A*, ..., phenyl acetate (0·02), phenyl butyrate. *B*, – – –, tripropionin (0·2), phenyl butyrate. *C*, ——, butyrylcholine (0·2).

Labrus: *B*, ..., phenyl butyrate (0·05), 'Tween' (0·2); – – –, tripropionin (0·1); shaded area refers to the blue-coloured fractions measured spectrophotometrically at 645 mμ.

Eel: *B* and *A*, ..., phenyl acetate (0·005), *iso*-amyl butyrate (0·15), triacetin (0·05); – – –, heroin (0·1).

ases in being resistant to tetra-*iso*propylpyrophosphoramide (but not to mipafox); this is characteristic also of the B-type esterases present in fish plasmata. The C-esterase is a typical butyrylcholinesterase with the same low specificity and similar inhibition pattern as that of human plasma. Phenyl acetate and phenyl butyrate are both split by all three esterases, the relative rates of hydrolysis by the A-, B- and C-esterases being 1·8 : 1 : 0·2 for the acetate and 1 : 5 : 4 for the butyrate. It will be seen that the A- and B-esterases migrate between the albumin and α_1-globulin components and the C-esterase between the α_2- and β-globulins.

Man (Fig. 2). Only A-esterase and C-esterase are present. The former hydrolyses phenyl acetate at a rate which is approximately 100 times greater than the hydrolysis-rate of phenyl butyrate; the enzyme is resistant to all inhibitors studied in this series and does not hydrolyse aliphatic esters. The C-esterase is a typical butyrylcholinesterase with low specificity, that is to say, the butyrates of both phenol and aliphatic alcohols (including glycerol) are split at relatively high rates. This enzyme is also capable of hydrolysing benzoylcholine and succinylcholine, as well as the carbon analogue of acetylcholine, procaine, atropine, and 'Tween 20'. It is sensitive to all inhibitors, physostigmine being the most potent compound (pI_{50} 7·7), and 62*C*47 and quinine the less potent ones (pI_{50} 5·0).

Dog (Fig. 2). The esterase pattern of this plasma closely resembles that of human plasma, in the first place by being devoid of B-esterase. The A-esterase is a typical acetyl-arylesterase, and the C-esterase is a butyrylcholinesterase of low specificity; the triglycerides are split at comparatively low rates. The C-esterase is otherwise similar to other butyrylcholinesterases present in the plasmata of various animal species.

Cow. An acetyl-A-esterase is the only esterase present in significant amounts. The plasma does not contain any B-type esterase, and the C-esterase, present in low concentration, is a propionylcholinesterase which is inhibited by excess substrate concentration. This enzyme is sensitive to those compounds (62*C*47 and 3318*CT*) which are regarded as being selective inhibitors of acetylcholinesterase (of erythrocytes and nerve tissue), and resistant to 'Astra 1397'.

Pig. The plasma has low, medium or high esterase activity, due mainly to the great individual variation in acetyl-arylesterase concentration. A B-esterase is probably not present. The properties of the C-esterase, also present in low concentration, differ from all other cholinesterases studied in this series regarding specificity, confirming previous results[3,10]; it does hydrolyse benzoylcholine, which has been a subject of discussion, and its sensitivity to inhibitors is otherwise similar to that of butyrylcholinesterases.

Cat (Fig. 2). Three esterases are present, of which the A-esterase is a propionyl-arylesterase. The B-esterase splits a variety of esters, the hydrolysis-rates being greatly dependent on the configuration of the alcoholic group; tripropionin is split at a higher rate than tributyrin, the reverse being true for the *iso*-amyl derivatives. The C-esterase is a butyrylcholinesterase similar to the human and horse C-esterases, except for being less sensitive to atoxyl and quinine.

Guinea pig (Fig. 2). Both A- and B-esterases are present in high concentration. The propionates and butyrates are split by the B-esterase at about the same rate, and more rapidly than the acetates. The

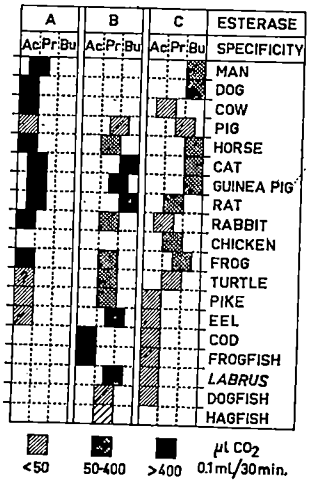

Fig. 3. Plasma esterase patterns of vertebrates

hydrolysis of 'Tween 20', the rate of which is comparatively high with this plasma, is catalysed by this enzyme. Guinea pig plasma also contains a second B-esterase (B 2), moving at a higher rate in electrophoresis than the C-esterase, and being sensitive to tetra-*iso*propylpyrophosphoramide but not to physostigmine. Both B-esterases are capable of hydrolysing *iso*-amyl butyrate. This ester is not split by the C-type esterase, which is a butyrylcholinesterase. It will be noted that all four esterases traced on the electropherogram are able to hydrolyse phenylacetate.

Rabbit. This plasma contains at least three esterases. Phenyl acetate and phenyl butyrate are hydrolysed by both an A-esterase (or probably two A-type esterases, running close together in electrophoresis) and a B-esterase; the latter enzyme has the properties of a propionylesterase and its concentration varies considerably from animal to animal. The C-esterase is an acetylcholinesterase (of a type found in the erythrocytes and nervous tissue). The properties are similar to those of such an enzyme in the following ways: splitting acetylcholine and propionylcholine at a higher rate than butyrylcholine; in being resistant to 'Astra 1397', atoxyl and quinine; in being less sensitive to tetra-*iso*propylpyrophosphoramide and mipafox than most other plasma cholinesterases, and very sensitive to 62*C*47; in that the activity is inhibited by high concentrations of acetylcholine.

Rat (Fig. 2). The esterase properties are very much like those of guinea pig plasma; the second B-esterase present in the latter plasma is, however, missing in rat plasma. The rat is the only mammalian species studied in this series which has a typical propionylcholinesterase in its plasma, confirming a previous observation[3]. In some respects, concerning inhibitory effects of various compounds, this enzyme differs from the butyrylcholinesterases.

Fowl (chicken; Fig. 2). This plasma is unique among those examined in being devoid of both A- and B-esterases. The B-type esterase described by Aldridge[5] is actually identical with the propionylcholinesterase present which splits acetyl-β-methylcholine at a comparatively high rate. The hydrolysis-rates of four different substrates, propionylcholine, tripropionin, phenyl acetate and phenyl butyrate, were all found to be influenced to the same degree by the eight inhibitors tested. The enzyme is extremely sensitive to mipafox pI_{50} 9·0) and is more or less resistant to 62*C*47, 3318*CT*[11], atoxyl and quinine.

Frog (*Rana temporaria*; Fig. 2). A-, B- and C-esterases are present, the A-esterase having similar properties to other plasma A-type esterases studied. The B-esterase differs from other B-type esterases in being somewhat sensitive to physostigmine (pI_{50} 4·5). Choline esters, however, are not hydrolysed by this enzyme, the C-esterase present being responsible for this reaction. The C-esterase is a propionylcholinesterase which splits butyryl choline at a relatively high rate, but differs otherwise from the C-esterase of chicken plasma. The most significant property of frog C-esterase is its relatively high electrophoretic mobility, higher than that of the B-esterase. The plasma of the toad, *Xenopus laevis*, contains an A-esterase, a propionyl- or/and butyryl-B-esterase, and a butyrylcholinesterase (in low concentration).

Eel (*Anguilla anguilla*; Fig. 2). This plasma is characterized by its ability to split aromatic esters and triglycerides (especially those of butyric acid) at a very high rate. The material seems to be the richest animal source of 'lipase' activity ever described; in this respect it is 100 times more active than human plasma, and has the same high esterase activity for phenyl butyrate as certain electric organs for acetylcholine. The enzyme is of the B-type and splits heroin at a comparatively high rate. In addition, an A-esterase in low concentration is present. It has the properties of an acetylesterase, and has a higher electrophoretic mobility than the B-esterase. Eel plasma also contains, as most fish plasmata, a C-esterase, the properties and sensitivity to inhibitors of which are those of an acetylcholinesterase.

Pike. The esterase pattern is similar to that of the eel plasma, except for lower enzyme activity and specificity more pronounced for propionates; heroin is hydrolysed at a low rate. Most of the esterase activity is due to a B-esterase, which is very sensitive to mipafox (pI_{50} 9·1) and less so to physostigmine (pI_{50} 4·8). The C-esterase, present in low concentration, is an acetylcholinesterase.

Cod. A B-esterase of the acetyl type is characteristic of this plasma. It splits heroin at a comparatively high rate and is sensitive to mipafox but not to tetra-*iso*propylpyrophosphoramide. An acetylcholinesterase is also present in low concentration.

Frogfish (*Lophius piscatorius*). The B-esterase, present in high concentration, is a typical acetylesterase which splits heroin at a high rate. It is sensitive to mipafox but not to tetra-*iso*propylpyrophosphoramide, and is also inhibited by physostigmine (pI_{50} 4·0). An acetylcholinesterase is present in low concentration.

Wrass (*Labrus berggylta*; Fig. 2). The B-esterase present splits butyrates and propionates at a higher rate than acetates, and is sensitive to mipafox but not to tetra-*iso*propylpyrophosphoramide. 'Tween' is split at a relatively high rate by this enzyme. The C-esterase, of low concentration, is an acetylcholinesterase. The blue colour characteristic of the labride plasmata is due to the presence of a chromoprotein (absorption maxima at 390, 600 and 645 mμ) which moves electrophoretically at a higher rate than other proteins present.

Dogfish (*Squalus acanthias*). The plasma has a very low esterase activity, being due to a propionyl-B-esterase and an acetylcholinesterase.

Hagfish (*Myxine glutinosa*). This plasma contains an esterase (probably an acetyl- or propionyl-B-esterase) in trace amounts. No other esterases have been detected.

A full account of this work will be published elsewhere. It was supported by a grant from the Swedish Natural Science Research Council. Grateful acknowledgments are due to Dr. V. P. Whittaker, of the Agricultural Research Council Institute of Animal Physiology, Cambridge, for valuable comments on the presentation of this work, and to Miss Toril Isachsen and Mrs. Gunnel Jonsson for skilled technical assistance.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Formaldehyde as an Acceptor Aldehyde for Transketolase, and the Biosynthesis of Triose

THE enzyme transketolase is biologically widely distributed, and, in presence of thiamine pyrophosphate and magnesium ions, transfers the ketol group or 'active glycolaldehyde' (CH$_2$OH.CO . . .H) from a variety of ketose phosphates (sedoheptulose 7-phosphate, D-fructose 6-phosphate, D-xylulose 5-phosphate), from certain free ketoses (L-erythrulose, D-xylulose) and from hydroxypyruvic acid to certain 'acceptor aldehydes', thus synthesizing new ketoses. The 'acceptor aldehydes' hitherto recognized are D-glyceraldehyde 3-phosphate, D-ribose 5-phosphate, D-erythrose 4-phosphate and 2-deoxyribose 5-phosphate; also free glyceraldehyde and glycolaldehyde (for reviews see refs. 1–3). Acetaldehyde and formaldehyde are stated not to be acceptors[4], but the former appears in our preliminary tests to be weakly active.

Formaldehyde, on the other hand, we find reacts quite effectively as an acceptor when pure lithium hydroxypyruvate[5] is the donor. The product formed corresponds chromatographically, chemically and enzymically with dihydroxyacetone:

$$\mathrm{CH_2OH.CO.COOH + H.CHO \rightarrow CH_2OH.CO.CH_2OH + CO_2}$$

Table 1 shows the manometric and other results. Table 2 shows the chromatographic identification.

Table 1. FORMALDEHYDE AS 'ACCEPTOR' FOR TRANSKETOLASE ACTION

Transketolase was prepared by the method of de la Haba, Leder and Racker (ref. 4); a sample purified by column adsorption kindly supplied by Dr. E. Racker behaved similarly. Contents of vessels: transketolase (500 μgm.), thiamine pyrophosphate (0·2 μmole), magnesium chloride (5 μmoles), pH 6·6 buffer to total volume of 2·5 ml. Substrates as below (formaldehyde or hydroxypyruvate, 20 μmoles of each). The values given are in μmoles after 2 hr. incubation at 37° C.

Substrate	Hydroxy-pyruvate	Hydroxy-pyruvate + formaldehyde	Hydroxy-pyruvate + formaldehyde (no enzyme)
Carbon dioxide produced	1·2	15·2	0
Formaldehyde utilized	0	15·7	0·8
Hydroxypyruvate utilized*	2·6	18·0	2·8
Triose formed†	none	+++	none

* Spectrophotometrically by specific dehydrogenase (cf. ref. 11).

† By glycerokinase and adenosine triphosphate (manometrically and also by formation of alkali-labile phosphate); by formation of methyl glyoxal on distillation with acid; and by chromatography (Table 2).

Table 2. CHROMATOGRAPHIC IDENTIFICATION OF DIHYDROXYACETONE FORMED

Deionized vessel-contents (Table 1) were concentrated *in vacuo* and analysed by descending chromatography on Whatman No. 1 paper; detection by aniline phosphate spray

Solvent (parts by vol.)	R_F values Unknown	Dihydroxyacetone	Glyceraldehyde	Erythrulose	Threose
Phenol/water (4 : 1)	0·81	0·81	0·44	0·72	0·65
Butanol/acetic acid/water (4 : 1 : 5)	0·45	0·45	0·49	0·36	0·43
Ethylmethyl ketone/acetic acid/4 per cent boric acid (9 : 1 : 1)	0·48	0·49	0·14	0·38	0·36

The interaction of transketolase with the numerous biological sources of formaldehyde opens the possibility of various new metabolic routes. The dihydroxyacetone formed in the above reaction is readily phosphorylated by 'glycerokinase' prepared from rat liver by the method of Bublitz and Kennedy[6]: the resulting phosphate could therefore enter the triose phosphate and hexose phosphate pools. Another route from L-serine to hexose, alternative to that proposed for phosphoserine by Ichihara and Greenberg[7], might proceed via serine aldolase (giving formaldehyde and glycine) in conjunction with the formation of hydroxypyruvate from L-serine by the specific transaminase of Sallach[8]. Transketolation of the hydroxypyruvate to formaldehyde could thus provide dihydroxyacetone. Whether the observed transformation in the rat of [3-^{14}C]serine[9] and of [2-^{14}C and 3-^{14}C] hydroxypyruvate[10] to liver glycogen actually follows this pathway is being investigated. The extent of formation of dihydroxyacetone from donors other than hydroxypyruvate and the question of reversibility of these reactions are also being studied by us.

Thanks are due to Mr. R. Carrick James for technical assistance.

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A Procedure for the Purification of Sirenin

SIRENIN (I am indebted to Dr. A. Vegis for suggesting, what seems to me, this aptly descriptive name) is the name, used here for the first time, for the chemotactic sexual hormone from the water-mould *Allomyces* which attracts the male gametes and is produced by the female gametes[1]. This hormone has now been produced and purified.

Fernbach flasks (1,800 ml.) containing 500 ml. of yeast extract–starch medium[2] were inoculated with mycelial fragments of the female strain *F*-2[1] and incubated for two days on shakers at 30° C. The plants obtained were washed with copious amounts of tap water and then placed in thin layers in dishes where they were just covered with double-distilled water. This water was replaced after 3, 8 and 24 hr., thereby inducing gamete formation and release for a total of 48 hr. The aqueous solutions, containing approximately 25–100 µgm. sirenin per litre, were freed of gametes by passage through Seitz filters and the solutes adsorbed on 'Norit *FNX* Special' charcoal used at the rate of 5 gm. per 500 ml. of solution.

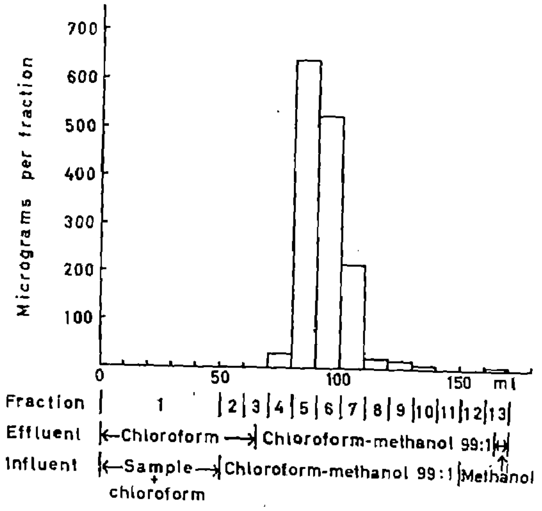

Fig. 1. The fractionation of sirenin on a silicic acid column

The solutes were eluted from the charcoal with chloroform, evaporated to dryness at room temperature, and the residue then extracted with water. Upon removing the water at 30° C., the residue was taken up in 3–10 ml. of redistilled chloroform, thereby providing the sample for fractionation on a silicic acid column[3]. The programme followed and the fractionation obtained are shown in Fig. 1. The last addition was followed by 50 ml. of chloroform to prepare the column for the next run.

The details of this procedure for purifying sirenin were clarified shortly before this investigation had to be terminated. Consequently, the various small samples in the laboratory were each passed through the column; fractions 1, 12, and 13 were discarded and the remaining fractions from all runs mixed and re-run. Fractions 5 and 6 of this final run (Fig. 1) were mixed, the solvent evaporated, and the residue analysed. A clearly detectable response in the bioassay[1] was observed with a concentration of 10 μgm. per litre. The fact that sirenin was not retained on 'Dowex' 2 and 50 ion exchange columns indicated that the molecule is neutral. Characteristic absorption peaks were absent from the ultra-violet spectrum.

The 6μ region of the infra-red absorption spectrum displayed a not very well resolved band consisting of several overlapping absorption bands. Of these bands, one at 5·63μ indicated the presence of a lactone ring, another at 6·85 indicated the presence of keto and/or aldehyde functions, and perturbances in the 5·95 to 6·03μ region suggested double-bond carbon and/or carbon–nitrogen functions. There was no evidence of aromatic rings and no positive indications of hydroxy and carboxyl functions.

The mass spectrum showed no very distinctive characteristics. However, peaks corresponding to *m/e* 31, 44, and 58, which often reflect ionized fragments representing methoxy, aldehyde and unsubstituted ketone (— CH_2COCH_2 —), respectively, were stronger than to be expected unless such groups were actually present in the molecule. There was in this spectrum, too, no indication of aromatic rings. The maximum molecular weight indicated by the mass spectrum was 386.

The ultra-micro[4] elementary analysis was consistent with the preceding inferences. There was found: C, 61·6 (± 1·5) per cent; H, 8·8 (± 0·3) per cent; N, 3·4 (± 0·3) per cent; and O (by difference), 26·2 per cent. On the basis of the formula $C_{21}H_{36}O_7N$ the minimum molecular weight is 414. This weight is of the same order of magnitude as that indicated by the mass spectrum. These tentative analyses are presented here since they may be useful to others in the determination of the structure of sirenin.

This work was performed in the Institute of Physiological Botany, University of Upsala, where I was on sabbatical leave, with the assistance of a fellowship from the John Simon Guggenheim Memorial Foundation, and was supported, in part, by a research grant (*G*1291) from the National Science Foundation.

I wish to acknowledge the assistance of the following: Prof. Nils Fries, whose guest I was at the Institute; Dr. A. Rosenberg for making and interpreting the infra-red spectra; Prof. P. E. Lindahl and his assistant for the ultra-violet spectra; Prof. E. Stenhagen and Dr. R. Ryhage for making and interpreting the mass spectra; and Mr. W. Kirsten for the ultra-micro elementary analysis. A more detailed report of this work is being published in *Physiologia Plantarum*.

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Formation of Lactate from Acetoacetate in the Perfused Heart

Seaman[1] and Davies[2] have recently described enzyme systems in protozoa and pig heart which catalyse the oxidative condensation of two molecules of acetyl coenzyme *A* to produce succinate.

$$2CH_3.\mathit{CoSCoA} + \mathit{DPN}^+ \rightarrow HOOC.CH_2.CH_2COOH + 2\mathit{CoA} + \mathit{DPNH} + H^+ \quad (1)$$

The existence of the enzyme in rat tissues is at present debatable[1]. The reaction is reversible, and, in fact, the equilibrium is very much in favour of cleavage of the succinate, but it may be driven in the direction of synthesis by the addition of suitable systems capable of oxidizing reduced diphosphopyridine nucleotide[2]. Since succinate may be transformed into pyruvate either through decarboxylation of oxaloacetate or oxidative decarboxylation of malate, reaction 1 is the key to a synthesis of carbohydrate from fat with net gain of carbon.

Recent experiments with isolated rat diaphragm in which the muscle was incubated with glucose and acetate or acetoacetate[3] have shown that significantly more lactate is produced, when acetoacetate is present, than can be accounted for by disappearance of glucose and glycogen. With acetate as substrate, lactate appearing exactly balanced the loss of carbohydrate. Since acetoacetate can be cleaved in muscle to acetyl coenzyme *A*, it was tentatively concluded that the pathway outlined above, followed by reduction of pyruvate to lactate, was operating in this tissue. The reason why net lactate synthesis took place from acetoacetate and not from acetate was thought to be the very high rate of uptake of the former compound.

Table 1. HEARTS FROM FASTED MALE ALBINO RATS PERFUSED WITH KREBS–RINGER BICARBONATE

Three periods, volume in each period 20 ml. (first period, 1·5 mgm./ml. glucose; second period, no glucose; third period, no glucose ± acetoacetate, 0·01*M*; concentration of sodium chloride in Ringer solution being reduced by 0·01 *M* when acetoacetate was present). 0·5-ml. samples removed from system at 10 min. intervals for estimation of lactate (ref. 5) and acetoacetate (ref. 6). The tabulated figures represent rates of lactate production ± standard deviation during each period; negative values indicate disappearance of lactate. A correction has been made for carry-over of lactate from one period to the next

Solution \ Time	50–60 min.	60–70 min.	70–80 min.	Final glycogen (μmole/gm.)
	Lactate produced (μmole/gm./hr.)			
Control (10)	6·9* ± 4·9	−1·8 ± 3·9	−0·8 ± 3·2	2·7 ± 1·3
Acetoacetate (10)	18·1* ± 14·4	3·0 ± 12·7	−7·6 ± 11·1	2·8 ± 0·7
	Acetoacetate utilized (μmole/gm./hr.)			
Control	—	—	—	*$t = 3{\cdot}18$
Acetoacetate	32·1 ± 15·5	26·7 ± 21·8	21·4 ± 16·9	$P < 0{\cdot}01$

The results were not, however, beyond doubt, in that proof of the formation of 'excess' lactate depends on the determination of the uptake of glucose, initial glycogen-content, final glycogen-content and lactic acid production, all of which values are subject to error. It was decided to repeat the experiments with a system which could be stripped of carbohydrate before adding the lactate precursor. The isolated perfused rat heart was found very suitable.

Hearts from fasted rats weighing 150–180 gm. were perfused, essentially according to the method of Bleehen and Fisher[4], in an apparatus which permitted the replacement of all the circulating perfusate when desired. Glucose was added to the perfusion fluid while the heart was being established; the fluid was then changed to one without glucose. After perfusion for 30 min. with this solution, the heart glycogen, which was initially 20·6 ± 4·2 μmoles/gm., had fallen to 3·7 ± 1·6 μmoles/gm. (mean values), and lactate had ceased to enter the perfusion fluid. There was indeed evidence of a slow disappearance of lactate, presumably by oxidation, towards the end of the period (Fig. 1). A second group of hearts was perfused for three periods: for 20 min. with Ringer + glucose; for 30 min. with Ringer − glucose; and for 30 min. with Ringer − glucose ± acetoacetate (0·01 *M*). The results are shown in Table 1.

Six of the ten hearts perfused with acetoacetate produced significantly more lactate during the first 10 min. of period 3; the average production for the whole group was 11·2 μmole/gm./hr. more than ten controls. Production fell off during the next 20 min. and a slow disappearance of lactate began (Fig. 1).

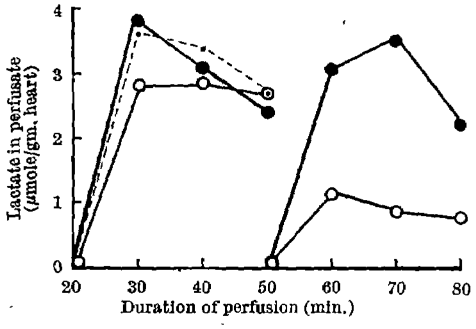

Fig. 1. Production of lactate by perfused hearts: perfusate changed at 20 and 30 min. ○—○, Control; ●—●, acetoacetate in period 3; ● - - - ●, hearts stopped at 50 min.

Simultaneously, the rate of uptake of acetoacetate fell off. There was always significantly more lactate in the perfused fluid when acetoacetate was present. The only carbohydrate sources for this lactic acid were from glycogen, which fell from 3·7 μmoles/gm. at 50 min. to 2·7 (2·8) μmoles/gm. at 80 min., accounting for 2·0 μmoles/gm. lactate, and intracellular lactate. By experiment, the intracellular lactate contents of hearts at the end of period 2 was found to be 4·8 ± 1·9 μmoles/gm. This, together with glycolysis, could just account for the lactate produced by the control hearts, but it is concluded that the extra lactate in the acetoacetate – perfused hearts can only have come from this substrate.

The significance of lactate may be that pyruvate reduction is coupled with succinate synthesis by means of reduced diphosphopyridine nucleotide, and so drives reaction (1) from left to right. Capraro and Milla[7] found that the injection of acetoacetate or β-hydroxybutyrate into dogs was followed by an almost immediate rise in blood lactate; Nath and Chakrabarti[8] reported that daily injection of acetoacetate over a period of time caused a gradual rise in the blood lactate-level in rabbits. In the present experiments, perfusion with acetoacetate did not alter the glycogen content of the hearts, so that there was no direct synthesis of glucose from acetoacetate in the muscle itself; it appears to be generally agreed that the heart cannot synthesize glycogen from exogenous lactate[9] at least. However, in the intact animal, glycogen can be synthesized from lactate in the liver, so that a synthesis of glucose from fat would be possible by means of a cycle running from liver to muscle to liver, in ketotic organisms. Recent experiments[10] on feeding high-fat diets to obese human subjects can be explained in these terms. Gluconeogenesis by such a mechanism can only be important, of course, in extreme conditions of starvation or diabetes when the level of ketone bodies in the blood is much above normal.

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Removal of Internally Deposited Plutonium

ATTEMPTS to remove plutonium from the mammalian system may be placed in two categories: (1) prevention of deposition by treatment within eight hours after exposure to plutonium and (2) removal of plutonium after it has become 'fixed' in the tissues. Zirconium citrate and ethylenediamine tetraacetic acid have been used with some success in the first category but with only limited success in removing firmly bound plutonium[1]. Among compounds tested in this laboratory, diethylenetriamine

Table 1. EFFECT OF CHELATING AGENTS ON PLUTONIUM DEPOSITION AND REMOVAL AS PERCENTAGE OF DOSE ADMINISTERED PER GRAM OF DRY TISSUE

The dosage was 0·3 m.mole per rat of each material with 0·2 m.mole calcium gluconate being administered with the chelating agent. There were 6–10 rats in each group. Results include the 95 per cent confidence interval around the mean

Treatment	Concentration in the tissue			
	Bone	Liver	Spleen	Kidney
Category 1 (Prevention of deposition)				
Saline controls	6·6 ±0·5	9·1 ±1·4	18·0 ±2·0	2·4 ±0·1
Ethylenediamine tetraacetic acid	4·6 ±0·3	4·9 ±0·7	10·7 ±2·2	1·4 ±0·1
Diethylenetriamine pentaacetic acid	0·87±0·06	2·7± 0·3	2·4 ±0·3	1·6 ±0·2
Category 2 (Removal)				
Saline controls	7·8 ±0·9	1·8 ±0·4	2·9 ±0·6	0·60±0·13
Ethylenediamine tetraacetic acid	6·3 ±0·6	1·2 ±0·2	1·2 ±0·2	0·45±0·10
Diethylenetriamine pentaacetic acid	4·0 ±0·2	0·23±0·04	0·93±0·26	0·30±0·10

pentaacetic acid has proved to be superior in both categories.

Adult Sprague–Dawley rats were injected intravenously with about 1 μc. of plutonium as the citrate. A single, intraperitoneal treatment was administered 1 hr. after the plutonium in the category 1 experiment, whereas several treatments a week, beginning 38 days after the plutonium injection and running for four weeks, were given in the removal experiment. Rats in the category 1 experiments were killed two days after the plutonium injection, and in the long-term experiment on the sixty-fourth day.

As shown in Table 1, diethylenetriamine pentaacetic acid is consistently more efficient than ethylenediamine tetraacetic acid in eliminating plutonium. The prompt administration of the former reduced the skeletal plutonium content from 61 per cent of the administered dose in the controls to about 9 per cent, whereas animals treated with the latter retained 44 per cent of the administered dose. The relatively poor results obtaining by administering diethylenetriamine pentaacetic acid promptly in preventing deposition in the kidney may be due to the short duration of the experiment (two days), since in longer experiments it was more effective than ethylenediamine tetraacetic acid in removing plutonium from the kidney. Its effectiveness as a therapeutic agent is also indicated in the removal of firmly bound plutonium. The four-weeks treatment reduced the plutonium content of bone by about one-half, and also markedly reduced the plutonium content of soft tissues. It should be noted that these experiments are of a comparative nature and do not represent treatment at the maximum tolerated dose, which is about three times that used here.

A more detailed account of these and other studies on plutonium detoxification will be published elsewhere. I am grateful to B. D. Chubb and the other assistants of the Metabolism Operation for their help on these experiments. The diethylenetriamine pentaacetic acid was supplied through the courtesy of the Geigy Chemical Corporation, Ardsley, New York. This work was performed under Contract No. *W*-31-109-*Eng*-52 between the Atomic Energy Commission and the General Electric Company.

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Molecular Weight of Condensed Tannins as a Factor determining their Affinity for Collagen

EXAMINATION of the chemical principles of vegetable tanning[1] has led to various considerations of the nature of the bonds between tannin and collagen; to an examination of the possible 'active sites' of tannin fixation on the collagen chain, and to the quantitative study of tannin uptake in relation to the swelling of collagen[2]. The critical function of the different tannins normally present in any extract mixture in determining the quantitative and qualitative aspects of tannin affinity for collagen[3] was, however, largely overlooked in work emphasizing those important aspects listed above.

From a study of the relation between chromatographic behaviour and average molecular weight of 'condensed' tannin fractions, Evelyn and I (unpublished work) have recently found that in aqueous medium a gradational increase in molecular weight with decrease of R_F occurs over the ranges 550–3,200 for black wattle bark tannins (*Acacia mollissima*) and 790–2,350 for quebracho heartwood tannins (*Schinopsis* spp.). Similar behaviour also occurs in the 'partitioning' mixture *n*-butanol/acetic acid/water (6 : 1 : 2). We find, both under conditions of 'adsorption' and 'partition', that a linear relation exists between the average molecular weight of these typical 'condensed' tannin fractions and their R_M $\left(\text{defined as } \log\left(\frac{1}{R_F} - 1\right)\right)$ values.

I previously directed attention[3] to the parallel between the chromatographic behaviour of wattle tannin constituents on collagen columns and on paper chromatograms. These constituents also show the same relative affinities for various modified collagen substrates as for cellulose[4]. This similarity of behaviour of condensed tannins towards such widely differing substrates is further reflected in the low chromatographic affinities of catechins, flavan-3 : 4-diols (monomeric leuco-anthocyanins) and wattle 'polyphenolic non-tannins' for both collagen and cellulose, and also in the parallel increase in relative affinity resulting from the atmospheric oxidation of these substances[5]. This indicates the predominant effect of the nature of the tannins in determining their relative affinities for any substrate, in much the same way as the constitution of closely related dyes determines their affinity for cellulose and other natural materials[1,7].

The almost exact parallel between the relative affinities in aqueous medium (as reflected by 'adsorption' chromatographic behaviour) of condensed tannin constituents for cellulose, collagen and modified collagens, and the linear relation between their R_M values on cellulose and their average molecular weights, suggest that a similar relationship also exists between the R_M values on collagen columns and molecular weight. This has been partly confirmed by Evelyn (unpublished work), who established a direct relation between the average molecular weight of wattle tannin fractions and the proportion of 'irreversibly fixed' tannins in leather tanned with these fractions. Page[8] has also shown that the stoichiometric relationship of the combination of gelatin with various wattle tannin fractions (obtained by fractional precipitation from aqueous solution with salt) varies from the least soluble to the most soluble fractions. The gradational decrease in the 'gelatin number' he surmised to be due to a decrease in the molecular weight of the tannins and, in relation to our more recent findings, it also emphasizes the importance of the tannins in determining the 'affinity' between tannin and collagen. Peters and Sumner[7] found a correlation between the molecular weight of aminoanthaquinones and their chemical affinities for cellulose. The lower affinity of monomeric leuco-anthocyanins and catechins (phenolic 'non-tannins'), compared with that of naturally occurring complex leuco-anthocyanins[9] and polymeric catechins[10] ('tannins'), for hide powder during estimation of tannin appears to be due to the low molecular weight of the former (±300) in comparison with the latter (550–3,200). Following atmospheric oxidation, other factors, for example, the presence of quinonoid groups, increase their affinity.

The relation between R_M and molecular weight suggests the operation of physical forces between tannins and cellulose or collagen. This appears to be in line with the increasing emphasis on the importance of van der Waals forces between cellulose and various solutes, such as dyes[7,11]. Tannin mechanisms are, however, exceptionally complex, and hydrogen-bond forces undoubtedly play an important part[13] in the swelling of the hide, in the sorption and de-sorption of tannins, and possibly also in their fixation to collagen.

On the basis of the above work, it has been found possible to use paper chromatography as a method of interpreting the relative affinities of wattle and quebracho tannins for collagen. Planar 'flavonoid' compounds, for example, flavones, flavanols, anthocyanidins, aurones and chalkones[3,12], are exceptions, due to their abnormally high affinity for cellulose in aqueous medium.

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Gas Chromatographic Separation of *Meta*- and *Para*-Xylenes in Aromatic Mixtures

THE xylene isomers have resisted all previous attempts at resolution by gas-liquid chromatography. An approach to their separation was made recently by Scott and Cheshire[1], who used a column with a calculated efficiency of 12,000 theoretical plates. Indeed, the chromatogram showed a very slight separation for *meta*- and *para*-xylene.

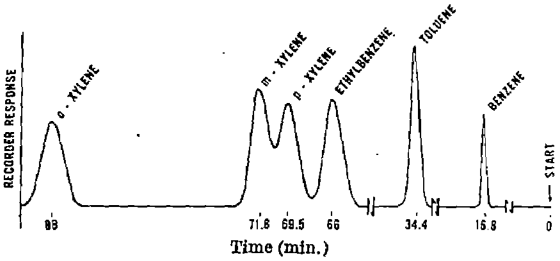

Fig. 1. Chromatogram of mixture of aromatics

The work reported here makes use of an aromatic hydrocarbon as the stationary liquid for effecting this difficult separation. Fig. 1 shows the resolution of a mixture of benzene, toluene, ethylbenzene, *ortho*-xylene, *meta*-xylene and *para*-xylene. Conditions for the separation were as follows:

Instrument	'Model 188' vapour fractometer
Column dimensions	5 m. × 5 mm.
Column temperature	100° C.
Stationary liquid	15 per cent w/w benzyldiphenyl (May and Baker Co.)
Column support	60–80 mesh 'Chromosorb' (Johns-Manville Co.)
Carrier gas	Helium
Carrier gas inlet pressure	59 lb./in.^{2}
Carrier gas flow	100 cm.^{3}/min.
Sample charge	0·005 ml.
No. of theoretical plates	9,500
Time of analysis	93 min.

The specificity of benzyldiphenyl and the high pressure-drop across the column permit the accomplishment of this separation in a reasonable time with columns of standard length and high efficiency. Sample sizes should, of course, be minimized.

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Crystal Structure of Chabazite, a Molecular Sieve

THE 'molecular-sieve' properties of chabazite, a zeolite occurring in basaltic rocks, have been studied extensively. Molecules such as argon (diameter 3·84 A.) and methane (4·25 A.) are rapidly sorbed in the dehydrated zeolite; propane (width 4·9 A.) and *n*-butane are slowly sorbed, while *iso*-butane (5·6 A.) is excluded. A crystal structure was proposed by Wyart[1] in 1933, which consists of a three-dimensional framework of four- and six-membered rings of $(Si,Al)O_4$ tetrahedra (Fig. 1*a*). The rings form two cages per unit cell, the cages sharing six-membered rings which provide apertures of maximum dimension

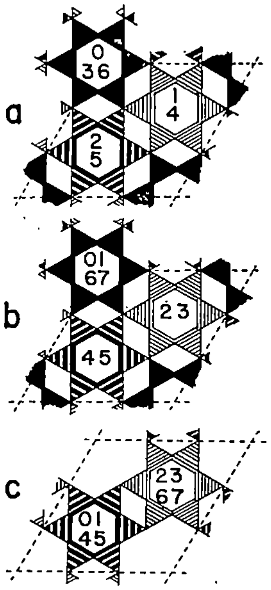

Fig. 1. Diagram to show stacking of six-membered rings of (Si,Al)O_4 tetrahedra in (*a*) Wyart's structure for chabazite, (*b*) the new structure for chabazite, (*c*) gmelinite. Different shading of the rings indicates different heights and the numerals represent the heights of the rings in which they occur, expressed as multiples of 2·5 A. In (*b*) and (*c*) each six-membered ring is linked directly to one immediately above or below it, forming hexagonal prisms. In (*a*) all linkages go outwards from the ring and hexagonal prisms are not formed. All the arrangements are idealized, especially in (*a*)

2·9 A. if the usual Si—O and Al—O distances are used, and 3·1 A. if the somewhat unusual distances in Wyart's structure are adopted. Although Kington and Laing[2] have interpreted the sorptive properties of chabazite in terms of Wyart's structure, the agreement can scarcely be regarded as satisfactory when a molecule of minimum dimension 4·25 A. passes easily through an aperture of diameter 2·9–3·1 A. As the structure of chabazite was proposed in the early days of crystal structure determination further investigation appeared desirable.

Using Fourier methods, a new structure has been determined which explains the X-ray intensities, the sorption and epitaxial intergrowth with the mineral gmelinite. The chabazite specimen contains two units of $(Ca_{0\cdot90}Na_{0\cdot15})$ $(Si_{4\cdot05}Al_{1\cdot95})_6O_{12}\cdot 6H_2O$ in a trigonal cell of symmetry $R\,\bar{3}m$ (or nearly so) and $a = 9\cdot40$ A., $\alpha = 94°\ 18'$. The positions of the silicon, aluminium and oxygen atoms are approximately:

Si,Al	0·34,	0·11,	−0·12
O_1	0·27,	−0·27,	0·00
O_2	0·17,	−0·17,	0·50
O_3	0·25,	0·25,	0·90
O_4	0·03,	0·03,	0·35

At the present stage of refinement, the distances (Si, Al)—O range from 1·63 to 1·68 A. and the O—O distances from 2·62 to 2·82 A., in excellent agreement with the standard values. From the positions of the silicon and aluminium atoms shown in Fig. 2 the nature of the framework may be seen. The new structure is built up of double six-membered rings (Fig. 1*b*) forming one 'cage' per unit cell. Each cage has six octagonal, two hexagonal and twelve quadrilateral faces, and is connected to the six neighbouring cages by eight-membered rings, permitting sorption in all directions, but limiting it by the octagonal (non-planar) apertures of minimum width about 3·9 A. Although the present work is being carried out on a hydrated specimen and the cavities are filled with water molecules and calcium ions, the framework is expected to differ only slightly in the dehydrated state and the size of the aperture should not change by more than 0·2 A. When thermal vibration is considered, the new structure gives an excellent explanation of the observed sorptive properties. The co-ordinates of all the atoms are being refined by successive Fourier series, and results for a dehydrated chabazite held at 300° C. in a stream of nitrogen are being collected in order to determine the movements of the framework and the calcium atoms as a result of dehydration.

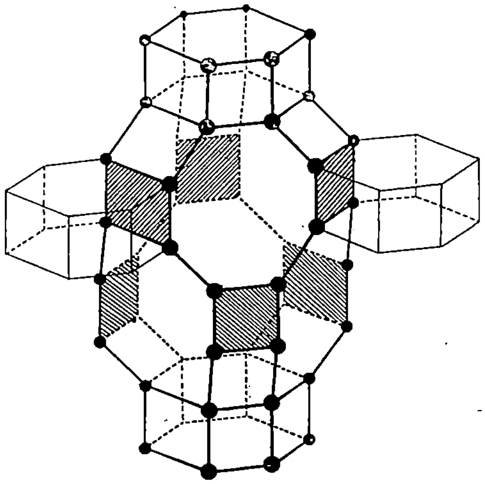

Fig. 2. The positions of the Si,Al atoms in chabazite. Shaded quadrilaterals represent points of attachment of hexagonal prisms, four of which are shown

Further confirmation of the validity of the structure arises from the ready interpretation that may be placed on the chabazite-gmelinite intergrowths. It has been pointed out[3] that not only are the hexagonal *a*-axes of the two minerals identical and the *c*-axes in the ratio of 3 : 2 but also that the two form oriented intergrowths, with streaks parallel to *c* joining the reflexions. The *c*-axis projection of gmelinite has been determined by O'Daniel and Fischer[4] and idealized in Fig. 1*c*. The *z* co-ordinates were not given, but it seems likely that they are as shown. The relationship of the stacking of the double rings in chabazite and gmelinite would be of cubic to hexagonal close-packing, and the intergrowths and diffuse streaks would be the result of stacking faults.

Such a structure for gmelinite would have channels the narrowest parts of which were twelve-membered rings, and it would be expected that gmelinite would sorb some *iso*-paraffins and aromatics. Barrer[5], however, reports that its sorptive properties are similar to those of chabazite, which excludes *iso*-paraffins and aromatics. One possible explanation of this anomaly is that Barrer's specimen (for which no X-ray data or locality were given) may have contained intergrown chabazite, or have been somewhat disordered; for either of which, sorption would be mainly limited by the eight-membered rings of chabazite. A second possibility is that the sodium ions of gmelinite may partially block the apertures, reducing the effective channel to the size of that in chabazite.

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Similarities in the Characteristics of Solar Radiation at λ 10·7 cm. and in the Far Ultra-violet

Denisse and Kundu[1] have directed attention to the close relation between the variations of two indices of the solar cycle which represent the flux of two different types of solar radiation. The first index ($Ch_E = f^4 \sec \chi$) is based on the monthly mean critical frequency (f) of the E-layer at noon at Freiburg (Germany); it is assumed to be proportional to the flux of the ultra-violet and X-radiation of solar origin which is responsible for the atmospheric ionization at heights near 120 km. The second index is the monthly mean value (Φ) of the solar radio-noise flux at λ 10·7 cm., measured at Ottawa, which is available from February 1947 onwards. Denisse and Kundu conclude that the two types of radiation are produced, if not by the same mechanism, at least under closely correlated conditions.

We have recently examined the characteristics of a number of indices of solar activity including both Ch_E, calculated using E-layer data for Slough (England), and Φ. We have confirmed that the correlation between the two indices is high ($r = 0{\cdot}90$), but we have also found that it is even higher if the data for each month are considered separately ($r_{\max.} = 0{\cdot}99$).

From Table 1, it can be seen that r is greater than 0·90, the value for all months taken together, in eleven out of twelve months. It may be inferred from this result that the correlation coefficient for individual months is significantly greater than that for all months considered together; the probability that the observed result occurred by chance is 3×10^{-3}.

The reason for the result just mentioned is that although the magnitude of Ch_E is controlled mainly by the flux of ionizing radiation, it also contains a small complicated seasonal component. For this reason, uncorrected values of Ch_E ought not to be assumed to be accurately proportional to the flux of the incident radiation. The seasonal component varies in amplitude with the level of solar activity, but a method of eliminating it has been devised and will be described elsewhere.

Table 1. CORRELATION COEFFICIENT (r) BETWEEN Ch_E (SLOUGH) AND Φ (OTTAWA). FEBRUARY 1947–DECEMBER 1956

Month	r
January	0·99
February	0·95
March	0·87
April	0·93
May	0·95
June	0·93
July	0·98
August	0·91
September	0·97
October	0·96
November	0·97
December	0·99
All months	0·90

A further similarity between the characteristics of the ionizing radiation and radio noise at λ 10·7 cm. is evident if the non-uniformity in the brightness of the Sun's disk at the two wave-lengths is studied when the disk is undisturbed. Such a study was possible during the eclipse of June 1954, when the Sun was unusually quiet and there were no localized active areas on the disk. During this eclipse, ionospheric measurements were made in the United Kingdom[2] and in Norway[3], and radio-noise measurements were made in Canada[4]. From these results it has been possible to make estimates of the relative brightness of the disk near the poles and near the east and west limbs, and the agreement between the ionospheric and the radio-noise results is quite striking[5] (Table 2).

Table 2. RELATIVE BRIGHTNESS OF THE EAST LIMB OF THE SUN AND THE POLAR REGIONS REFERRED TO THE CENTRE OF DISK (JUNE 30, 1954)

Type of measurement	East limb	Poles
Ionosphere ($F1$ layer)	1·8	0·86
Radio-noise (λ 10·7 cm.)	1·5	0·91

The results summarized in Tables 1 and 2 appear to confirm the conclusion reached by Denisse and Kundu; but it is probably premature to speculate on the precise reasons for the observed similarities in the characteristics of the two types of radiation.

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'Whistlers' in the Antarctic

'WHISTLERS' are being heard consistently at Scott Base, the New Zealand International Geophysical Year Antarctic Station, McMurdo Sound. From the time observations commenced on April 15 until the time of writing considerable activity has been observed, including 'bonks', 'tweeks', short and long 'whistlers', whistler trains, and periods of strong 'sferics'. No dawn chorus has yet been observed.

The geomagnetic co-ordinates of Scott Base are 79° 15′ S., 294° 30′ E. The base is located approximately 1,200 km. north-east of the geomagnetic pole and approximately 1,250 km. south-east of the dip pole. It is believed that this is the first time that whistlers have been heard in such a high geomagnetic latitude.

The whistlers appear to have dispersion characteristics similar to those heard in lower geomagnetic latitudes. However, the characteristics cannot be truly determined until tape recordings of them are sent to New Zealand for spectrographic analysis, at the end of the Antarctic winter.

Maximum activity occurred on April 15, 16, 19, 20 and 23. No consistent diurnal variation in activity has been noted. On all occasions of strong whistler activity the local geomagnetic activity has been moderate or quiet and the ionosphere undisturbed. During an intense auroral display no activity was heard, nor has any correlation been observed with visible meteor showers.

It seems most improbable that the whistlers heard here are propagated along the dipole field passing through Scott Base, as the lines of force in this case would extend to 24 Earth radii above the magnetic equator, and the gyro-frequency would be in the vicinity of 100 c./s.

Distortion of the dipole field by a strong equatorial ring current could possibly allow whistler propagation along lines of force between conjugate points in high geomagnetic latitudes. This hypothesis, however, does not seem tenable when it is considered that periods of maximum whistler activity at Scott Base have so far occurred during quiet magnetic conditions.

There is no record of lightning discharges being observed in high polar latitudes, and it seems improbable that these could occur as there is insufficient thermal radiation from the Sun to produce the necessary air movements. In these regions there appear to be no natural phenomena capable of initiating whistlers.

During the period that whistlers and 'sferics' have been heard an intense and electrically active low-pressure area has existed some 3,000 km. north of Scott Base. Many of the noises heard could undoubtedly have originated in this area. It is probable that the whistlers heard at Scott Base are propagated from lower latitude regions, first along the appropriate magnetic flux line, and then by reflexion from the lower ionosphere.

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Scott Base, Ross Dependency.
April 30.

Visibility of Noise on Television Pictures

In investigations of the visibility of random noise in television pictures[1,2], it has been found that for narrow-band noise which is just visible the required noise power increases by about 20 db. as the centre frequency is raised from 0·15 to 2 Mc./s. For frequencies between 2 and 3 Mc./s., the noise power remains nearly constant[1], or shows a small fall[2]. It has been suggested[1] that this may be because of the generation of intermodulation products of low-frequency noise, due to the non-linearity of the voltage/brightness characteristic of the television tube. These low-frequency products should be much easier to see than the original high-frequency noise. It follows that the non-linearity should also affect visibility of noise if a sinusoidal signal, together with noise, is applied to the tube control-grid. In this case, sum and difference frequencies of the signal and noise should be produced. An experiment which appears to demonstrate the expected intermodulation effect has been carried out.

A normal television raster was displayed on the tube of a television monitor, the monitor being adjusted so that zero-level signal at the video amplifier input, that is, 0·7-V. double-amplitude peak, produced a brightness excursion between subjective black and peak white. A sinusoidal signal and random noise were then applied at the video amplifier input. The root-mean-square level of the noise, set at −40 db., was obtained by subtraction of 17 db. from oscilloscope measurement of the quasi peak-to-peak level[1] relative to 0·7-V. double-amplitude peak. This noise-level was quite low, but fairly representative for television. The noise band had a sharp top-cut at 3 Mc./s., and extended down to about 50 c./s. The noise was either 'white' (uniform power distribution over the frequency band) or 'quasi-triangular' (power per unit band-width increasing with frequency). The following results were practically independent of tube brightness setting. The visibility of 'white' noise appeared to be unaffected by presence of the sinusoidal signal, although the signal was increased to zero-level, and the frequency varied between 0·1 and 3 Mc./s. However, application of a sinusoidal signal of small amplitude drastically increased the visibility of 'quasi-triangular' noise. Visibility of noise increased with signal-level and, for a fixed level, maximum visibility occurred at a particular signal frequency f_s. This frequency was between 2·5 and 2·9 Mc./s., and increased as the noise spectrum was increasingly peaked at the higher frequencies. As the signal frequency was shifted towards f_s, from either above or below, the noise became progressively coarser in appearance. This was presumably because the approach of f_s to the mean 'carrier' frequency of the noise tended to give the noise envelope as the difference intermodulation product. For the 'quasi-triangular' noise spectrum of Fig. 1, an appreciable increase in visibility of noise was produced by application of a −40 db. signal, f_s being 2·9 Mc./s.

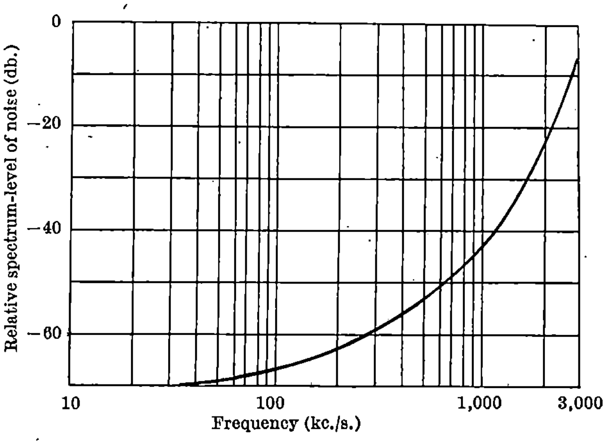

Fig. 1

Further details of this experiment, and others concerned with the effect of non-linearity on noise in television, will be published elsewhere. I wish to thank the Director of Engineering of the British Broadcasting Corporation for permission to publish this communication, and the head of the Designs Department under whose direction the work was carried out.

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Repetitive Stimulation of Muscle

During a study of the effects of repetitive stimulation on the intracellular electrical activity of frog sartorius muscle fibres, alterations were noticed in the voltages of the second and subsequent spikes. At the same time, there was a progressive decrease in $t_{1/2}$ after-potential following the second and following spikes. All the experiments were performed on the green frog *Hyla coerulea* at a temperature of 22° C.

In preliminary experiments, the frequency of stimulation was increased from 10/sec. to 330/sec., which was the maximum frequency the muscle would follow on indirect stimulation. Up to a frequency of approximately 140/sec., spike voltage and duration remained of normal dimensions, and the $t_{1/2}$ after-potential was not appreciably altered after multiple spikes. Above this frequency, important changes were produced in spike voltages and durations, and $t_{1/2}$ after-potential. Fig. 1 shows the records obtained in a single muscle fibre with a progressively increasing number of stimuli at a frequency of 200/sec. A single muscle spike is followed by a negative after-potential of 13–17 mV., with a $t_{1/2}$ value of 13–18 m.sec. A second impulse 5 m.sec. later causes a reduction in the spike voltage, an increase in spike duration, and a shortening of the after-potential. As the number of spikes is increased, spike voltage decreases further until approximately the sixth spike, when a constant voltage is maintained for following spikes. At the same time, $t_{1/2}$ after-potential decreases until it reaches 6 m.sec., in this record, after the eleventh spike. Generally, once a $t_{1/2}$ of 6 m.sec. had been reached, no more spikes could be elicited. These results were repeated in many fibres, and all showed the same general trend of reduction in spike voltage and $t_{1/2}$ after-potential to limiting values which were constant for each muscle studied. Voltage of the negative after-potential did not appreciably alter as the number of stimuli was increased.

Experimental procedures which altered the $t_{1/2}$ after-potential, such as varying external concentrations of potassium, sodium and calcium ions, decreased or increased the number of spikes necessary to produce a $t_{1/2}$ of 6 m.sec. In all experimental conditions, a $t_{1/2}$ value of 6 m.sec. was reached.

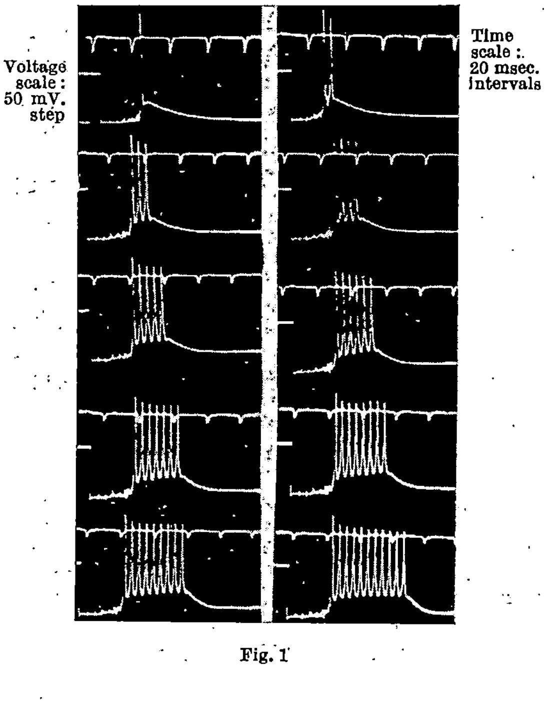

Fig. 1

It is thought that the progressive shortening of the after-potential is due to an accumulation of potassium ions immediately outside the muscle fibres.

Publication of details of this work will follow after these preliminary observations have been more fully studied.

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Electrical Responses of Neuron Cell-Bodies in Sodium-free Media

The electrical activity of frog spinal ganglion cells is maintained, and even enhanced, when the external sodium has been totally replaced by equimolar amounts of either choline or tetraethylammonium[1]. Further investigations suggested that quaternary ammonium ions do not actually substitute for sodium as carriers of the action current, but probably exert a pharmacological action on the membrane or in the perikaryon[2].

A new series of experiments were performed to assess the effects on frog spinal ganglion cells of other related compounds which maintain the excitability of frog nerve fibres[3] or crab muscle fibres[4] deficient in sodium. The various solutions used contained, in addition to the amount of the drug tested, 1·8 m*M* calcium, 2 m*M* potassium, and sucrose to make up isotonicity (*p*H 6·4–7·0).

Sodium-free 112 m*M* solutions of tetramethylammonium, diethanol-dimethylammonium and acetylcholine chlorides had effects similar to those of a 112 m*M* choline chloride solution. A sodium-free 5–10 m*M* solution of tetrabutylammonium chloride maintained the excitability of a number of cells, but higher concentrations irreversibly depolarized and blocked them. A sodium-free 112 m*M* solution of ammonium chloride (*p*H adjusted to 7·0) exerted a powerful depolarizing action on the cells, but overshooting and prolonged electrical responses were obtained with 25 m*M*, although the resting potential still had a low value. A sodium-free 112 m*M* solution of guanidine hydrochloride maintained the excitability of the cells though the latter were slightly depolarized in this medium. A sodium-free 112 m*M* solution of hydrazine (*p*H adjusted to 6·4) had a very characteristic effect on the cell-body, as compared with the other onium ions. The configuration of the action potentials obtained in this medium was practically indistinguishable from that of responses in normal Ringer. Action potentials could be evoked by 'direct' and also by 'indirect' (that is, by propagated nerve impulses) stimulation.

With the exception of hydrazinium ion, the various active onium ions used in sodium-free solutions produced action potentials with a characteristic configuration (namely, peak, plateau, slow falling-phase), different from the 'normal' brief spikes recorded in Ringer's solution. The duration of the electrical responses, more than their peak height or rate of rise, was dependent on the kind and concentration of the drug applied. These prolonged action potentials might be considered as a particular, 'abnormal' manifestation of electrical activity induced by drugs. However, the striking similarity between 'hydrazinium spikes' and 'sodium spikes' suggests a single mechanism underlying the production of at least both brief responses, and apparently denies the exclusive necessity of external sodium for the generation of a 'normal' type of action potential in spinal ganglion cells. Moreover, it seems reasonable to assume that hydrazinium ion acts in the same way as the other onium ions, and it is not responsible for the actual transport of charge[2]. Electrical activity in the sodium-free media also seems unrelated to sodium entry, although the possibility of a partial retention of this ion in the extracellular spaces cannot be dismissed altogether. Calcium ions do not seem to play a direct part in the generation of electrical activity (Koketsu, K., Cerf, J. A., and Nishi, S., unpublished work). It could be suggested that hydrazinium and other onium ions condition the excitatory reaction and play an indirect part in the generation of electrical activity. The shape of the action potentials produced would depend on the ion species, however, and all intermediates can actually be recognized between the brief 'sodium' or 'hydrazinium spikes' and the prolonged 'tetraethylammonium' and 'tetrabutylammonium potentials'. It can be noted in this connexion that a moderate lengthening of the action potential, with appearance of a slight hump on the falling-phase, was occasionally observed in normal Ringer.

We wish to thank Dr. R. Lorente de Nó, of the Rockefeller Institute for Medical Research, for kindly supplying most of the drugs used in this study, and for his valuable suggestions.

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Anomalous Bactericidal Action of Bromamine

As part of an investigation on the properties of the bromamines, their bactericidal efficiency was examined. These compounds are formed during the chlorination of sea water swimming pools in the presence of ammonia[1] and also in fresh water where bromine and not chlorine is used to sterilize the water.

Houghton[2] has made some studies of the bactericidal effects of solutions prepared by the action of chlorine on solutions containing ammonium salts and bromide ions, and found that these solutions were more efficient in destroying bacteria than were solutions containing only chloramine.

I have shown spectrophotometrically that solutions so prepared contain mainly monochloramine together with some monobromamine[1]. Experiments were accordingly made to determine the bactericidal effect of pure monobromamine relative to pure monochloramine.

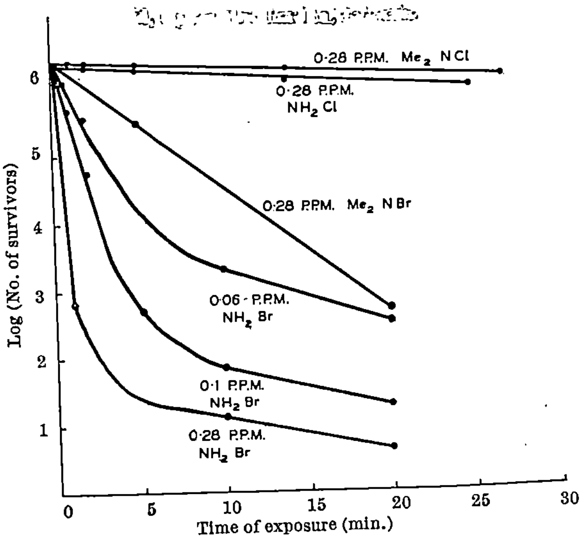

Fig. 1

Solutions of the amines were prepared by adding excess ammonium sulphate to solutions of hypochlorite for mono-chloramine, and to solutions of hypobromite for mono-bromamine. The solutions were buffered to approximately *p*H 8·2 with bicarbonate. 1-litre quantities of these solutions were treated with suspensions of *Escherichia coli* type 1, wild strain (from 18-hr. cultures that had been well washed), to give a cell density in the solutions of approximately 10^7/ml. Aliquots were taken after 1, 2, 5, 10 and 20 min. and pipetted into 0·5 per cent solution of sodium thiosulphate. The numbers of viable bacteria were then estimated by conventional plate counts and the results were plotted as the logarithm of the number of survivors against time.

For monochloramine the plot gave the expected linear relationship, but for monobromamine the curve showed a sharp break between 2 and 5 min., after which the rate became more linear and slower (Fig. 1). Amperometric determination of the halogen remaining after the experiments showed very little loss.

Unpublished work has shown that monobromamine reacts with dimethylamine even in the presence of a substantial excess of ammonium ion, and it was thought likely that a reaction of the type:

$$\text{(Bacterial)}\ -R_2NH + NH_2Br \rightarrow R_2NBr + NH_3 \quad (1)$$

took place. Accordingly, N-chlorodimethylamine and N-bromodimethylamine were prepared as described, substituting dimethylamine hydrochloride for the ammonium sulphate; and tested for their bactericidal action. For both the chloro- and the bromo-compounds the plot of the logarithm of the survivors against time was linear, the bromo-compound acting more rapidly than the chloro-compound.

The pK_a values of the monobromamine and monochloramine are respectively 6·5 (unpublished work) and 1·0 (ref. 3), and thus at the experimental *p*H value nearly 1 per cent of the bromo-compound is present as the monobromammonium ion (NH_3Br^+), which will have a strong tendency to react as follows:

$$NH_3Br^+ \rightarrow NH_3 + Br^+ \quad (2)$$

whereas monochloramine will have only an extremely small amount of the monochlorammonium ion (NH_3Cl^+) present: one part in 10^7 of the chloro-compound present.

The presence of this considerable amount of monobromammonium ion would account for the strong bactericidal properties of the bromo-compound, and further it would facilitate the exchange reactions as exemplified in reaction 1, the nitrogenous substances originating from the bacterial tissue.

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Infectivity of Ribonucleic Acid from Mouse Brains infected with Semliki Forest Virus

EVIDENCE has been recently presented to show that the ribonucleic acids isolated by phenol extraction from tobacco mosaic virus[1], from ascites tumour cells in mice infected with Mengo encephalitis virus[2] and from mouse brains with Eastern equine encephalitis virus[3] are infectious. In the present communication, the infectivity of the ribonucleic acid isolated from the brains of mice infected with Semliki Forest virus is reported. This virus can also multiply in mosquitoes[4] but causes no known human disease.

Three-day-old Swiss mice were inoculated intracerebrally with 0·02 ml. of a 10^{-4} dilution of a homogenate of mouse brain infected with Semliki Forest virus. One day after infection, the brains were harvested, frozen in 'dry-ice'–ethanol and homogenized with 0·14 *M* sodium chloride–0·01 *M* sodium phosphate, *p*H 7·0, to give a 10 per cent homogenate. The supernatant is here designated as 'virus preparation'.

The ribonucleic acid was prepared by phenol extraction and precipitated twice with 65 per cent ethanol and once with 1 *M* sodium chloride following the procedures of Wecker and Schäfer[3]. The final precipitate was resuspended in phosphate buffer to a volume equal to that of the original mouse brain before dilution.

Infectivity titres, expressed as *LD*50, were determined by the intracerebral injection of serial 10-fold dilutions in mice, 0·02 ml. for one-day-old mice and 0·03 ml. for 30- to 40-day-old mice. The 10 per cent brain homogenate and the ribonucleic acid preparation were regarded as 10^{-1} and 10^0 dilutions respectively in calculating these titres.

The ribonucleic acid preparation exhibited about 0·1 per cent of the infectivity of the infected brain homogenate from which it was prepared (Table 1). The homogenate of the brains, harvested after infection with 10^{-3} dilution of the ribonucleic acid preparation, fixed complement with anti-Semliki Forest virus serum, an indication that the virus had multiplied in the recipient mice. Thus, the ribonucleic acid preparation contains all genetic information necessary for the production of complete Semliki Forest virus.

The ultra-violet absorption spectrum of the ribonucleic acid preparation was characteristic of nucleic acid, with a maximum at 257 mμ and a minimum at 230 mμ. The ratio between the optical densities was 2·1. Protein could not be detected by the biuret reaction. However, these results do not exclude the possibility that the infectivity might be due to small amounts of contaminating virus particles.

Table 1. COMPARISONS OF SEMLIKI FOREST VIRUS AND RIBONUCLEIC ACID PREPARATIONS

		Log *LD*50	
		Virus preparation	Ribonucleic acid preparation
A	No treatment	6·9	3·8
B	Control	5·5	3·7
	After ribonuclease 50 μgm./ml. 25° C.; 10 min.	5·6	*
	After deoxyribonuclease 50 μgm./ml. 25° C.; 10 min.		3·3
C	Control	3·6	1·9
	After centrifugation (top supernatant)	1·6; 1·6	1·3
D.	Control	6·0	3·5
	After sodium deoxycholate 0·1 per cent; 4° C.; 1 hr.	4·0	3·7
E	Control	4·1	2·3
	After sodium deoxycholate 0·1 per cent; 4° C.; 1 hr.	2·0	2·2

* No mice died at 10^0 dilution

In attributing the observed infectivity to the ribonucleic acid itself, rather than to contamination with intact virus, previous authors have relied on the differential effects of centrifugation and nuclease digestion on crude preparations of virus and ribonucleic acid[2,3] (cf. Table 1, *B* and *C*). In the present investigation, precautions were taken to make the two reaction systems reasonably comparable before repeating the differentiating procedures. The Semliki Forest virus was diluted ten-fold and centrifuged at 40,000*g*. for 1 hr. at 3° C. to remove extraneous tissue material, and the supernatant was diluted with the ribonucleic acid preparation to give an infectivity only one to two hundred times that of the ribonucleic acid system. The concentration of free ribonucleic acid was equal in the two systems.

As shown in Table 1, *B* and *C*, even under these conditions ribonuclease treatment did not reduce the infectivity of the virus preparation, presumably because the ribonucleic acid of the intact virus is protected by its protein coat. Furthermore, centrifugation sufficient to remove 99 per cent of the original infectivity of the Semliki Forest virus preparation reduced the infectivity of the purified ribonucleic acid by only 50 per cent.

In an effort to provide further evidence, the two preparations were exposed to the action of sodium deoxycholate, which has been shown to inactivate many of the arthropod-borne viruses[5]. 99 per cent of Semliki Forest virus was inactivated, but the infectivity of the ribonucleic acid preparation was not affected (Table 1, *D* and *E*).

These results, although not decisive, add to the now impressive body of evidence that the infective entity in ribonucleic acid preparations is ribonucleic acid itself and not a contaminating virus particle.

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Protective Effect of Trace Elements other than Selenium against Dietary Necrotic Liver Degeneration

Rats fed on diets containing certain yeasts as their sole source of protein develop a dietary necrotic liver degeneration, leading to early and rapid death. Necrogenic diets are deficient in three factors, vitamin E [1], cystine [2] and a 'Factor 3' [3], each of which will alone prevent the manifestations of disease. Potent Factor 3 concentrates have been prepared from casein hydrolysates[4] and, recently, Schwarz and Foltz[5] have shown that similar concentrates prepared from kidney powder hydrolysates contain selenium in bound form. Addition of sodium selenite to rat diets (to supply 4 μgm. of selenium per 100 gm. of diet) gave complete protection against death from liver necrosis during the experimental period of thirty days, indicating that selenium might be part of Factor 3. Schwarz and Foltz have inferred that "selenium is an essential trace element".

We were prompted to investigate the addition of certain other trace elements to necrogenic diets, particularly those which, it was considered, might take part in oxidation-reduction mechanisms. Table 1 shows the results obtained by the addition of a number of trace elements at levels below their toxic levels (where these are known)[6]. Lead (alone) and a group of four metals, cerium, mercury, titanium and vanadium (together), were inactive. Molybdenum, osmium and cobalt (together) delayed the deaths by necrosis beyond 130 days in three rats out of seven. In the same test, the protective effect of selenium, cystine and α-tocopherol has been demonstrated. In a second test (Table 2), molybdenum, osmium and cobalt were given separately as well as in combination. Each of the three metals had some activity at the levels employed, but not all the animals receiving the supplement were protected. Further studies are in progress.

Table 1. Effect of Additions to the Neorogenic Diet*

Supplement	p.p.m.	No. of rats †		Remarks
		Total	Alive at 88 days	
Nil		6	0	
Sodium selenite	0·05	7	7	7 alive at 200 days
L-Cystine (0·6 per cent)		7	7	6 ,, ,, ,, ,,
DL-α-Tocopherol acetate (100 mgm./kgm.)		8	8	7 ,, ,, ,, ,,
Lead acetate	0·5	10	1	Survivor died at 89 days
Ammonium molybdate	0·5	7	3	Survivors died at 130, 154 and 170 days
Osmium tetroxide	1·0			
Cobalt sulphate	1·0			
Ceric sulphate	1·0	8	1	Killed. Liver normal
Mercuric chloride	1·0			
Titanous chloride	1·0			
Ammonium metavanadate	5·0			

* Basal diet (per cent): dried bakers' yeast, 30; vitamin E-free lard, 5; sucrose, 55; salts, 5; B vitamins in glucose, 5; vitamins A, D and K orally. The salt mixture contained the following trace elements: iodine, fluorine, copper, manganese and aluminium.

† Norwegian hooded rats.

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Heparin and Christmas Factor

Heparin has been shown to combine with Chargaff's[1] lung thromboplastin, which contains phospholipid. It inhibits the formation of intrinsic plasma thromboplastin[2], and Douglas[3] has shown that it must inhibit blood coagulation at an early stage. Heparin is also known[4] to combine specifically with the β-lipoproteins of plasma or serum and to depress the plasma β-lipoprotein concentration when injected *in vivo*. Christmas factor has been shown to be present in a crude α- and β-globulin fraction of plasma[5] and it may contain phospholipid[7].

A normal thromboplastin generation test was carried out using normal absorbed plasma, serum and platelets but with the prior addition of a suitable concentration (0·85 unit/ml.) of heparin. Little thromboplastin was formed. If the addition of heparin to the normal mixture is delayed until 3 min. after recalcification when the formation of thromboplastin is already maximal, the addition of heparin does not then affect the result; that is, maximal thromboplastin activity persists. Thus it is probable that heparin at this concentration prevents the formation of thromboplastin, but does not prevent its action once it is formed, and does not exhibit

Table 2. Effects of Molybdenum, Osmium and Cobalt

Supplement	Element (p.p.m.)	No. of rats	No. dying	Mean age at death (days)	Range (days)	Survivors at 100 days	Remarks*
Nil		10	9	60	42–92	1	Livers grossly necrotic
Ammonium molybdate	0·5	9	5	50	35–67	4	Post-necrotic scarring in two livers†
Osmium tetroxide	1·0	10	6	58	40–86	4	Livers normal
Cobalt sulphate	1·0	10	6	55	40–78	4	Post-necrotic scarring in one liver
Ammonium molybdate	0·5	9	5	55	37–84	4	Post-necrotic scarring in two livers
Osmium tetroxide	1·0						
Cobalt sulphate	1·0						

* Survivors killed and examined at 100 days.

† In all livers the scarring was confined to the left lobes and was accompanied by enlargement of the right central lobe.

any antithrombic activity in the sub-sample tubes.

Attempts to correct the defect produced by the addition of this critical amount of heparin showed that the addition of excess serum normalized the system. The addition of serum absorbed on alumina, which is deficient in Christmas factor and Factor VII, or the addition of serum from two cases of Christmas disease which is presumably deficient only in Christmas factor, both failed to do so. The addition of toluidine blue and protamine sulphate, both of which prevent the antithrombic activity of heparin, also failed to correct the defect.

A volunteer was given 2,500 units of heparin intravenously. 30 min. later blood was taken and it was found to have a long clotting time, but when mixed with normal plasma it did not prolong the clotting time of the normal plasma. Thus there was probably no free heparin in the volunteer's plasma at this time. In the thromboplastin generation test the volunteer's serum was shown to be abnormal, and this abnormality was corrected by the addition of normal serum diluted 1:10, but not by sera from two cases of Christmas disease similarly diluted. In these tests the volunteer's blood was therefore indistinguishable from that of a case of Christmas disease. It is concluded that heparin, *in vitro* and *in vivo*, may in some way interfere with the formation or the action of serum Christmas factor.

The apparently specific effect of heparin on Christmas factor was compatible with this factor being a lipoprotein. The lipoproteins of normal serum were separated by mixing serum with 20 per cent glycerin and centrifuging for 13 hr. at 170,000*g* in a preparative ultracentrifuge. The supernatant β-lipoprotein was removed and samples of this and the remainder were dialysed free of glycerol and tested in the thromboplastin generation test. The β-lipoprotein was inactive, while the remainder contained the full activity of the original serum. Thus Christmas factor is not in the β-lipoprotein fraction as isolated by this method.

It is concluded that the inhibition of the early stages of blood coagulation *in vitro* by heparin might be due to the action of heparin on Christmas factor. Since the intima of blood vessels may be lined by mucoitin, an acidic muco-polysaccharide like heparin, and since Christmas factor is involved at an early stage in blood coagulation, these tentative conclusions may be related to the inception of thrombosis *in vivo*. Further investigations are in progress.

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Isolation of an Erythropoietic Fraction from the Plasma of Rabbits made severely Anæmic with Phenylhydrazine

The plasma of rabbits made severely anæmic with phenylhydrazine, with less than 3·7 gm. hæmoglobin per 100 ml. of blood, contains erythropoietic material. The erythropoietic activity has been demonstrated in heterologous species, for example, rats[1], mice[2] and dogs[3], in the filtrate obtained after boiling the anæmic rabbit plasma at *p*H 5·5 for a few minutes.

The following procedure has yielded a fraction which, on a protein basis, is 5–10 times more potent than the filtrate of the boiled anæmic plasma. The plasma proteins were precipitated at 5° C. at *p*H 6·0 by the addition of four volumes of saturated ammonium sulphate. The precipitate was extracted with 50 per cent saturated ammonium sulphate, and the soluble fraction was dialysed free of sulphate. Sodium chloride was added to the dialysand to 0·9 per cent, the *p*H of the solution was adjusted to 5·5, after which it was heated at 95–100° C. for 5 min., cooled quickly and filtered. The filtrate was concentrated by lyophilization to one-tenth its volume, dialysed until negative for chloride. The dialysand was concentrated further to a protein concentration of 2 per cent. Seven volumes of saturated ammonium sulphate solution were added to three volumes of the protein solution. The *p*H was brought to 6·0. After standing overnight at 5° C. the solution was filtered. The filtrate was dialysed free of sulphate and dried by lyophilization. 300 mgm. was obtained from 2·8 l. of anæmic plasma.

0·18 mgm. injected subcutaneously into mice daily for three days increased the reticulocytes from 2·1 to 10·2 per cent. 0·75 mgm. injected daily for three days into starved rats increased the uptake of injected iron-59 in the circulating blood to 22·6 per cent. 2·16 mgm. injected daily for two weeks into normal adult rats increased their hæmoglobin from 13·2 to 16·2 gm. per 100 ml. of blood.

When 750 μgm. of the dried material was submitted to electrophoresis on a strip of paper 30 mm. wide (veronal buffer, 0·05 *M*, *p*H 8·6) nearly all the protein material appeared as a broad band, which moved a little slower than serum albumin and faster than α_1-globulin, with a faint trace in the α_2-globulin region.

The dried material was submitted to moving boundary electrophoresis by the method of Mitchell and Herzenberg[4]. Two-thirds of the protein and all the demonstrable erythropoietic activity were in one band. Two faster-moving and one slower-moving bands had no demonstrable activity, and gave no augmented activity when added to the one active band.

On the basis of these and other experiments the following properties may be assigned to the erythropoietic principle. Erythropoietic activity so far has been inseparable from protein. Digestion with chymotrypsin or trypsin destroyed the activity. The active material is not dialysable, it is not lost after dialysis with 6 *M* urea, and it may be dried by lyophilization. It is stable to boiling at *p*H 5·5 for short periods. It is precipitated in the presence of all the plasma proteins by 80 per cent saturation with ammonium sulphate; the purified material in 0·6 per cent solution is soluble in 70 per cent saturated ammonium sulphate. Erythropoietic activity as measured by reticulocytosis in mice, increased uptake of iron-59 in rats and polycythæmia in rats went together in one electrophoretic fraction. Neither dialysis nor electrophoresis has separated a prosthetic group necessary for its activity. The active fraction gave a positive test for sialic acid[5] (mucoprotein).

Work is in progress on purification of the electrophoretic fraction.

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Cytolipin *H*, a Pure Lipid Hapten isolated from Human Carcinoma

ANTISERA prepared by injecting rabbits with cytoplasmic fractions or homogenates of human tissues frequently contain antibodies directed against substances extractable from the tissue with organic solvents and presumably lipid in nature. Material derived from tumours is reported to be more effective than that from normal tissues in eliciting this type of antibody[1], suggesting that tumours may contain larger quantities of one or several lipoprotein antigens or possibly antigens qualitatively different. Exploration of this problem by the methods of immunochemical analysis is obstructed by several complications: the antigenic complexity of lipid extracts, the multiplicity of antibodies in the antiserum reagents, and the paucity of information regarding non-specific lipid–protein interactions for many classes of lipids. A fourth complication is of even greater moment than the other three combined, namely, the fact that specific lipid–protein interactions are markedly influenced by certain ubiquitous, non-specific lipids[2].

Analytical measurements can therefore shed only dim light on the problem of antigenic specificity and distribution until methods are developed which take into account the complex nature of the observed interactions. The development of such methods has, in turn, been hampered by lack of knowledge concerning the structure of lipid molecules which combine specifically with antibody as well as the absence of an adequate number of models for study. This communication reports the isolation from human carcinoma of a pure lipid hapten, its partial chemical characterization and its immunochemical properties. This substance, for which we propose the name 'cytolipin *H*', is a four-residue molecule the structure of which is capable of exact determination. It therefore offers a promising point of departure in attacking the complex problems associated with immunochemical studies of lipids.

The method of isolation was as follows: human epidermoid carcinoma (H.Ep. No. 3) grown in cortisonized rats was homogenized in a Waring blendor with 20 ml./gm. chloroform/methanol (2 : 1). The extract was washed with water according to Folch *et al.*[3], giving 2·5 gm. of a crude lipid soluble in chloroform per 100 gm. of wet tissue. The crude lipid was fractionated on silicic acid at 5° C. in 6 gm. lots using a discontinuous-gradient elution method with hexane and ethanol[4,5]. Fractions eluted with hexane and 5 per cent ethanol in hexane were rejected; the fractions emerging with 17 per cent ethanol in hexane were collected, yielding 30–90 mgm. per run, phosphorus 2–3 per cent, hexose (aminodiphenyl method[6]) 6–12 per cent. Material from ten runs was pooled to give 630 mgm., phosphorus 2·1 per cent, hexose 6·9 per cent. This was dissolved in 5 ml. of ethyl ether and 10 ml. of ethanol at 60°. A small quantity of insoluble material was rejected. On chilling, 171 mgm. was deposited, hexose 18·5 per cent. An additional 90 mgm. was obtained by adding 15 ml. of ethanol and 4 ml. of water, hexose 19·9 per cent. The supernatant, containing 376 mgm., phosphorus 2·49 per cent, hexose 2·7 per cent, was discarded. The fractionation was repeated to remove an additional 57 mgm. of soluble material, phosphorus 2·0 per cent, hexose 3·2 per cent, and the remaining phospholipid was removed by chromatography over 'Florisil' in chloroform/methanol (2 : 1)[7]. The yield was 80·9 mgm. of colourless material, phosphorus less than 0·02 per cent, hexose 36·5 per cent, nitrogen 1·47 per cent, which was recrystallized three times from hot pyridine/acetone (1 : 6) to give 63·8 mgm. having $[\alpha]_D^{24°} = -10{\cdot}8°$ (concentration 2 per cent in pyridine). Recrystallization from methanol/chloroform (9 : 1) did not affect the rotation.

This substance, cytolipin *H*, is insoluble in water and contains no ester groups or phosphorus. It is ninhydrin-negative, but on acid hydrolysis (3 *N* hydrochloric acid, 100°, 2 hr.), ninhydrin-positive material is released that is associated exclusively with a long-chain base (sphingosine). Hydrolysis also releases two molecules of hexose that migrate on paper (ethyl acetate/pyridine/water[8]) with the R_F values of glucose and galactose and appear in equal concentration. Evidence at hand suggests that cytolipin *H* is a cerebronyl–sphingosyl–glucosido–galactoside, but much additional structural work remains to be done. The composition is consistent with the formula $C_{54}H_{103}O_{14}N$ (molecular weight, 990·4); calculated: C, 65·49; H, 10·48; N, 1·41; hexose, 36·4 per cent; iodine No. 26; found: C, 65·46; H, 10·31; N, 1·38; hexose, 36·7 per cent; iodine No. 32.

Cytolipin *H* activity was followed by complement-fixation with rabbit anti-human reticulum cell sarcoma serum. The pure substance reacts very poorly in this test, but when combined with the optimal quantity of auxiliary lipid (a mixture of equal parts of lecithin and cholesterol), less than 0·001 μgm. can be readily determined. Under these conditions, cytolipin *H* reacts with rabbit antisera prepared by injecting many different types of human tumours. Isofixation curves[9] of cytolipin *H* with two rabbit anti-human tumour sera are shown in Fig. 1.

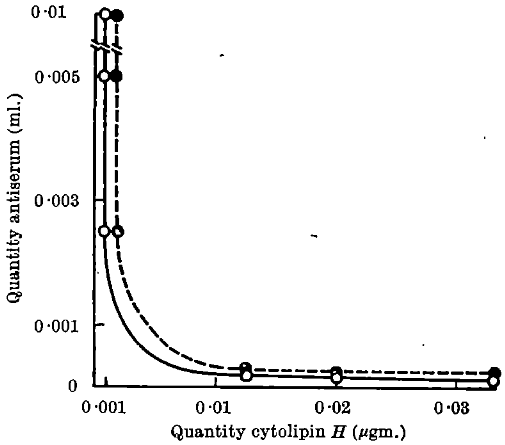

Fig. 1. Isofixation curves determined with cytolipin *H* and antisera to cervix carcinoma (broken line) and reticulum cell sarcoma (solid line). Three 50 per cent hæmolytic units (0·00375 ml. of guinea pig serum); 2 hr. incubation at 20° C. (ref. 9)

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Effect of Certain Polyphenylated Aliphatic Hydrocarbons on the Phagocytic Activity of the Reticulo-Endothelial System

In a recent communication to *Nature*, Nicol *et al.*[1] reported the effect of various stilbene compounds on the phagocytic activity of the reticulo-endothelial system, intimating that stimulation was associated with certain aspects in the chemical structure, and that the strongest stimulants possessed high œstrogenicity. The present communication reports the effect on reticulo-endothelial phagocytic activity of some polyphenylated aliphatic hydrocarbons related to the synthetic œstrogens of the diphenylmethane series.

The present experiments were carried out on 50 male white mice (*T.O.* Swiss strain) of 20–30 gm. body-weight. Five of the animals were used for assessing the effect of each compound on the phagocytic activity of the reticulo-endothelial system, each animal receiving one subcutaneous injection of 0·5 mgm. of each substance in 0·05 ml. of arachis oil daily for six days. The phagocytic activity of the reticulo-endothelial system was measured on the eighth day, as described in the previous communication[1].

Twenty-five animals were used as controls. Each received one subcutaneous injection of 0·05 ml. arachis oil daily for six days and then showed an average phagocytic index or *K* value of 13 ± 2·4.

Table 1. Effect of Certain Polyphenylated Aliphatic Hydrocarbons, containing at least one *para*-Hydroxyl Group, on the Phagocytic Activity of the Reticulo-Endothelial System

	Compound used	Phagocytic index (*K* value)	Œstrogenic activity (R.U.) (mgm.)
A	3 : 3-Di-(*p*-Hydroxyphenyl)-*n*-pentane	16 ± 2·2	5
B	3-(*p*-Hydroxyphenyl)-3-phenyl-*n*-pentane	11 ± 1·1	10
C	*p*-Hydroxyphenyldiphenyl-methane	13 ± 1·7	25
D	1-(*p*-Hydroxyphenyl-1 : 1-diphenylpropane)	10 ± 0·6	100 (inactive)
E	*p*-Hydroxyphenyltriphenyl-methane	8 ± 1·6	100 (inactive)
	Control values for 25 animals	13 ± 2·4	

Table 1 shows the relative *K* values of five polyphenylated aliphatic hydrocarbons investigated, together with their known levels of œstrogenicity. The results indicate that compound *E* has a profound depressant effect on phagocytosis only hitherto found following the administration of cortisone[2] in which the phagocytic index was reduced to *K* = 7. Compound *E* is the only non-steroid found by us to cause such marked depression of phagocytic activity. Compounds *B* and *D* show only a minor depressant action; compound *C* causes no alteration; while compound *A*, which is œstrogenic in the rat following doses of 5 mgm., has a slight stimulatory effect.

We are indebted to Prof. D. H. Hey for help in the interpretation of the above results and to Sir Charles Dodds for generously supplying these compounds. We also gratefully acknowledge assistance from the Central Research Fund of the University of London and from the Medical Research Council.

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Species Difference in Pyridine Nucleotide Synthesis by Erythrocytes

Leder and Handler[1] have described the synthesis of pyridine nucleotide from nicotinamide and glucose by human erythrocyte homolysates in amounts as much as ten times the normal content and they identified the synthesized material as nicotinamide mononucleotide. These authors also suggested that fructose diphosphate and adenosine triphosphate

Table 1

Species	No. of observations	γ-Pyridine nucleotide (as diphosphopyridine nucleotide per c.c.):		Synthesis of pyridine nucleotide by erythrocytes from nicotinamide + glucose (γ-pyridine nucleotide formed/c.c. red blood cells)	γ Ribose/c.c. of whole blood	γ Ribose synthesized/c.c. red blood cells/hr.
		whole blood	erythrocytes			
Man	8	30·6	62·5	314·7	—	—
Monkey	6	63·1	145·0	nil	—	—
Rat	6	94·2	205·0	nil	186·0	82·3
Mouse	2	194·1	407·5	nil	—	—
Guinea pig	6	37·8	77·1	346·9	147·2	75·3
Rabbit	2	59·5	131·8	nil	—	—
Sheep	3	—	192·1	nil	—	—

were required for optimal synthesis of nicotinamide mononucleotide. While synthesis of pyridine nucleotide is thus known to occur *in vitro* by washed human erythrocytes, its presence and its synthesis in other mammalian species have not yet been examined.

In our recent studies on the metabolism of pyridine nucleotide it was observed that the washed red blood cells of the rat were unable to synthesize that substance under conditions similar to those employed by Leder and Handler[2] in human erythrocyte studies. This finding induced us to examine further the behaviour of different species of animals, namely, mouse, rat, guinea pig, rabbit, sheep, monkey and man, as regards synthesis of pyridine nucleotide by erythrocytes.

The total pyridine nucleotide content of the whole blood was estimated by the method of Levitas *et al.*[3]. The capacity of fresh erythrocytes, washed four times at 3° C. with four volumes of glucose–Ringer phosphate, *p*H 7·2, to synthesize nicotinamide mononucleotide was estimated by the method of Leder and Handler[2]. In some experiments with rats and mice, the incubation mixture contained fructose-1 : 6-diphosphate, adenosine triphosphate and D-ribose, in addition to nicotinamide and glucose.

The results presented in Table 1 demonstrate that, of the seven species studied, only man and guinea pig erythrocytes were capable of synthesizing pyridine nucleotide under the conditions of the experiment. However, all the species that were unable to synthesize it had a higher pyridine nucleotide content of blood than guinea pig or man. This suggests that the major site for synthesis of nicotinamide mononucleotide in these species may be a tissue other than blood.

Although it is uncertain whether the formation of nicotinamide mononucleotide in blood cells occurs by the direct phosphorylation of nicotinamide riboside by adenosine triphosphate as shown in liver preparations by Rowen and Kornberg[4], or by the reaction between the base and ribose-5-phosphate or 5-phosphoribosyl-1-pyrophosphate[5], it is reasonable to assume that the conversion of glucose-6-phosphate to ribose phosphate by way of a hexose monophosphate shunt may be an essential step in the synthesis of nicotinamide mononucleotide from nicotinamide and glucose. My results demonstrate that the formation of ribose phosphate from glucose-6-phosphate in rat and guinea pig erythrocytes, as well as the ribose content of the whole blood of these two species, were almost equal. It was evident, therefore, that the ribose phosphate did not seem to be a limiting factor in synthesis of pyridine nucleotide in rat erythrocytes. It is hoped that experiments with erythrocyte homolysates and liver preparations now in progress may provide some information regarding the comparative role of these tissues in synthesis of pyridine nucleotide in different species of animals.

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Investigations into Temperature Changes on the Surface of Human Tooth Enamel

In one of the first observations made with the aid of the microscope, Leeuwenhoek[1,2] found that he could detect fewer organisms in scrapings taken from teeth after drinking hot fluids than in scrapings taken before the drink. Although many investigations have been made into the physical effect of thermal changes upon enamel and into the effects of conducted heat upon the dental pulp, there is no evidence in the literature of Leeuwenhoek's observation having been pursued.

In the present series of experiments, investigations are being carried out from the aspect of the effects of temperature changes upon chemical or bacterial activity taking place upon the surfaces of human teeth. To ascertain the range of such changes on enamel surfaces during meals, pilot experiments were performed using copper-constantan thermocouples attached to the surface of enamel and in areas between teeth. Meals were eaten at a serving temperature of 60–70° C., during which thermocouple readings were taken every 30 sec.

It was found that maximum temperatures of 50–60° C. were reached and temperatures of 40–45° C. were maintained for up to ten minutes at a time. In areas between the teeth, the temperature on the enamel surface took, on average, thirty minutes after the finish of the meal to return to 37° C.

When measuring surface temperatures it is necessary to know the thermal conductivity of the material the surface of which is under examination, and since only a rough estimate of the thermal conductivity of enamel has been made[3] it was thought that as a preliminary investigation the thermal conductivity of enamel should be determined. The apparatus in use for this is a modification of that used by Phillips, Johnson and Phillips[4] for the determination of the thermal conductivity of dentine and dental cements. Results indicate that the value of the thermal conductivity of enamel is of the order 0·002 c.g.s. units, and that variations occur with the age of the enamel. Since the value is in the same range as ceramic materials, thermistors will be more suitable for use on enamel surfaces than thermocouples. Experiments are being conducted with thermistors recording on to pen-recorders.

It would seem that if the detailed investigations confirm the indications of the pilot work, it may be incorrect to perform *in vitro* experiments into dental caries at 37° C. and regard them as being a reproduction of *in vivo* conditions.

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Effect of the Nitrogen and Sulphur Content of Organic Matter on the Production of Ammonium and Sulphate

AT this Laboratory, investigations into the decomposition of soil organic matter have been concerned with the effect of sulphur and nitrogen content on decay. To simplify the problem in its preliminary stages, and to gain better control of variables, the decomposition of mixtures of pure organic substances was studied.

This communication reports the effect of varying the nitrogen and sulphur content of such 'organic matter' on production of ammonium and of sulphate.

Mixtures of sucrose, casein, glycine and cysteine were used to vary the nitrogen and sulphur content of the organic matter—the carbon content was kept constant. Solutions of mixtures of these compounds, together with an inorganic salt solution, were inoculated with a soil extract and 40 ml. was then added to 300 gm. of clean sand in a series of 500-ml. flasks. After placing a small tube of sodium hydroxide solution in the flasks, they were closed with a thin sheet of polyethylene and were incubated at 27° C. With the quantities of organic matter used, diffusion of oxygen through the polyethylene into the bottle was rapid enough to sustain respiration at a rapid and probably maximal rate. Absorption of the carbon dioxide by the sodium hydroxide was much more rapid than diffusion out through the polyethylene. (Negligible loss of carbon dioxide occurred even when it was evolved very rapidly by action of acid on carbonate.) On the other hand, the concentration of carbon dioxide in air is so low that diffusion into the bottle was very small and in any event could easily be measured by a blank determination. At each sampling two bottles per treatment were taken to determine the sulphate, ammonium and carbon dioxide produced (no nitrate was detected). This allowed calculation of the carbon, nitrogen, and sulphur remaining in the organic form—though this calculation is subject to error if losses occur by formation of volatile compounds. It was thus possible to follow changes in the ratios of organic carbon to organic nitrogen and of organic carbon to organic sulphur (carbon/nitrogen and carbon/sulphur ratios).

Formation of ammonium was sometimes considerably delayed. This only happened when the initial carbon/nitrogen ratio was wider than about 5/1 and was only well marked when there was at least one part of sulphur to every hundred parts of carbon. One such curve is shown in Fig. 1, treatment 1. Calculations showed that the upward trend in such curves never occurred until respiration had lowered the carbon/nitrogen ratio to about 5/1.

However, when the proportion of sulphur in the organic matter was reduced, ammonium was formed more rapidly and before the carbon/nitrogen ratio had fallen to 5/1. Fig. 1 shows release of ammonium from organic matter with an initial carbon/nitrogen ratio of 13·3/1 and initial carbon/sulphur ratios varying from 100/1 to 400/1. Release of ammonium from material of wide carbon/sulphur ratio occurred much more rapidly and at much wider carbon/nitrogen ratios—as wide as 12/1 for treatments 4 and 5. It would seem that utilization of nitrogen was limited by the supply of sulphur and that nitrogen in excess of microbial needs was mineralized.

The highly significant initial rise and subsequent fall in the curve for treatment 4 in Fig. 1 is worthy of note. On this treatment the micro-organisms apparently did not attack the organic compounds at the same rate: it would seem that the nitrogen-rich compound (in this case glycine) was attacked more rapidly than the energy-rich compound (sucrose) and excess nitrogen was mineralized. Later, presumably when the sucrose was fully utilized, some of this nitrogen was immobilized. A similar 'premature' formation of sulphate occurred in some other experiments, but in most cases the micro-organisms appeared to attack the simple organic compounds at the same rate.

Graphs of sulphate production against time—like those for ammonium production—sometimes showed a flat initial phase before production of sulphate occurred. The upward trend in the curves did not

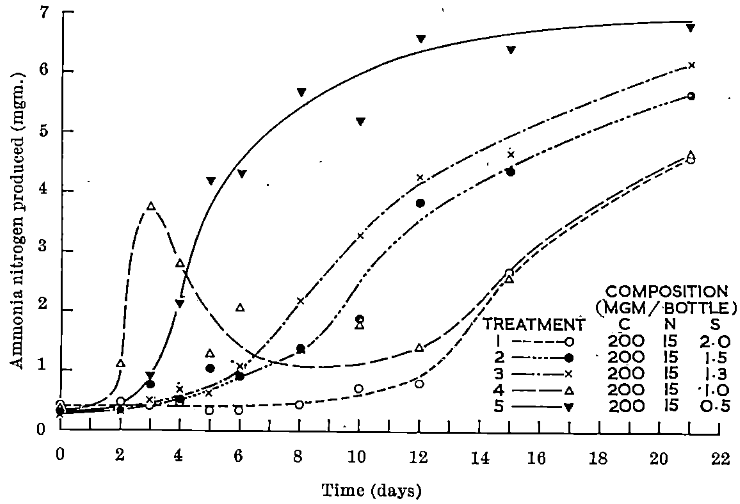

Fig. 1. Release of ammonium from mixtures of sucrose, glycine, and cysteine of the composition shown. The maximum value of the least range for significance (ref. 1) at $P < 0·01$ is 1·45 mgm. ammonia nitrogen

occur until respiration had lowered the carbon/sulphur ratio to about 50/1. When the proportion of nitrogen in the organic matter was reduced, production of sulphate tended to be more rapid—though the effect did not seem to be nearly as well marked as the effect of reducing the proportion of sulphur on production of ammonium.

These results suggest that mineralization of an element from organic matter depends not only on the proportion of that element in the organic matter but also on the proportion of the other elements. It is probable that a similar generalization applies to immobilization of elements, and in fact other results from these experiments have shown that immobilization of phosphorus was reduced when the proportion of nitrogen or of sulphur in the organic matter was reduced.

The statistical analysis was performed by Mr. P. F. May, of the Division of Mathematical Statistics, Commonwealth Scientific and Industrial Research Organization. It is intended to publish this work in greater detail elsewhere.

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Absence of γ-Aminobutyric Acid from Brain Extracts containing Factor I

Florey[1] and Florey and McLennan[2,3] have described some of the actions of extracts of brain and spinal cord which possess an inhibitory activity on certain synaptic processes, both in mammals and in invertebrate animals. For example, these extracts, which are said to contain 'Factor I', can block transmission in sympathetic ganglia, can inhibit monosynaptic reflexes, can block neuromuscular transmission and the neurogenic heartbeat of Crustacea, and can inhibit the discharge of crustacean stretch receptor neurones. Bazemore, Elliott and Florey[4] have reported that an active component of extracts containing Factor I is γ-aminobutyric acid. Since that time it has been shown that γ-aminobutyric acid does have effects of an inhibitory nature, especially in Crustacea[5] and when applied to the mammalian cerebral cortex[6]. However, a comparison of the actions of Factor I and γ-aminobutyric acid on those structures where the former is active has shown that, except in Crustacea, the effects obtained with the two are not comparable, and it was concluded that they are not identical[7].

In the present experiments a solution of Factor I was applied to Whatman No. 4 filter paper, and subjected to chromatographic separation for free amino-acids. The solvents used were *n*-butanol/glacial acetic acid/water (4 : 1 : 5, v/v/v) in one dimension, and 80 per cent (w/w) aqueous phenol in the second. The chromatograms were developed with ninhydrin solution to reveal the amino-acid spots.

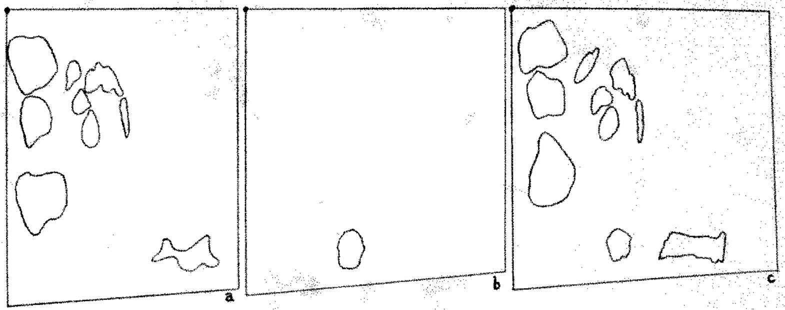

Fig. 1. Tracings of descending chromatograms developed with ninhydrin. In each case the solution was applied to the upper left-hand corner. The horizontal dimension represents movement in the butanol/acetic acid/water solvent, and the vertical the movement in phenol. (*a*) Factor I solution, 0·025 ml.; (*b*) γ-aminobutyric acid solution, 0·01 ml. of 1 mgm./ml.; (*c*) Factor I solution, 0·025 ml.; γ-aminobutyric acid solution, 0·01 ml.

Fig. 1*a* shows the distribution of spots obtained with a solution of Factor I prepared according to Florey and McLennan[2]. Fig. 1*b* shows the spot obtained when a solution of pure γ-aminobutyric acid was applied to the paper, and Fig. 1*c* the result when Factor I with added γ-aminobutyric acid was applied. It is evident from these chromatograms, which were all performed simultaneously, that there is no spot in Fig. 1*a* corresponding to γ-aminobutyric acid, such as appears clearly in Fig. 1*c*, where the substance was added artificially to the solution of Factor I.

It can be concluded from this experiment that extracts containing Factor I prepared by the method of Florey and McLennan, which possess the whole complex of actions described by those authors, contain no γ-aminobutyric acid, which cannot therefore be the active component of Factor I. Nor can it be argued that the quantity of Factor I applied to the paper in Fig. 1*a* contains an undetectably small amount of γ-aminobutyric acid, for the amount applied is 2½–5 times that required to block the crayfish stretch receptor neurone, and is therefore at least 2½ times more than the amount applied in Fig. 1*b*[7]. A possible explanation for the finding of Bazemore *et al.*[4] that γ-aminobutyric acid was present in the extracts containing Factor I is that it was split off from some larger molecule in the course of the relatively drastic extraction procedures which were used. It may perhaps be conjectured that this postulated larger molecule, of which γ-aminobutyric acid is a fragment, is the true active ingredient of Factor I solutions.

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Composition of the Rous Virus Nucleoid

A TECHNIQUE, modified from that of Gessler, Bender and Parkinson[1], was recently devised to investigate the purifying effect of a fluorocarbon on vaccinia virus[2].

The technique has now been applied to nodules of Rous tumour grown on the chick chorio-allantois in order to prepare suspensions of the Rous virus. Such suspensions have been subjected to high-speed centrifugation and the pellets which resulted have been fixed, embedded, sectioned and examined in the electron microscope. It has been found that the only recognizable formed structures present in the pellets were uniform spherical particles about 75 mμ in diameter (Fig. 1), and biological tests integrated with the morphological work have established that these particles were in fact the Rous virus[3]. Fragments of the pellets containing the virus are ideal both for examination by electron and fluorescence microscopy after enzyme digestion, and for cytochemical study.

The nucleoid of the Rous virus is known to lie in a central zone separated from the viroplasm by a fine membrane[4]. In order to investigate the nature of the nucleoid, samples of the pellets containing the virus have been treated with ribonuclease. The samples were first fixed with potassium permanganate[5] which, unlike the more commonly used osmium–sucrose fixative for electron microscopy[6], allows subsequent digestion by both deoxyribonuclease[7] and, under certain conditions, ribonuclease. After fixation, the samples were placed in iced 30 per cent alcohol and allowed to warm to room temperature[5]; they were then incubated for 2 hr. at 37° C. in 30 per cent alcohol containing 0·1 per cent by weight of ribonuclease, protease-free, and recrystallized three times (Worthington Biochemical Corporation, Freehold, New Jersey). Control samples were incubated simultaneously in 30 per cent alcohol without the enzyme. After incubation, all the samples were dehydrated, embedded in *n*-butyl methacrylate and sectioned for examination in the electron microscope.

The incubation procedure made the particles appear ragged and extracted (Fig. 2). It is nevertheless clear that in the control preparations, which were not exposed to the ribonuclease, the nucleoid and outer limiting membrane remained intact (Fig. 2*a*). On the other hand, the nucleoids were removed from particles which had been subjected to ribonuclease digestion (Fig. 2*b*); such particles also appeared slightly swollen as if some central supporting structure had been removed. The specificity of the ribonuclease digestions in conjunction with the findings of the control experiments demonstrate that the nucleoid of the Rous virus contains a substantial amount of ribonucleic acid. This work will be reported in detail elsewhere[8] together with a discussion of its significance.

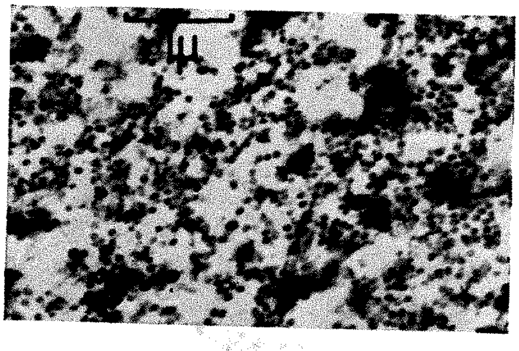

Fig. 1. Electron micrograph of a section through a pellet prepared from a suspension of the Rous virus which had been treated seven times with a fluorocarbon. Uniform virus particles about 70–75 mμ in diameter are almost the only formed structures present. Permanganate fixation. × 14,000

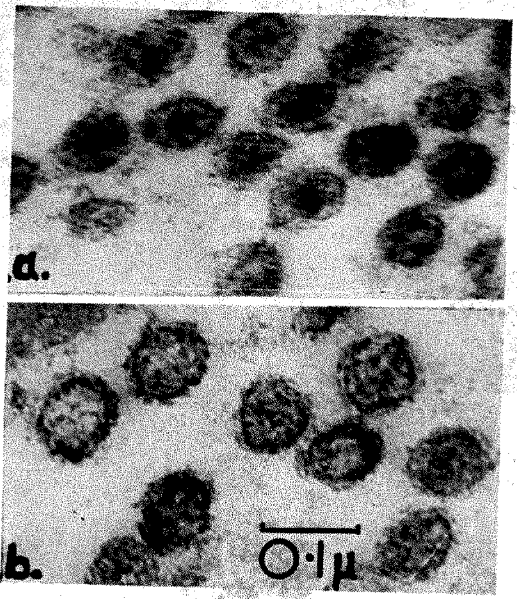

Fig. 2. Electron micrographs of thin sections of Rous virus particles. (*a*) Control particles which had been incubated in 30 per cent alcohol at 37° C. for 2 hr.; the nucleoid and outer limiting membrane can be distinguished. (*b*) Particles which had been incubated in the same way as the controls except that the 30 per cent alcohol contained 0·1 per cent by weight of ribonuclease; the nucleoids have been removed and the particles appear slightly swollen. Permanganate fixation. × 130,000

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A Cobalt-Accumulator Plant, *Clethra barbinervis* Sieb. et Zucc.

DURING an investigation to determine if variations in the heavy-metal content of vegetation and soil could be used in prospecting for chromite ore bodies in the Hinokami district, Tottori Prefecture, a tree, *Clethra barbinervis* Sieb. et Zucc., was unexpectedly found to be an accumulator of cobalt.

Leaves of seventeen different kinds of trees collected from 199 locations in the neighbourhood of the mine were analysed for iron, nickel, cobalt, copper, zinc, manganese and chromium. The cobalt and nickel

Table 1. Cobalt, Nickel and Iron Content of Plant Leaves

Species	No. of samples	Average content (p.p.m. of ash) Co	Ni	Fe	Average ratios Ni/Co	Fe/Co
Clethra barbinervis Sieb. et Zucc.	17	661	140	548	0·38	1·37
Quercus crispula Blume	69	2·6	42·2	614	20·7	386
Deutzia crenata Sieb. et Zucc.	26	5·3	24·0	791	7·8	175
Castanea crenata Sieb. et Zucc.	24	3·6	31·8	846	11·1	243
Cynoxylon japonica Nakai	24	2·0	24·6	688	20·3	482
Lindera umbellata Thunberg	11	4·3	26·7	696	7·1	204
Other species	28	3·9	32·2	671	12·8	289

content of the ash of a variety of trees other than *Clethra* sp. ranged from less than 1·0 to 22·5 p.p.m. and from 3·2 to 120 p.p.m., respectively. More than one hundred times as much cobalt and several times as much nickel were found in *Clethra* sp. as in other plant species. Normally, plants contained from seven to twenty times more nickel than cobalt, but *Clethra* sp. contained more cobalt than nickel, although it was not richer in iron.

The total nickel content of the soil (*B*-horizon), which was mostly derived from serpentine parent material, ranged from less than 100 to 3,010 p.p.m. dry weight, the average being 1,005 p.p.m.; the total cobalt content also ranged from 10 to 9,250 p.p.m., the average being 652 p.p.m. The soil on which *Clethra* sp. was growing did not show any anomalous levels in these elements, yielding on average 1,125 p.p.m. of nickel and 511 p.p.m. of cobalt.

There is no evidence that cobalt is essential for higher plants, although certain species of lower plants and bacteria require this element. The large accumulation of cobalt in leaves of *Clethra* sp. suggests that this element may have some function in higher plants. Further work is proceeding and will be reported in detail elsewhere.

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Morphology of Yeast Mitochondria

There has recently been some controversy as to the possibility of demonstrating other than granular mitochondria of yeast cells[1-3]. It is well known that for a long time the only mitochondria that cytologists were able to demonstrate in yeast cells were round, granular structures. As their minute dimensions make it practically impossible to observe the same cell before and after treatment with fixatives, stains, etc., the identification of yeast mitochondria must necessarily be doubtful. However, knowledge of the structure of the living cell, and the comparison of cytochemical results with the state of the living untreated cell, should be good safeguards against incorrect interpretation. One frequently abstains from using phase-contrast when examining yeast cells because, under the usual conditions of examination, cells of the yeast type which have a high solid content and refractive index give unsatisfactory images[4]. The fact that incomparably better results can be obtained with phase-contrast, provided immersion media of suitable refractive index are used, was stressed in Britain by Barer *et al.*[5], and this principle has been used by us for the study of micro-organisms, notably yeast cells.

From the cytochemical investigations of Ephrussi and his school[6], who used both normal and respiration-deficient strains of yeast, it can be concluded with certainty that in the case of yeasts a positive Janus green *B* reaction depends on the activity of the cytochrome *c* – cytochrome oxidase system. So far as is known, therefore, those structures of the yeast cell which, after careful treatment, can be stained with Janus green may be considered as mitochondria.

When Yotsuyanagi[1], using a double differential staining method, observed thread-like as well as granular structures in yeast cells and identified them as mitochondria, Williams *et al.*[2] denied the presence of long cylindrical mitochondrial threads in yeasts and emphasized that thread-like structures in such cells were only seen as artefacts after they had been stained with 2,3,5-triphenyltetrazolium.

The controversy between Williams *et al.*[2] and Ephrussi *et al.*[3] is solely based on what I believe to be Williams's incorrect interpretation of Yotsuyanagi's results. I should like to correct the statement of Williams *et al.* that "no other observer has ever reported long cylindrical cytoplasmic structures in *Saccharomyces*".

Quite independently of Yotsuyanagi's work, I have in recent years investigated the morphology and continuity of yeast mitochondria. According to my results, thread-like mitochondria seen in yeast cells are true structures of the living cell and not artefacts produced by the use of stains[7]. Using phase-contrast refractometry[8], I succeeded in demonstrating thread-like mitochondria in a number of yeast strains. This method so greatly facilitates their analysis that I was able some years ago to study their living structure by time-lapse microcinematography. One of my film-strips, which shows thread-like mitochondria during budding (*Sacch. carlsbergensis*) and cell-division (*Saccharomycodes ludwigii*) was shown at the meeting of the Research Film Section of the International Scientific Film Association in Göttingen in 1956. Fig. 1 shows the typical shape of thread-like mitochondria with negative phase-contrast. The interpretation of Williams *et al.* that such thread-like structures in yeast cells must be regarded as artefacts is thus refuted by the demonstration of thread-like mitochondria in living, untreated cells.

Provided special care is used, it is possible to stain these thread-like mitochondria with Janus green *B*.

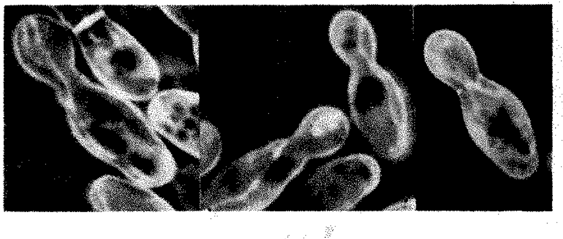

Fig. 1. *Saccharomycodes ludwigii*: long, thread-like mitochondria in living, unstained cells (*a* and *b*) and during cell-division (*c*). Negative phase-contrast, magnification, × 1,200; refractive index of the medium, 1·377

I could not, however—in contrast to Yotsuyanagi[1]—demonstrate them after fixation. My experience showed that thread-like yeast mitochondria are extremely sensitive to any type of interference with the cell, including vital staining and fixation. Great importance must therefore be attached to the analysis of their living structure. Fragments of thread-like mitochondria, as found, for example, after treating the cells with vital stains, may for a limited period remain stainable with Janus green. Their structure does not, however, correspond completely with what is found in the living cell.

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Fluoroacetamide as a Systemic Insecticide

It has previously been reported that sodium fluoroacetate is a very effective systemic insecticide against *Aphis fabae* Scop.[1,2]. Unfortunately, its use cannot be recommended since it is a very dangerous poison, being both highly toxic and rapid in action.

As a result of the above report, related compounds have been investigated, and it has now been stated that fluoroacetamide is an active insecticide[3], although no details of biological tests have been published. Fluoroacetamide is claimed to be considerably less hazardous to handle than sodium fluoroacetate because it is less toxic and acts more slowly[4,5]. Furthermore, in rats acetamide acts as an antidote to fluoroacetamide but not to sodium fluoroacetate[5,6].

The biological tests were carried out as previously described[2,7]. The test insects were the bean aphis, *A. fabae* Scop., on broad beans, the cabbage aphis, *Brevicoryne brassicae* L., the peach potato aphis, *Myzus persicae* Sulz., on young cabbage plants and the eggs and larvæ of the large white butterfly, *Pieris brassicae* L., also on young cabbage plants.

In tests in which leaves bearing *A. fabae* and *B. brassicae* were dipped, fluoroacetamide was as effective as sodium fluoroacetate, 0·001 per cent solutions containing a wetting agent giving 100 per cent kill. Both were superior to schradan. When leaves bearing eggs of *P. brassicae* were similarly dipped in 0·1 per cent fluoroacetamide solution, 85 per cent of eggs failed to hatch and 70–80 per cent of the larvæ were killed. The same concentration of sodium fluoroacetate had no effect on the number of eggs hatching but killed 98 per cent of the newly emerged larvæ. Less than 10 per cent of the fourth instar larvæ were killed following immersion for 0·5 min. at 20° C. in the 0·1 per cent fluoroacetamide solution plus wetting agent.

When poured on to the soil, for systemic action against *A. fabae*, fluoroacetamide was as immediately effective and as persistent as sodium fluoroacetate: 2 mgm. (in 20 ml. solution) applied to 400 gm. of moist compost giving 100 per cent kill. It was therefore superior to schradan. When applied in the same way against *B. brassicae* and *M. persicae*, fluoroacetamide was superior to sodium fluoroacetate. The former aphid was killed by a dose of 0·2 mgm. and the latter by 1·0 mgm. of fluoroacetamide on the same weight of compost. Applied in this way, neither compound prevented the eggs of *P. brassicae* on the leaves of young cabbage plants from hatching, but all the young larvæ were killed by a dose of 10 mgm. fluoroacetamide or 20 mgm. of sodium fluoroacetate on the soil.

When administered to broad bean plants by the cut tap-root technique[2], the approximate *LD*100 in mgm. per kgm. of fresh plant tissue for *A. fabae* was fluoroacetamide 0·09–0·9, sodium fluoroacetate 0·7, schradan 50. When taken up through the petioles of the leaves of small cabbage plants 5 mgm. of the fluorine compounds or 50 mgm. schradan per kgm. of fresh plant tissue killed all *B. brassicae*. The growth of *P. brassicae* larvæ was prevented by 20 mgm./kgm. of either fluorine compound. For schradan more than 2,900 mgm./kgm. was required.

When applied to the older leaves against all three species of aphids feeding on the younger leaves of their host plants, fluoroacetamide was as effective as or slightly superior to sodium fluoroacetate as a systemic insecticide and in varying degrees superior to schradan.

It is clear that fluoroacetamide is as effective as the more dangerous sodium fluoroacetate as a systemic insecticide. Whether or not it would be safe for use on food crops remains to be proved. A more detailed report will be published elsewhere.

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It may be of interest to report that we found, as preliminary to many field experiments on the systemic insecticidal activity of fluoroacetamide against aphid pests of a number of flowering plants, that cuttings of rose bushes (unidentified species), infested very seriously with *Macrosiphum rosae* L. and their cut ends dipped in solutions of the insecticide at certain concentration (with 0·05 per cent wetting agent added), gave the kills indicated (Table 1).

Table 1

Dilution	Aphid kill	Phytotoxicity
1 in 1,000	100 per cent in 8 hr.	Some signs
1 in 10,000	100 per cent in 8–10 hr.	Nil
1 in 20,000	100 per cent in 24 hr.	Nil
1 in 100,000	Some kill in 24 hr. (young insects) Complete kill in 72–96 hr.	Nil

The above work was done in the late spring of 1953, and arose from the pioneer work of David and Gardiner[1] on the systemic insecticidal activity of sodium fluoroacetate; later work showed that the insecticide was persistent in the rose bushes for a period of about 2–3 weeks, applied as spray or via root only, at a strength of 1 part in 10,000; that is, aphids occasionally began to reappear after this period of time, necessitating a second spray.

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Systemic Insecticides and the Ratio of Green to Dried Hops

In England when hops are picked by hand the work is assessed in terms of the volume of green hops measured as bushels. The green hops are later kiln-dried to about 9 per cent water content before being pressed into bales and sold by weight. Some growers keep a record of the average number of bushels of green hops required each year to give 1 cwt. of dried hops; this average is called the bushel/cwt. ratio. The ratio may vary from year to year on the same farm and from farm to farm in the same year. This variation has been discussed by Glasscock[1], who suggested meteorological conditions at harvesting as one of a number of possible factors concerned.

During recent years it has been reported that the ratio was increasing beyond the limits of normal variability[2]. Data from five East Kent farms (including Wye College) were examined; in three farms the data related to 1942–57 inclusive, and in the other two they related to 1944–57 and 1949–57 respectively. These data are summarized in Table 1, which also gives values for rainfall during August–September of the appropriate years, recorded at Wye College.

Table 1 shows that: (*a*) The average bushel/cwt. ratio for all farms increased from 91 for 1942–49 to 104 for 1950–57; (*b*) the average rainfall during August–September increased from 3·87 to 6·52 in. for the same two eight-year periods. Both these increases are statistically significant at $P = 0{\cdot}01$. The possibility at once suggests itself that the increase in rainfall may have been responsible for the observed increase in the ratio, but this hypothesis is not confirmed by statistical examination of the data. No correlation exists between rainfall and the bushel/cwt. ratio within either of the two periods 1942–49 or 1950–57.

Systemic organo-phosphorus insecticides for control of aphis and red spider were first used commercially on hops in 1949. They have proved most effective and their use has since become general. Of the five farms examined, three introduced systemic insecticides in 1950, one in 1951 and Wye College in 1953; all five farms have since continued to use them. Data for individual farms show that in the years when systemic insecticides were first used the bushel/cwt. ratio rose at once to a level well above the existing average; in three farms it rose to levels greater than previously recorded. It is of significance to note that at Wye College the ratio remained low in the very wet years of 1951 and 1952; when systemic insecticides were introduced in 1953 the ratio rose at once to the high levels at which it has since remained.

Table 1. Data on the Ratio of Bushels of Green Hops harvested per cwt. of Dried Hops for Five Farms in East Kent, and on August–September Rainfall at Wye, Kent, for the Years 1942–57 Inclusive

Year	Bushel/cwt. ratio values for five farms in East Kent					Average ratio for all farms	August–September rainfall (in.)
	Wye College	Farm "E"	Farm "H"	Farm "M"	Farm "W"		
1942	—	109	77	92	—	93	4·53
1943	—	103	88	94	—	95	2·67
1944	—	96	88	86	91	90	4·48
1945	—	98	88	93	100	95	2·83
1946	—	89	87	90	85	88	7·01
1947	—	89	89	91	88	89	0·90
1948	—	99	83	88	85	89	4·47
1949	100	99	86	84	89	92	4·08
	Average 1942–49					91	3·87
1950	100	110*	89*	93	94*	97	4·59
1951	114	112	96	97*	99	104	8·93
1952	103	115	97	97	99	102	8·17
1953	120*	115	92	95	93	103	6·33
1954	127	111	87	96	93	103	5·83
1955	115	110	98	100	107	106	4·71
1956	127	120	88	97	108	108	5·95
1957	125	125	87	105	107	110	7·68
	Average 1950–57					104	6·52

* Year in which systemic insecticides were first used.

It appears probable that the introduction of systemic insecticides has played an appreciable part in increasing the bushel/cwt. ratio. The causes of this increase have not been investigated. A possible explanation is that the superior control of aphis and red spider given by these systemic compounds results in the crop being picked in a more succulent condition than when contact insecticides only were used. It is also possible that the presence of these compounds in the plant may have had physiological side-effects resulting in this increase in the ratio.

This work will be discussed in more detail in the Annual Report of the Department of Hop Research for 1957 which is to be published shortly.

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A New Species of *Atolla*

While making a study of the scyphomedusan *Atolla* in north Atlantic waters I recently found that there were two species, *A. wyvillei* and *A. vanhöffeni*[1]. I can now state that there is a third species. Like *A. vanhöffeni*, this is a small species, apparently not exceeding 30 mm. in diameter, but the shape of the base of its stomach is similar to that of *A. wyvillei*.

Whereas *A. vanhöffeni* and *A. wyvillei* have typically 20 and 22 marginal tentacles respectively, this new species has usually 20 or 24 tentacles. It differs also from *A. wyvillei* in that the septa separating the rhopalar and tentacular gastral canals tend to be nearly straight and of uniform thickness, and are almost completely covered to their centripetal ends by the thin part of the coronal muscle. In *A. wyvillei* the septa tend to be club-shaped in appearance, diverging at their ends and extending centripetally beyond the margin of the thin part of the coronal muscle. Its range of coloration appears to be similar to that of *A. wyvillei*.

In view of its small size, I propose to name this species *Atolla parva* n.sp. A fuller description will be given in a later publication, but in the meantime it is hoped that those engaged in studying plankton collections may be able to add to our knowledge of the distribution of the species.

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Grain in the Glume of Wheat

In the wheats, as in most grasses, there are empty glumes at the base of each side of the spikelets, and the florets consist of a lemma (flowering glume), palea and flower. In *Triticum vulgare* Host, ten or eleven flower primordia are formed in most spikelets[1] and although in some varieties under good conditions many spikelets carry four or five grains, in most varieties grain is produced only in the two or three basal florets, and the higher florets are undeveloped. The only recorded regular departure from this system is the basal sterility found in some speltoid mutants of *T. vulgare*[2]. In these the lemma of the first floret of most spikelets is empty, and in one mutant both the basal florets are sterile: the initiation of the flower primordia is partially or completely suppressed[3]. One of the more rare abnormalities of flower development in normal varieties is the occurrence of rudimentary florets in the axils of the glumes[3].

Regular development of flower parts in the axil of the second glume has been found in a compactoid wheat. The development varies from the production of a rudimentary palea within the glume to the formation of a complete flower which may set a grain; no increased growth of lodicules[3] has been observed. The 42 ears from five plants grown in the Crop Research Division glasshouse have been examined, and of the 648 well-developed spikelets three, from one plant, were 'normal', 608 showed the abnormality within one glume and 37 showed it in both glumes. Where the order of the florets was noted it was found that the second glume had flower parts in the axil, and where both sides were affected the development in the second glume was the more advanced. Of 222 grains produced by the five plants, 44 were formed in the glumes. In all ears there was incomplete development of the terminal spikelets.

The density of the ears was similar to those of awnless compactoids previously described[4,5], and the appearance of two of the spikelets is shown in Fig. 1. In Fig. 2 the parts of one spikelet are arranged in order. The glumes are long (up to 13 mm.), keeled and fragile, and the shoulder is very narrow; the lemmas and the glumes are awned.

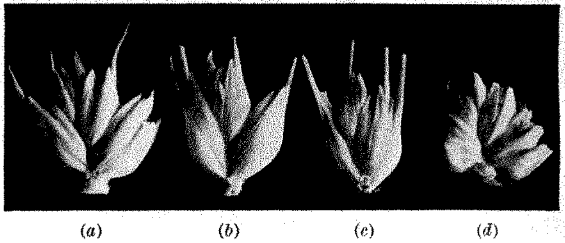

Fig. 1. Spikelets of wheat: (*a*) *T. vulgare* var. Aotea; four grains. (*b*) Compactoid; on left, glume normal, no grain in first flower; grains on right in second flower and in glume. (*c*) Reverse of spikelet from same ear as (*b*); on left, glume with palea, no grain in second flower; grain on right in first flower. (*d*) *T. compactum*, *S*2767; four grains

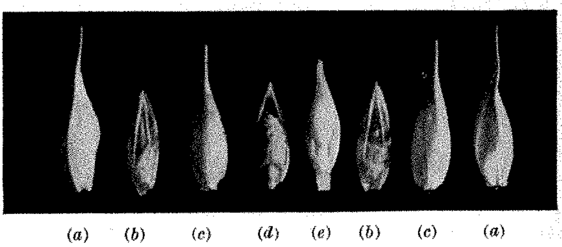

Fig. 2. Spikelet of compactoid, parts in order: (*a*) Glume; (*b*) unfertilized flower; (*c*) lemma; (*d*) grain in second normal floret; (*e*) central florets

The compactoid line is descended from the cross[6] of two awned varieties from the Crop Research Division wheat collection, *S*357 from Crete and *S*1556 from India. The awned progeny of a sub-compactoid F_2 plant consisted of 27 compactoids, 43 sub-compactoids and 32 normal plants, and an F_5 of 42 plants grown from three compactoid F_4's was all compactoid. Chromosomes were counted in root tips of nine of these, including the five discussed above, and all had 44 chromosomes; the material is presumably a stable tetrasome IX compactoid[5].

In the F_3 the abnormality was shown in compactoids, and in the compact part of a sub-compactoid ear, but not in a normal ear. It is thus closely related to compactoidy, and appears, like compactoidy[4], to be independent of the *compactum* factor. It is not found in *T. compactum* Host, and in ears from the F_1 with *T. compactum* (*S*2767) as male parent only the upper spikelets had flower parts in the glumes. It is possible that all compactoids show the character, though some (Mac Key[4], Fig. 53; Sears[5], Fig. 10) do not appear to have fertile glumes. The glumes of another tetrasome compactoid[7] were, apart from being awnless, similar to those of the present material, but their fertility could not be assessed from the photograph (their Fig. 22). A duplication compactoid found recently in unrelated material had relatively short glumes, and no awns; in the one ear harvested most of the 16 spikelets contained two grains, 11 of them had flower parts in the second glume, and in the top third of the head five grains were produced in glumes. It is suspected that the abnormality had not been recorded previously because the effect is not conspicuous unless a grain is formed, and if a grain is formed the impression is given that the glume has been broken off. Both the outer bracts are structurally glumes, and not lemmas.

The production of flower parts in the compactoid glume is an extension of the cytological and phenotypic reciprocality between speltoids, particularly 'sterile base', and compactoids. Awnedness may be of significance[5]; the present material is fully awned, and basal sterility is expressed more fully in awnless speltoids[3], but it is doubtful whether much importance should be attached to simply-inherited characters. Compactoids provide evidence of the genetical characteristics of chromosome IX, part of the *B* genome of wheat, the origin of which is unknown[8], but the normal disomic effects of chromosome IX cannot be predicted, and not until an *Aegilops*, or perhaps an *Agropyron*, with a fertile glume is discovered should any evolutionary significance be attached to this character. (*Added in proof:* Okamoto (*Wheat Inf. Service*, 6, 3; 1957) (E. R. Sears, personal communication) has shown that chromosome IX is in the *A* genome, and has thus reduced the historical importance of speltoidy and compactoidy.)

I wish to thank Mr. E. J. Beuzenberg for the chromosome counts, and Mr. C. J. Miles for the photographs.

G. M. Wright

Crop Research Division,
Department of Scientific and Industrial Research,
Christchurch, New Zealand. April 23.

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Bat Erosion as a Factor in Cave Formation

Observations in three bat-infested caves in Trinidad suggest that roosting bats can play a considerable part in cave excavation where the rock is soft. The best example of this bat erosion is to be seen in a cave in soft coral reef limestone in Mt. Tamana. Wherever the roof is dry, as indicated by the absence of stalactite growth, it is pitted with numerous bell-shaped cavities, the upper parts of which are lined, by day, by a layer of closely packed sleeping bats. On the cave floor below each such cavity is a conical mound of bat guano.

Measurement of these cavities with a pair of long wooden calipers showed depths ranging from 3 ft. to 6 ft. and diameters at the mouth from 1½ ft. to 2½ ft. In the deeper ones measured, the terminal dome and upper part of the shaft were of much the same dimensions as a complete smaller cavity, while the lower part of the shaft widened farther. However, the majority were of irregular shape, having merged with neighbouring cavities.

The bell shape, consisting of a tapered shaft surmounted by a dome, accords with the view that the cavities have been excavated by the claws of generations of roosting bats. Certain species tend to sleep clinging to an overhanging surface and crowded close together, and they can be observed to jostle each other, trying to secure a central position. Such jostling could, over a long period, be expected to erode a cavity in soft granular rock. As the cavity deepened, bats would tend to alight at the lip and climb up the shaft to reach the dome. Thus the lowest and oldest part of the shaft would have been subjected for the longest time to erosion by climbing bats, and could be expected to be of greater diameter than the upper part.

At least nine species of bat have been recorded from these caves, and both total and relative numbers have been observed to vary. Their roosting habits would make an interesting study, but the remoteness of the caves renders such an undertaking difficult.

W. A. King-Webster
J. S. Kenny

Fisheries Department,
Port-of-Spain,
Trinidad, B.W.I. Sept. 26.

The Cromer Forest Bed: Preglacial or Interglacial?

The relation of the Cromer Forest Bed Series to the overlying glacial deposits and to the earlier Crag Series has long been a problem, but the recent communication in *Nature* by Prof. P. G. H. Boswell[1] should do much to dispel the idea that the Cromerian stage can be described as an 'Interglacial'. No glacial tills or similar deposits have ever been seen below this Series, and therefore from the point of view of stratigraphy its description as 'Interglacial' can only cause confusion. The very few glacial erratics which have been found in and below the Crag can be attributed to the action of sea-ice, and cannot be counted as representing a 'glaciation'; these erratics are so rare that in practice unfossiliferous Crag deposits can be distinguished in the field from most glacial beds by the fact that erratics are scarcely ever found in the Crag.

As regards conditions during the formation of the Cromer Forest Bed itself, Clement Reid[2] believed that the fossil plants and non-marine shells are in general similar to those now living in Norfolk, with a few exceptions such as *Corbicula fluminalis*. More recently, Woldstedt[3] described a pollen analysis of samples taken from part of the Forest Bed Series as showing a phase with early birch and pine forests succeeded later by a mixed oak association. If work now being done at Cambridge confirms Woldstedt's conclusions, this will suggest that a major climatic fluctuation took place during the formation of the Cromer Forest Bed of a type seen in some interglacial episodes, though differing in detail. This apparent contradiction of a climatic fluctuation which is not preceded by a glacial deposit makes an examination of the marine fauna of the underlying Weybourne Crag most important, in order to find out whether this fauna represents arctic conditions.

In the absence of glacial erratics or actual glacial deposits, it has in fact been argued by Zeuner[4] that the marine fauna of the Weybourne Crag, which underlies the Forest Bed Series, contains sufficient cold indicators to prove glacial conditions before the formation of the Cromer Forest Bed. He considered that an analysis of the marine fauna proves that the cold increased unevenly during Crag times, and that at least two cold episodes represent pre-Cromerian glacial phases; one of his cold episodes is stated to have occurred during the formation of the Weybourne Crag. But Clement Reid[2] showed that only a few cold indicators are known in the Weybourne Crag, and that only one of these (*Astarte borealis*) is at all common, the rest being very rare indeed; in any event a Mediterranean shell is also known to occur (*Astarte incrassata*). Among the marine formations of eastern England it is not the Weybourne Crag which shows the coldest conditions, but the Bridlington Crag of Yorkshire, which is believed to be later than the Cromer Forest Bed[5]. It seems to me that we can conclude that Zeuner's analysis suggests that there may have been fluctuations of climate during Crag times, and these may even go back into the Pliocene, but there is insufficient faunal evidence for calling these fluctuations 'glacials' or 'interglacials'. For similar reasons it is difficult to agree with Woldstedt's use[3] of the term 'Cromer Forest Bed Interglacial'.

As Sainty has pointed out[6], Clement Reid came to the conclusion after several years of work on the Cromer coast that among the occasional marine shells found in the estuarine parts of the Cromer Forest Bed Series, no new 'arrivals' have been recognized as compared with the Weybourne Crag fauna; and in fact the marine fauna of the Weybourne Crag itself only differs from that of the earlier Norwich Crag in the 'arrival' of one new species (*Tellina balthica*) as compared with the Norwich Crag; this species is a common living British shell to-day, and (in spite of its name) is not typical of specially cold conditions. As no new 'arrivals' of cold indicators have yet been found in the Weybourne Crag, there is no proof from the marine fauna that this deposit represents any colder conditions than the Norwich Crag. In view of the lack of geological evidence for truly glacial conditions in the later Crag beds which were formed before the Cromer Forest Bed Series, it seems to me unwise to refer to the Cromer Forest Bed as an 'Interglacial', at least until we know more about conditions during the formation of the Norwich and Weybourne Crags.

D. F. W. Baden-Powell

University Museum,
Oxford.
May 24.

[1] Boswell, P. G. H., *Nature*, **181**, 1087 (1958).
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"Physics and Metaphysics"

Nature of March 8 contained, over the signature of Prof. L. Rosenfeld, a very lively criticism of the book "Causality and Chance in Modern Physics", published last year by Prof. David Bohm, a book for which I have written the preface. I do not think that the criticisms of Prof. Rosenfeld are justified.

The current probabilistic interpretation of the quantum theory leads in its general lines to exact conclusions. But since it denies every possibility of a precise image of the development of phenomena in space and time, it continues to be surrounded by a certain obscurity. It is not at all certain that it furnishes a complete description of physical reality: scientists as eminent as Planck, Einstein and Schrödinger have always expressed doubts on this subject. The idea of Prof. Bohm that it may be necessary to introduce new 'levels' of physical reality deeper and more hidden than those revealed by current experience therefore seems perfectly defensible to me. For my part, returning after a number of years to certain ideas that I had considered previously when I was developing the first bases of wave mechanics, I have examined this question in the light of the conceptions of Prof. Bohm and in collaboration with certain young scientists at the Institut Henri Poincaré. In particular, I have asked myself whether it would not be possible to find an interpretation which, while retaining all the results given by probabilistic quantum physics, would permit us to obtain a more clear and more intelligible image of microphysical facts. The problem is certainly not an easy one, but I do not believe it to be so impossible as Prof. Rosenfeld thinks; and a certain number of results already obtained in this direction seem encouraging to me.

In any event, no theoretical interpretation can ever be established with a final and complete definitiveness, and for this reason alone it is always permissible to submit those that have already been accepted to a new examination. At the end of the previous century, the great majority of physicists belonged to the 'energeticist' school, which wanted to develop thermodynamics and its related subjects on purely formal bases, and which rejected, often with great disdain, all atomic and corpuscular representations. However, the interpretation of thermodynamics in terms of statistical mechanics, while taking complete account of the success of classical thermodynamics, has permitted us to go very much further. The existence of 'microphysical levels' of atoms and molecules, which the statistical mechanical interpretation of thermodynamics introduces, has been completely and clearly demonstrated. It is not forbidden to think that something analogous could happen again in the years to come. The introduction of a 'sub-quantum' milieu, deeper than the level of current microphysics, could permit the interpretation of the calculations of the present quantum theory in a clearer way, and might lead us further than the current theory can go.

In addition, the quantum theory in its accepted form seems, in a certain measure, to have exhausted its powers of prevision. After a number of years, becoming more and more formal, it has begun to have as many failures as it has successes. Even its proponents themselves seem now to admit the need to make some efforts to modify its bases. In these conditions, it does not seem to me justified to condemn *a priori* the efforts of those who try to take in a new point of view, and to obtain an image of the physical world more intelligible than that based on the conception of complementarity which remains, in spite of everything, rather obscure.

Louis de Broglie

Academie des Sciences,
Paris 1e.

THE impossibility of eliminating the relations of complementarity from atomic physics is not a question of opinion but a simple logical point, as devoid of obscurity, as, for example, the impossibility of defining absolute simultaneity. For a detailed discussion of the points raised in M. de Broglie's comments I may refer the reader to my contribution to the book "Louis de Broglie, Physicien et Penseur" (Paris, 1952), a revised version of which appeared in *Science Progress*, 41, 393 (1953).

L. Rosenfeld

University of Manchester,

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, June 30

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 5 p.m.—Dr. J. D. Robertson: "The Molecular Biology of Cell Membranes".*

Wednesday, July 2

MEDICAL RESEARCH COUNCIL (at the National Institute for Medical Research, Mill Hill, London, N.W.7), at 5 p.m.—Prof. Samuel Graff (U.S.A.): "Experiments with Continuous Metazoan Cell Cultures".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURERS, Grade II (honours graduates or associate members of a professional institution), IN MATHEMATICS at Singapore Polytechnic—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (July 3).

SENIOR LECTURER (with a good honours degree or higher degree in chemistry and experience in industry, or teaching and research) IN CHEMISTRY—The Principal, Wigan and District Mining and Technical College, Wigan (July 4).

LECTURER IN THEORETICAL PHYSICS—The Registrar, The University, Manchester 13 (July 5).

RESEARCH ASSISTANT IN THE DEPARTMENT OF PHYSICAL AND INORGANIC CHEMISTRY, to undertake research and to assist with the supervision of Ph.D. students, either (*a*) in the field of physical adsorption; or (*b*) in the field of thermodynamics of solutions—The Registrar, The University, Bristol (July 5).

SENIOR LECTURER (medically qualified and with special qualifications in chemical pathology) IN CHEMICAL PATHOLOGY—The Registrar, The University, Manchester 13 (July 5).

DEMONSTRATOR IN PHYSICAL CHEMISTRY—The Registrar, The University, Hull (July 8).

LECTURER IN GEOLOGY—The Registrar (Room 22, O.R.B.), The University, Reading (July 12).

RESEARCH ASSISTANT (preferably with a good knowledge of biology and physical sciences) IN THE DEPARTMENT OF ANATOMY, for work mainly connected with electron microscopy—The Secretary, University College, Gower Street, London, W.C.1 (July 12).

RESEARCH ASSISTANT (with a good degree and preferably research experience in botany or biochemistry) IN THE DEPARTMENT OF BOTANY, to work on biochemical physiology—The Secretary, University College, Gower Street, London, W.C.1 (July 14).

ASSISTANT EXPERIMENTAL OFFICER (graduate) IN THE BEE DEPARTMENT, for work on field behaviour of bees—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (July 15).

LECTURER (with special experience in plant physiology) IN BOTANY—The Registrar, The University, Birmingham (July 15).

VOKES RESEARCH FELLOW IN THE DEPARTMENT OF MECHANICAL ENGINEERING, to undertake research in the field of filtration, the separation of mixtures, or allied problems in fluid mechanics—The Registrar, The University, Southampton (July 15).

DEMONSTRATOR IN THE DEPARTMENT OF GEOGRAPHY—The Secretary of the Appointments Committee, Department of Geography, The University, Downing Place, Cambridge (July 16).

RESEARCH WORKER (with a university degree, preferably in forestry, and some practical forestry and research experience), to continue the special study of shelterbelt problems in Scotland by the Department of Forestry—The Secretary, The University, Edinburgh (July 18).

RESEARCH ASSISTANT (graduate in zoology or candidate for honours this year) IN ZOOLOGY, to work on the biology of fish populations in the River Thames—The Registrar (Room 22, O.R.B.), The University, Reading (July 19).

ASSISTANT LECTURER or LECTURER IN CHEMISTRY—The Secretary, Royal College of Science and Technology, Glasgow (July 21).

SENIOR LECTURER IN BIOCHEMISTRY at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 21).

LECTURER IN THE DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY—The Registrar (Room 22, O.R.B.), The University, Reading (July 31).

LECTURER or SENIOR LECTURER IN PATHOLOGY in the Faculty of Rural Science, University of New England, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (July 31).

LECTURER (preferably with special qualifications in applied mathematics) IN MATHEMATICS at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

LECTURER (with an honours degree in zoology and preferably familiar with vertebrate zoology and an interest in the ecology of mammals) IN THE DEPARTMENT OF ZOOLOGY at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

LECTURER IN SOCIAL ANTHROPOLOGY at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 10).

CHAIR OF BOTANY in the University College of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 15).

LECTURER or SENIOR LECTURER IN POULTRY SCIENCE in the Faculty of Rural Science, University of New England, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (August 31).

CHEMIST (with an honours degree in chemistry or equivalent professional qualification plus a minimum of three years post-qualification experience) IN THE MEDICAL DEPARTMENT, Hong Kong, for general analytical and supervisory work—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.117/51/018/T.

LECTURER (with experience in rock and mineral analysis) IN THE PURE GEOCHEMISTRY SECTION OF THE GEOLOGY DEPARTMENT, for duties which will include teaching petrology and research in pure geochemistry or chemical petrology—Professor D. Williams, Geology Department, Imperial College, London, S.W.7.

PROFESSOR (familiar with gas turbines, jet propulsion and internal combustion engines) OF THERMODYNAMICS, for duties which will include lecturing to undergraduate and postgraduate students and the direction of research—The Dean of Engineering, Ecole Polytechnique (Canadian University), 1430 St. Denis Street, Montreal, Canada.

RESEARCH ASSISTANT IN THE CRYSTALLOGRAPHIC LABORATORY, for structure analysis of organo-metallic compounds—Secretary of the University of Cambridge, Department of Physics, Cavendish Laboratory, Free School Lane, Cambridge.

RESEARCH ASSISTANTS, IN THE DEPARTMENTS OF BOTANY AND ZOOLOGY, CHEMISTRY, MATHEMATICS, METALLURGY AND PHYSICS—The Secretary, Sir John Cass College, Jewry Street, London, E.C.1.

SCIENTIFIC ASSISTANT (with a good science degree, a reading knowledge of two European languages (preferably other than French or German), ability to write good English, and preferably a knowledge of soil science and plant physiology), for work in a scientific information service involving abstracting and indexing—The Director, Rothamsted Experimental Station (Commonwealth Bureau of Soils), Harpenden, Herts.

SCIENTIST (with a first- or second-class honours degree in physics, physical chemistry or mathematics as a principal subject, and preferably with some previous experience in airborne dust measurement), for research on methods of assessing the dust content of the atmosphere, and the investigation of airborne dust conditions in mines, involving some underground work—Divisional Chief Staff Officer, National Coal Board, East Midlands Division, Sherwood Lodge, Arnold, Nottingham, quoting S.V.851.

SENIOR LECTURER (highly qualified in mathematics, considerable teaching and/or industrial experience, and preferably the ability to organize special courses in mathematics for highly qualified students in industry) IN MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Planning, Vol. 24, No. 421 (14 April, 1958): The Debate on Sterling. Pp. 69–88. (London: Political and Economic Planning, 1958.) 2*s*. 6*d*. [164

Institution of Chemical Engineers. Proceedings of the Joint Symposium on the Scaling-Up of Chemical Plant and Processes, held at Church House, London, S.W.1, on 28 and 29 May, 1957. Edited by Dr. J. M. Pirie. Pp. 136. (London: Institution of Chemical Engineers, 1958.) 60*s*. [164

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Theoretical Chemistry: Looking Before and After. By Prof. D. P. Craig. (An Inaugural Lecture delivered at University College, London, 21 October, 1957). Pp. 14. (London: H. K. Lewis and Co., Ltd., 1958.) 2*s*. 6*d*. net. [244

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Imperial Cancer Research Fund. Fifty-Fifth Annual Report, 1956–1957. Pp. 45. (London: Imperial Cancer Research Fund, 1958.) [244

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 982, Vol. 250 (17 April, 1958): The Mobilities of Ions in Unlike Gases. By A. Dalgarno, M. R. C. McDowell and A. Williams. The Mobilities of Ions in their Parent Gases. By A. Dalgarno. (London: Royal Society, 1958.) 9*s*. [244

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World Federation for Mental Health. Introductory Study No. 1: Identity. Pp. 46. (London: World Federation for Mental Health, 1958.) 5*s*. net. [284

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Commonwealth Scientific and Industrial Research Organization, Australia. Soil Publication No. 10: Depositional Systems of the Riverine Plain of South-Western Australia in Relation to Soils. By B. E. Butler. Pp. 35+4 plates. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1958.) [164

Meddelelser fra Kommissionen for Danmarks Fiskeri- og Havundersøgelser. Serie: Plankton, Bind 5, Nr. 6: Investigations in the Phytoplankton in Sheltered Danish Marine Localities. By Jul. Grøntved and E. S. Nielsen. Pp. 52+1 plate. (København: C. A. Reitzels Forlag, 1957.) 10 kr. [164

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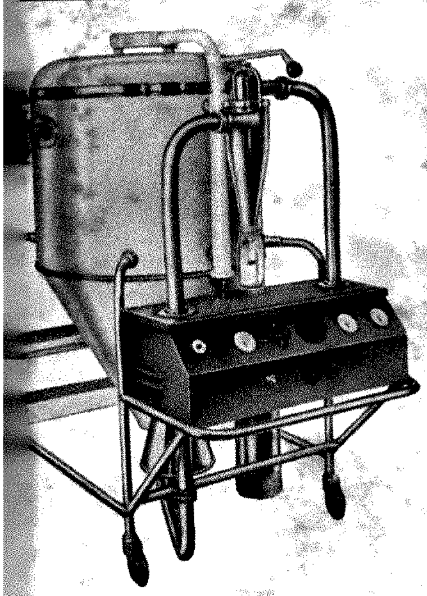

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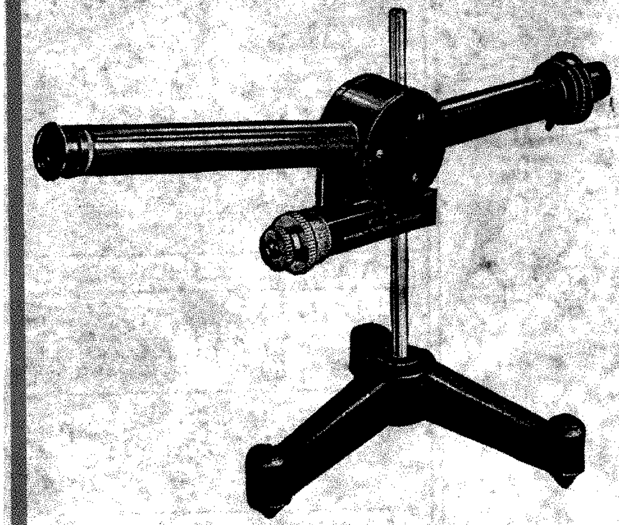

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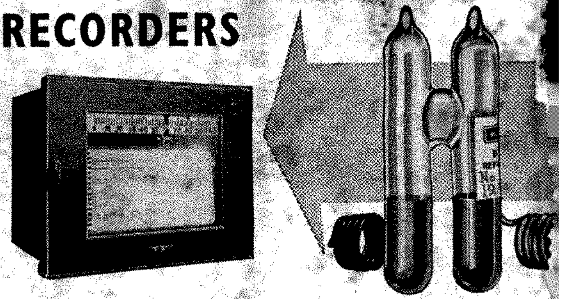

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